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ORIGINAL RESEARCH

Effects of Erector Spinae Plane Block and Transmuscular Quadratus Lumborum Block on Postoperative Opioid Consumption in Total Laparoscopic Hysterectomy: A Randomized Controlled Clinical Trial

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ABSTRACT

Introduction: Total laparoscopic hysterectomy (TLH) is a common surgical procedure that is frequently associated with substantial postoperative pain. As part of multimodal analgesia, the erector spinae plane block (ESPB) and transmuscular quadratus lumborum block (TQLB) have been demonstrated to be effective. This study aimed to evaluate whether ESPB and TQLB reduce postoperative pain and opioid consumption after TLH.

Methods: A total of 90 female patients undergoing TLH were randomized to receive either ESPB, TQLB, or no intervention before general anesthesia. All patients received a patient-controlled sufentanil analgesia postoperatively. Postoperative pain and sufentanil consumption were evaluated. The primary outcome was cumulative sufentanil consumption at 12 h postoperatively.

Results: The cumulative sufentanil consumption at 12 h postoperatively was significantly lower in Group ESPB than in Group CON after Bonferroni correction (median [interquartile range], 0 [0, 4] μg vs. 6 [0, 10] μg; median difference = − 3; 95% confidence interval, − 6–0; $P = 0.010$). There were no significant differences between Group TQLB and CON (0 [0, 4] μg vs. 6 [0, 10] μg; $P = 0.098$) or between the two block groups ($P = 1.000$). When compared with Group CON, ESPB and TQLB persistently reduced pain scores until 6 and 4 h after surgery, respectively ($P < 0.05$). However, no significant differences were found in pain scores between the two block groups.

Conclusions: ESPB and TQLB improved the quality of multimodal analgesia for TLH. ESPB may be more favorable due to the prolonged period of analgesia and decreased opioid consumption after TLH.

Clinical Trial Registration: Chinese Clinical Trial Registry: ChiCTR2100048165, Registry URL: http://www.chictr.org.cn/showproj.aspx?proj=129578. Date of registration: July 4, 2021. The patient enrollment began on July 12, 2021.

Keywords: Erector spinae plane block; Transmuscular quadratus lumborum block;

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Multimodal analgesia; Opioid consumption; Postoperative pain; Total laparoscopic hysterectomy

Key Summary Points

Why carry out this study?

Interfascial plane blocks have been demonstrated to be effective in multimodal analgesia. Literature regarding the interfascial plane blocks for total laparoscopic hysterectomy (TLH) is limited.

This study aimed to evaluate whether interfascial plane blocks of erector spinae plane block and transmuscular quadratus lumborum block reduce postoperative pain and opioid consumption after TLH.

What was learned from the study?

This study demonstrated that the interfascial plane blocks of erector spinae plane block and transmuscular quadratus lumborum block both improved the quality of multimodal analgesia for TLH.

Erector spinae plane block may be more favorable due to the prolonged period of analgesia and decreased opioid consumption.

INTRODUCTION

Total laparoscopic hysterectomy (TLH) is a preferred alternative to open abdominal hysterectomy [1]. Though minimally invasive, patients may still experience significant and multifactorial postoperative pain owing to surgical manipulation [2, 3]. Based on anatomical knowledge of the visceral afferent fibers from the uterus and anterolateral abdominal wall, we considered that local anesthetic (LA) anesthetizing the ventral rami and sympathetic trunk in the thoracolumbar paravertebral space would provide somatic and visceral pain relief after TLH [4].

Interfascial plane block techniques including the erector spinae plane block (ESPB) and transmuscular quadratus lumborum block (TQLB) provide effective multimodal analgesia with technical safety and simplicity [5–8]. For ESPB, an LA is injected into the plane between the erector spinae muscle and transverse process of the thoracic vertebra, spreading the LA cephalad, caudally, and through the paravertebral space [9]. For TQLB, the LA is deposited into the plane between the quadratus lumborum and psoas major, leading to a dense block of the thoracolumbar sympathetic trunk and segmental nerves after the LA spreading through the paravertebral space [10, 11]. However, literature regarding ESPB for postoperative analgesia in TLH is limited. Meanwhile, controversy regarding the efficiency of TQLB for TLH remains. Although a study demonstrated promising results of TQLB on pain control after TLH [12], this technique failed to show a significant reduction in opioid consumption as seen in another study [4].

Therefore, we designed a randomized controlled trial (RCT) to differentiate the analgesic efficacy of ESPB and TQLB by comparing the results with a control group in patients scheduled for TLH. Additionally, we evaluated the relative efficacy of ESPB compared to TQLB. The primary outcome was cumulative sufentanil consumption at 12 h postoperatively. We hypothesized that both TQLB and ESPB would reduce the postoperative opioid consumption and pain intensity in patients undergoing TLH.

METHODS

Study Design and Randomization

This prospective RCT was conducted from July 2021 to May 2022, after approval by the Ethics Committee of the Second Affiliated Hospital of Anhui Medical University (approval no. YX2021-054[F1]) on June 29, 2021 and was prospectively registered in the Chinese Clinical Trial Registry (http://www.chictr.org.cn/showproj.aspx?proj=129578, ChiCTR2100048165; principal

investigator: YW) on July 4, 2021. This study was conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) criteria [13] and in compliance with the Helsinki Declaration. Written informed consent was obtained from all patients.

Female patients who underwent elective TLH were enrolled in this study. The inclusion criteria were age between 18 and 65 years and American Society of Anesthesiologists (ASA) physical status of I–II. The exclusion criteria were a body mass index $> 35\ kg\ m^{-2}$, coagulopathy, history of opiate abuse, pre-existing chronic pain, allergy to local anesthetics or analgesics, infection at the injection site, mental or neurological disorders, severe cardiovascular disease, hepatic or renal insufficiency, and pregnancy or lactation.

Patients were randomly allocated to receive either ultrasound-guided ESPB (Group ESPB), TQLB (Group TQLB) or no intervention (Group CON) using computer software at a ratio of 1:1:1. An assistant, who was not involved in the study, prepared the randomization list and concealed group assignments in consecutively numbered, sealed, opaque envelopes. A consultant anesthesiologist who had performed over 200 TQLB and ESPB procedures and was unaffiliated with the study opened the envelopes to reveal the group allocation shortly before nerve block performance. Ultrasound-guided peripheral blocks were performed according to randomization. Thereafter, the surgeons, anesthesiologists, nurses providing postoperative care, investigators, and outcome assessors were blinded to the patients' group allocation and did not have access to randomization until data analysis was complete.

Regional Anesthesia Technique

After arrival in the preoperative holding area, intravenous access was established and premedication (midazolam $0.02\ mg\ kg^{-1}$ and sufentanil $0.1\ \mu g\ kg^{-1}$) was administered. Vital parameters, including heart rate, electrocardiogram, blood pressure and pulse oximetry, were monitored throughout the procedure. All blocks were performed with a 22-gauge block needle using the same ultrasound machine (SonoSite M-Turbo; FUJIFILM Sonosite, Inc., Bothell, WA, USA). The patients were placed in a lateral decubitus position, and skin preparation was performed with 10% povidone-iodine. Bilateral ESPB and TQLB were performed as previously described [4, 14].

For ESPB, a linear ultrasound transducer (13–6 MHz) inside a sterile transparent plastic cover was positioned in a longitudinal orientation approximately 3 cm lateral to the midline at the T10 level to obtain a parasagittal view. After the tip of the T10 transverse process, the overlying erector spinae muscle and pleura were identified, the needle was inserted and in contact with the tip of the transverse process using an in-plane technique. After confirmation of the correct needle tip position by hydrodissection with normal saline, 25 ml of 0.4% ropivacaine was injected into the erector spinae plane between the tip of the transverse process and the erector spinae muscle on the left side. The same procedure with the same LA solution was injected at the T10 level on the right side (Fig. 1A–C).

For TQLB, a curvilinear ultrasound transducer (5–2 MHz) was placed in the transverse position immediately cranial to the iliac crest, at the level of the posterior axillary line. The needle was inserted in-plane in a posterolateral to anteromedial direction from the posterolateral edge of the probe until penetration of the medial part of the quadratus lumborum muscle, but without piercing the psoas major muscle. After confirmation of the correct needle tip position by hydrodissection, 25 ml of 0.4% ropivacaine was injected into the interfascial plane between the quadratus lumborum muscle and the psoas major muscle on the left side. The same procedure with the same LA solution was also injected on the right side after the patient was changed to the left lateral position (Fig. 1D–F).

In Group CON, the patients only received premedication in the preoperative holding area.

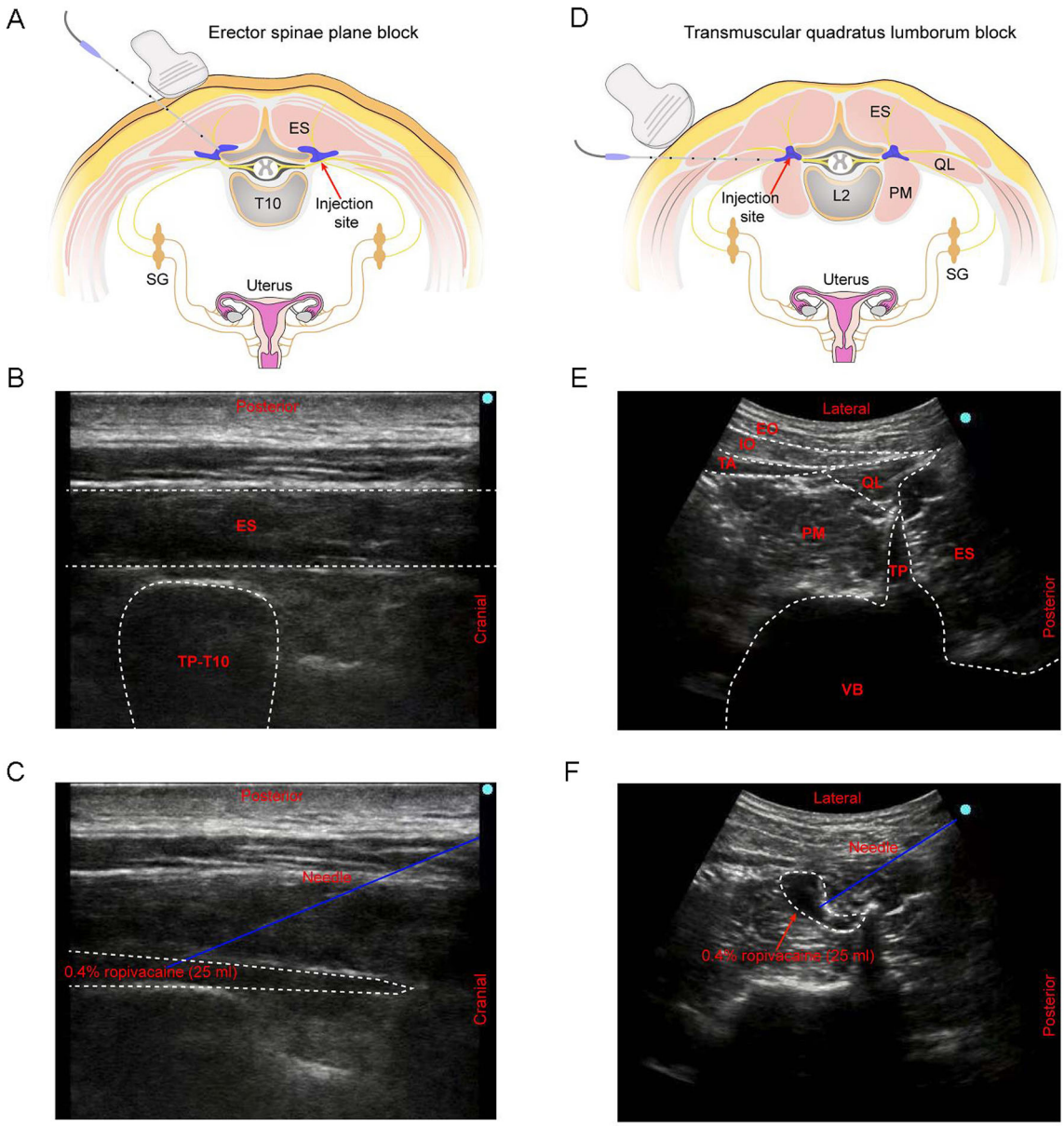

Fig. 1 A schematic diagram of ESPB and TQLB. **A** The LA injected into the erector spinae plane was expected to extend to the paravertebral space, anesthetizing the thoracolumbar ventral rami and the sympathetic trunk which innervate the uterus and anterolateral abdominal wall. **B** Ultrasound image of ESPB at T10. **C** The LA was injected into the erector spinae plane between the tip of the transverse process and the erector spinae muscle. **D** The LA injected into the plane between the quadratus lumborum and the psoas major was expected to extend to the paravertebral space, anesthetizing the thoracolumbar ventral rami and the sympathetic trunk which innervate the uterus and anterolateral abdominal wall. **E** Ultrasound image of TQLB. **F** The LA was injected into the interfascial plane between the quadratus lumborum muscle and the psoas major muscle. *ES* erector spinae muscle, *SG* segmental ganglion, *TP* transverse process, *QL* quadratus lumborum muscle, *PM* psoas major muscle, *EO* external oblique muscle, *IO* internal oblique muscle, *TA* transversus abdominis muscle, *VB* vertebral body

General Anesthesia Technique

After nerve block, patients were transferred to the operating room and received general anesthesia with standardized monitoring. Intravenous dexamethasone (8–10 mg) was administered to prevent postoperative nausea and vomiting (PONV). General anesthesia induction and tracheal intubation were performed using midazolam (0.05 mg kg^{-1}), sufentanil (0.4 μg kg^{-1}), etomidate (0.3 mg kg^{-1}) and cisatracurium (0.2 mg kg^{-1}). Parecoxib sodium (0.8 mg kg^{-1}) was administered after induction for pre-emptive analgesia. Maintenance of anesthesia was achieved by continuous infusion with propofol (4–-6 mg kg^{-1} h^{-1}) and remifentanil (0.15–-0.25 μg kg^{-1} min^{-1}). The depth of anesthesia was adjusted to maintain a bispectral index target range of 40–60. Anesthesiologists administered intravenous sufentanil (5–10 μg) when the patient's heart rate or blood pressure increased by > 20% from basal measurements.

Postoperative Management and Assessment

All patients were transferred to the post-anesthesia care unit for recovery after extubation (0 h postoperatively). A nurse blinded to the protocols instructed patients how to evaluate the incisional, visceral, shoulder and perineum pain [15] at rest and in motion using the 11-point Numeric Rating Scale (NRS), which ranges from '0' (meaning no pain) to '10' (meaning worst pain imaginable). Incisional pain was defined as a superficial pain, wound pain, or pain located in the abdominal wall, a pain that one can "touch"; visceral pain was defined as pain inside the abdomen, which may be deep, dull, and more difficult to localize, and may resemble a biliary pain attack; perineum and shoulder pain were defined as the sensation of pain in the perineum or shoulder, respectively. The sedation level was assessed using Richmond Agitation-Sedation Scale (RASS) [16] at 0.5 h postoperatively. Postoperative analgesia was maintained with sufentanil infusion using a patient-controlled intravenous analgesia (PCIA) device. The PCIA device administered a 3-μg bolus dose with a 15-min lock-time; no basal infusion and was initiated when the NRS score at rest was ≥ 4 or patients verbalized the need for pain relief. If three boluses of sufentanil did not alleviate pain, pentazocine 30 mg was administered intravenously as rescue analgesia. After transfer to the ward, patients used PCIA, as needed. The patient's quality of recovery was assessed using the Quality of Recovery-15 (QoR-15) scale [14, 17, 18] at 24 h postoperatively. At 3 and 6 months postoperatively, the intensity of the patients' average pain during the previous week was assessed using the NRS via telephone interview.

Outcomes

The primary outcome was cumulative sufentanil consumption at 12 h postoperatively. The secondary outcomes included cumulative sufentanil consumption at 24 h postoperatively; the RASS score at 0.5 h postoperatively; the NRS pain scores of incisional, visceral, shoulder, and perineal pain at rest and in motion, evaluated at 0.5, 2, 4, 6, 12 and 24 h after surgery; QoR-15 score at 24 h postoperatively; time to first PCIA; rescue analgesia requirement; time to first postoperative ambulation; block-related and anesthetic-related complications; postoperative length of hospitalization; and chronic pain in 3 and 6 months, postoperatively.

Sample Size and Statistical Analysis

The sample size was calculated based on the primary outcome of sufentanil consumption at 12 h postoperatively, using PASS V.15.0 (PASS, NCSS, USA) for Windows. Based on the results of our pilot study with six patients in each group (mean consumption of sufentanil at 12 h postoperatively was 3.5, 4.5, and 10.0 μg for Group ESPB, TQLB and CON, respectively, using a pooled standard deviation [SD] of 7.6), one-way analysis of variance (ANOVA) was selected and grouped into three groups; group allocation ratios were equal. At a power of 0.80 and an alpha error of 0.05, to account for 20% loss to follow-up, the required sample size for each

group was calculated as 30. Thus, 90 participants were included in this study.

All statistical analyses were performed using SPSS Statistics (version 26.0; IBM, Armonk, NY, USA). Kolmogorov–Smirnov test and visual inspection of histograms were performed to assess data normality. Continuous variables were expressed as mean (SD) or median (interquartile range, IQR), and inter-group differences were assessed for significance using ANOVA for normally distributed data or Kruskal–Wallis test for nonparametric data followed by Bonferroni correction. Pairwise comparison for postoperative sufentanil consumption was analyzed using the Mann–Whitney *U* test, and by calculating the Hodge–Lehman median difference with a constructed 95% confidence interval (CI) with $P < 0.0167$ (0.05/3) was considered significant. Categorical variables were expressed as number (percentage) and intergroup differences were assessed using chi-squared or Fisher's exact tests in cases of expected frequency < 5. The time to first PCIA was analyzed using Kaplan–Meier survival analysis followed by log-rank test, with adjustment for multiple comparisons.

Repeated measurements of postoperative pain scores were analyzed using a linear mixed model [19, 20] to evaluate the association between NRS pain score over time and the intervention technique. This model included intervention, time and the interaction between time and intervention as the fixed effects. Time was included as a repeated effect; NRS pain scores were included as dependent variables. We corrected for comparisons between groups at multiple time points using Bonferroni correction. Assessments were 2-tailed, and statistical significance was set at $P < 0.05$.

RESULTS

The CONSORT flow diagram for this trial is shown in Fig. 2. Patients were recruited from July 12, 2021 to November 26, 2021; follow-up of the last enrolled patient was completed on May 30, 2022. Initially, 106 patients were screened for suitability. Ten patients did not meet the inclusion criteria (one patient was 68 years of age, six patients were ASA III physical status, and three patients were morbidly obese with BMI > 35 kg m^{-2}), and six patients declined to participate in the study. In total, 90 patients were enrolled and randomized. All enrolled patients were followed-up successfully; and no patients were lost to follow-up.

The patients' general and surgical characteristics and the intraoperative analgesic consumption are summarized in Table 1. Group ESPB and TQLB both had lower mean dosage of remifentanil than Group CON; however, only Group TQLB showed a statistically significant difference after Bonferroni correction (Group TQLB vs. CON: mean difference, 0.05 μg kg^{-1} - min^{-1}; 95% CI 0.01–0.09 μg kg^{-1} min^{-1}; $P = 0.021$). There were no significant differences among the three groups regarding other parameters (Table 1).

The median [IQR] sufentanil consumption at 12 h postoperatively was significantly different among the three groups (Group ESPB, 0 [0, 4] μg; Group TQLB, 0 [0, 4] μg; Group CON, 6 [0, 10] μg; $P = 0.019$). This difference was statistically significant for Group ESPB vs. CON after Bonferroni correction ($P < 0.0167$ was considered significant) (mean difference = − 3; 95% CI − 6–0; $P = 0.010$), but not for Group ESPB vs. TQLB (mean difference = 0; 95% CI 0–0; $P = 0.533$) or Group TQLB vs. CON (mean difference = − 3; 95% CI − 6–0; $P = 0.031$). Moreover, Group ESPB had significantly lower sufentanil consumption than Group CON at 24 h postoperatively (mean difference = − 3; 95% CI − 6–0; $P = 0.016$). No significant differences in sufentanil consumption were found between the two block groups or between Group TQLB and CON after surgery (Table 2).

The linear mixed-effect model analysis showed that the interaction of treatment and time in NRS scores of visceral pain both at rest and in motion was significant (both $P < 0.05$). In comparison with Group CON at 0.5 h after surgery, Group ESPB and TQLB exhibited significantly reduced visceral pain scores at rest (Group ESPB vs. Group CON: mean difference = 1.6; 95% CI 0.8–2.4; $P < 0.001$; Group TQLB vs. Group CON: mean difference = 1.3; 95% CI 0.5–2.1; $P < 0.001$) and in motion (Group ESPB vs. Group CON: mean

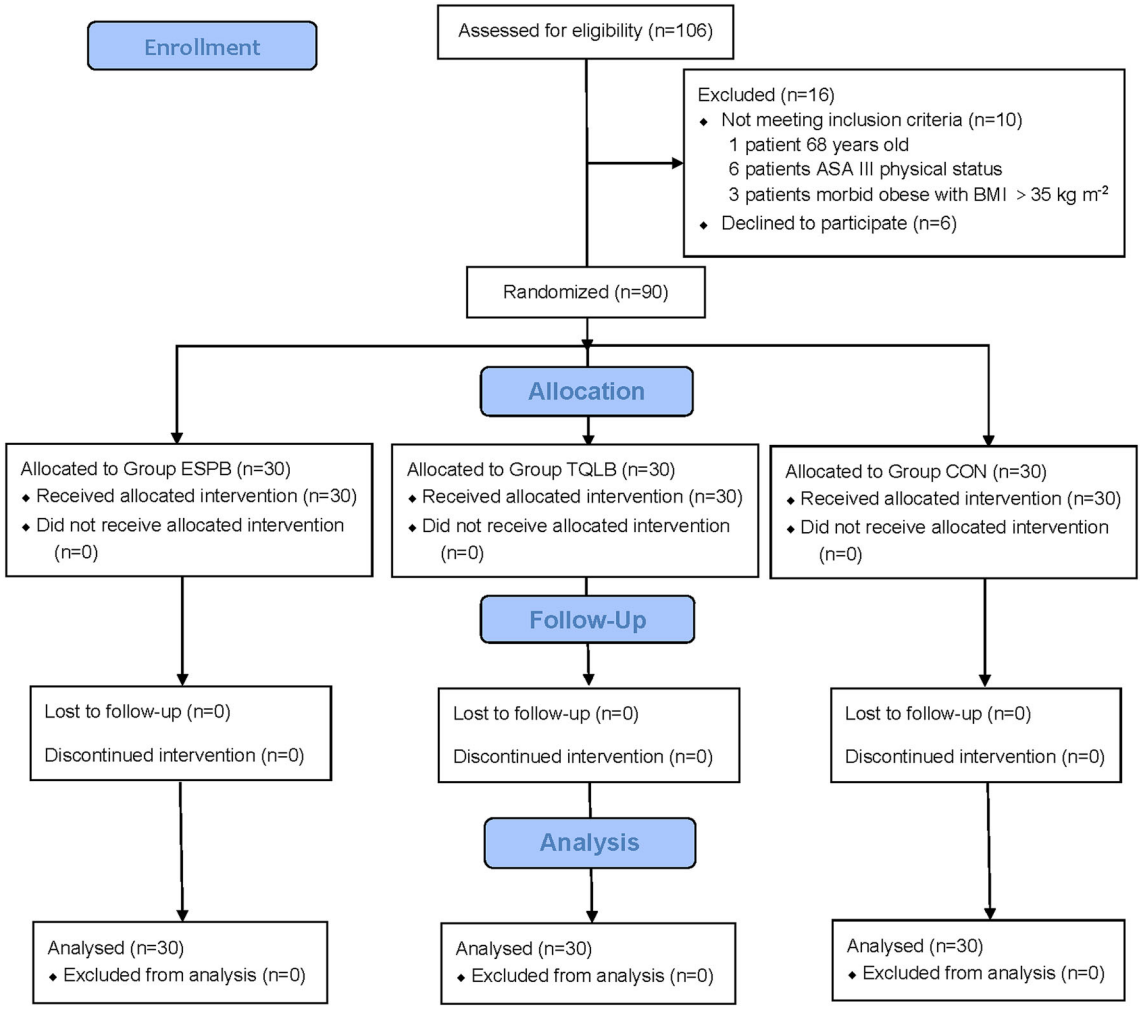

Fig. 2 Consolidated Standards of Reporting Trials flow diagram of participants through each stage of the randomized trial. *ASA* American Society of Anesthesiologists, *BMI* body mass index, *ESPB* erector spinae plane block, *TQLB* transmuscular quadratus lumborum block, *CON* control

difference = 1.8; 95% CI 0.9–2.6; $P < 0.001$; Group TQLB vs. Group CON: mean difference = 1.3; 95% CI 0.5–2.2; $P = 0.001$). Furthermore, patients in Group ESPB maintained significantly lower visceral pain scores at rest until 4 h and in motion until 6 h after surgery ($P < 0.05$), while TQLB provided a prolonged pain-relief in motion until 4 h postoperatively ($P < 0.05$). No significant differences in visceral pain scores were found between the two block groups after surgery (Fig. 3).

The time to first PCIA was significantly longer in Group ESPB than in Group CON after Bonferroni correction ($P = 0.030$). However, there were no significant differences between the two block groups or between Group TQLB and CON (Fig. 4).

No statistical differences were observed among the three groups for any of the following secondary outcomes: incisional, shoulder and perineum pain scores (Table S1), RASS scores, QoR-15 scores, time to first postoperative ambulation, incidence of PONV, and postoperative length of hospitalization. No cases of rescue analgesia requirement or block-related complications were observed. There were no complications of pruritus or respiratory depression. No significant differences in the chronic

Table 1 Patients' and surgical characteristics and intraoperative analgesic consumptions

Parameters	ESPB $n = 30$	TQLB $n = 30$	CON $n = 30$	*P* value
Mean age (years)	51.5 (4.6)	50.8 (5.6)	50.7 (5.9)	0.799
Body mass index ($kg\ m^{-2}$)	23.8 (2.5)	24.0 (2.5)	24.2 (3.1)	0.824
ASA physical status, *n* (%)				0.382
I	10 (33)	6 (20)	6 (20)	
II	20 (67)	24 (80)	24 (80)	
Delivery history, *n* (%)				0.088
None	0 (0)	0 (0)	3 (10)	
Vaginal	28 (93)	23 (77)	24 (80)	
Cesarean	2 (7)	6 (20)	3 (10)	
Vaginal + cesarean	0 (0)	1 (3)	0 (0)	
Type of surgery, *n* (%)				0.326
TLH + BSO	30 (100)	28 (93)	30 (100)	
TLH + USO	0 (0)	2 (7)	0 (0)	
Number of abdominal wall incision, *n* (%)				0.540
1	0 (0)	1 (3)	2 (7)	
3	0 (0)	1 (3)	0 (0)	
4	30 (100)	28 (93)	28 (93)	
Duration of surgery (min)	100.4 (29.1)	102.3 (39.0)	97.4 (36.6)	0.864
Intraoperative analgesic consumption				
Sufentanil (μg)	26.9 (4.0)	28.2 (5.1)	28.3 (7.0)	0.540
Remifentanil ($\mu g\ kg^{-1}\ min^{-1}$)	0.20 (0.08)	0.19 (0.05)	0.24 (0.07)	0.018
Parecoxib sodium (mg)	47.0 (6.1)	47.3 (6.9)	48.1 (8.6)	0.852

Data are presented as mean (standard deviation) or *n* (%)
ESPB erector spinae plane block, *TQLB* transmuscular quadratus lumborum block, *CON* control, *ASA* American Society of Anesthesiologists, *TLH* total laparoscopic hysterectomy, *BSO* bilateral salpingo-oophorectomy, *USO* unilateral salpingo-oophorectomy

pain scores at 3 and 6 months postoperatively were observed among the three groups (Table 3).

DISCUSSION

Herein, the interfascial plane blocks of ESPB and TQLB provided a prolonged pain-relief after TLH. Patients receiving ESPB exhibited a delayed and less analgesic requirement of opioid after THL when compared with those in Group CON. However, no significant differences in the analgesia efficacy of ESPB and TQLB were observed.

As a novel interfascial plane block technique, ESPB can be performed more easily and safely than paravertebral block [9]. The LA spreads

Table 2 Postoperative cumulative sufentanil consumption

Cumulative sufentanil consumption (μg)	ESPB (n = 30)	TQLB (n = 30)	CON (n = 30)	Median difference (95% CI) of pairwise comparisons *P* value		
				ESPB vs. TQLB	ESPB vs. CON	TQLB vs. CON
Postoperative 12 h	0 (0, 4)	0 (0, 4)	6 (0, 10)	0 (0 to 0)	− 3 (− 6 to 0)	− 3 (− 6 to 0)
				0.533	0.010	0.031
Postoperative 24 h	0 (0, 6)	0 (0, 6)	6 (0, 12)	0 (0 to 0)	− 3 (− 6 to 0)	− 3 (− 6 to 0)
				0.601	0.016	0.045

Data are presented as median (interquartile range). All groups were compared using Kruskal–Wallis test. Pairwise comparisons were analyzed using Mann–Whitney U test and $P < 0.0167$ (Bonferroni correction) was considered statistically significant

ESPB erector spinae plane block, *TQLB* transmuscular quadratus lumborum block, *CON* control, *CI* confidence interval

deep to the erector spinae muscle and is expected to extend to the paravertebral space which may provide effective analgesia by blocking both the ventral and dorsal rami of the spinal nerves [14]. ESPB performed at T10 can induce a sensory loss from T5 to L2 [21]. Based on anatomical knowledge that visceral afferent fibers from the uterus relay at T11–T12 [22], we performed bilateral ESPB at the T10 level. As hypothesized, ESPB provided visceral pain relief persistently after TLH compared with Group CON. Meanwhile, patients initiated PCIA later and consumed less sufentanil in Group ESPB, which supports bilateral ESPB as an option for TLH. Similarly, two case reports both showed promising results with ESPB performed at T8 and T10, separately, for visceral pain management after TLH [21, 23]. Thus, together with our results, bilateral ESPB performed at low thoracic level would be a prospective interfascial plane block for pain control in TLH.

In cadaveric studies regarding transmuscular quadratus lumborum injection, the dye spread to the L1 and L3 nerve roots [10], and was also found in the thoracic paravertebral space and intercostal spaces to surround the somatic nerves and the thoracic sympathetic trunk at the T9 level [11]. Therefore, we assessed this technique in TLH and found that TQLB, as ESPB, significantly reduced visceral pain scores after surgery. However, we did not find a postoperative opioid-sparing effect of TQLB, as was seen in a previous study [4]. Due to the discrepancy between the hypothesis and clinical results, we speculated that the anatomic characteristics of patients differs from those of cadavers; the post-mortem changes in temperature and lack of muscle tone may alter injectate spread compared with that in living patients [11]. Interestingly, performing TQLB after TLH [12] or depositing LA on both the anterior and posterior aspects of the quadratus lumborum muscle [22] has shown favorable results in pain management. Thus, the timing of block performance and techniques enhancing drug spread might be crucial in TQLB action.

It is worth noting that TQLB, but not ESPB, reduced the mean dosage of remifentanil when compared with Group CON. The erector spinae is a bundle of muscles and tendons; the transverse process interspace is bounded by intertransverse connective tissues. The anatomical variations may slow LA penetration through the paravertebral space, making the ESPB effective in the later phase [24].

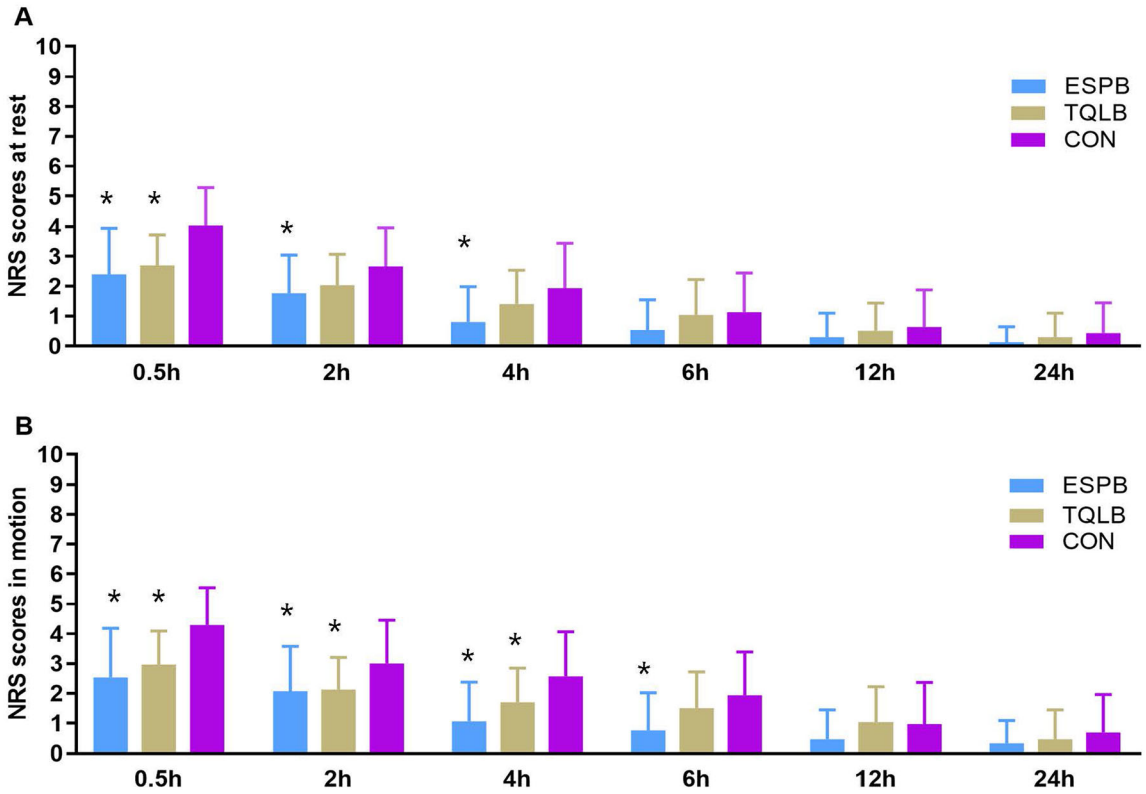

Fig. 3 NRS scores of visceral pain in the studied groups. Data are expressed as mean (standard deviation). Comparisons between groups were made using linear mixed-model analyses, showing Group ESPB and TQLB exhibited reduced visceral pain scores at rest (**A**) and in motion at 0.5 h postoperatively (**B**). Patients in Group ESPB remained significantly lower visceral pain scores at rest until 4 h postoperatively (**A**) and in motion until 6 h postoperatively (**B**). *$P < 0.05$ indicates statistically significant differences compared with Group CON. *P* values are corrected using Bonferroni correction. *ESPB* erector spinae plane block, *TQLB* transmuscular quadratus lumborum block, *CON* control, *NRS* numeric rating scale

We found no significant difference in the analgesia efficacy of ESPB and TQLB, and the statistically significant differences in postoperative pain control among the three groups were relatively small in clinical practice. Additionally, all patients experienced mild and comparable pain in incision, shoulder, and perineum even without regional blocks. We used the most potent opioid of sufentanil [25, 26] and adjunctive analgesics for multimodal analgesia [27]. Moreover, good manipulation abilities and surgical skills might have helped minimize the pain intensity, thus explaining the lack of clinically significant differences between groups. We did not find any promising results of time to first ambulation and length of hospitalization after surgery. However, it partly indicated that ESPB and TQLB did not induce lower limbs weakness. Since acute pain was treated, all patients reported high recovery scores and experienced mild chronic pain at 3 and 6 months after surgery.

This study had several limitations. First, even if the patients were sedated, they likely knew the intervention they received. However, the choice was guided by ethical considerations, and the blinding of the outcome assessors minimized biases. Second, we did not perform sensory or motor measurement because of the risk of further unblinding of patients. Third, we expected that primary outcome results would follow normal distribution and calculated the

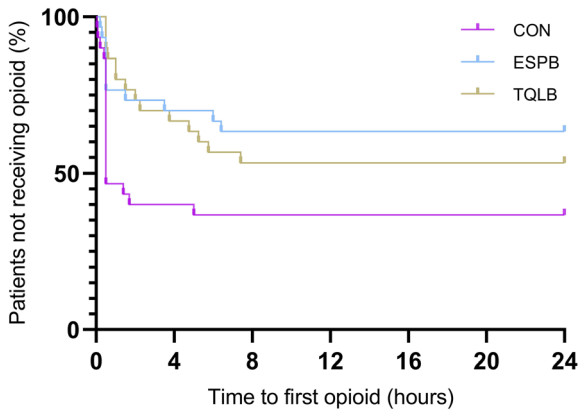

Fig. 4 Kaplan–Meier survival curve representing the time to first sufentanil administration of PCIA from arrival at PACU (T0). The time to first PCIA was significantly longer in Group ESPB compared with Group CON after Bonferroni correction ($P = 0.030$). There were no significant differences between the two block groups or between Group TQLB and CON. *PCIA*, patient-controlled intravenous analgesia, *PACU* post-anesthesia care unit, *ESPB* erector spinae plane block, *TQLB* transmuscular quadratus lumborum block, *CON* control

power analysis with ANOVA. However, it ended up using Kruskal–Wallis test because the primary outcome was not normally distributed, which weakened the analysis power. Additionally, Bonferroni correction was not used in the sample size calculation, which may further confirm the underpower of the study. Forth, surgical type was not standardized and the TLHs were not performed by the same surgeon. However, we considered this desirable as our inclusion criteria were close to real-world clinical practice situations.

CONCLUSIONS

In conclusion, we showed that ESPB and TQLB improved multimodal analgesia quality in patients undergoing TLH. Additionally, ESPB may be a preferred interfascial plane block technique owing to its significant reduction of postoperative visceral pain and opioid consumption after TLH.

Table 3 Postoperative parameters

Parameters	ESPB ($n = 30$)	TQLB ($n = 30$)	CON ($n = 30$)	*P* value
RASS score	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.603
QoR-15 score				
Preoperative	149 (2)	148 (4)	148 (3)	0.413
Postoperative	147 (2)	146 (3)	146 (2)	0.208
Time to first ambulation (h)	19 (3)	17 (4)	19 (4)	0.057
Incidences of PONV, *n* (%)	4 (13)	7 (23)	6 (20)	0.602
Postoperative length of hospitalization (days)	4 (2)	5 (3)	4 (1)	0.479
Postoperative pain score				
3 months				
At rest	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.520
In motion	0 (0, 1)	0 (0, 0)	0 (0, 1)	0.780
6 months				
At rest	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.582
In motion	0 (0, 0)	0 (0, 0)	0 (0, 0)	0.984

Data are presented as mean (standard deviation), median (interquartile range) or *n* (%)
RASS Richmond Agitation-Sedation Scale, *QoR* Quality of Recovery-15, *PONV* postoperative nausea and vomiting, *ESPB* erector spinae plane block, *TQLB* transmuscular quadratus lumborum block, *CON* control

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Compliance with Ethics Guidelines. This study was approved by the Ethics Committee of the Second Affiliated Hospital of Anhui Medical University (approval no. YX2021-054[F1]) on June 29, 2021. This study was conducted in accordance with the Consolidated Standards of Reporting Trials criteria and in compliance with the Helsinki Declaration. Written informed consent was obtained from all patients.

Data Availability. Data is available on Mendeley at: https://data.mendeley.com/datasets/ty4hnmf9yh/1

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REFERENCES

1. Ghisi D, Fanelli A, Vianello F, et al. Transversus abdominis plane block for postoperative analgesia in patients undergoing total laparoscopic hysterectomy: a randomized, controlled, observer-blinded trial. Anesth Analg. 2016;123:488–92. https://doi.org/10.1213/ANE.0000000000001267.

2. As-Sanie S, Till SR, Mowers EL, et al. Opioid prescribing patterns, patient use, and postoperative pain after hysterectomy for benign indications. Obstet Gynecol. 2017;130:1261–8. https://doi.org/10.1097/AOG.0000000000002344.

3. Wang M, Wang D, Zuo J, et al. A dose-response relationship study of prophylactic nalbuphine to reduce pain during the awakening period in patients undergoing laparoscopic total hysterectomy: a randomized, controlled, double-blind clinical study. Drug Des Dev Ther. 2022;16:981–90. https://doi.org/10.2147/DDDT.S356582.

4. Hansen C, Dam M, Nielsen MV, et al. Transmuscular quadratus lumborum block for total laparoscopic hysterectomy: a double-blind, randomized, placebo-controlled trial. Reg Anesth Pain Med. 2021;46:25–30. https://doi.org/10.1136/rapm-2020-101931.

5. Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. Anaesthesia. 2017;72:452–60. https://doi.org/10.1111/anae.13814.

6. Altıparmak B, Korkmaz Toker M, Uysal AI, Kuşçu Y, Gümüş Demirbilek S. Ultrasound-guided erector spinae plane block versus oblique subcostal transversus abdominis plane block for postoperative analgesia of adult patients undergoing laparoscopic cholecystectomy: Randomized, controlled trial. J Clin Anesth 2019;57:31–6. https://doi.org/10.1016/j.jclinane.2019.03.012

7. Yuan Q, Lu S, Cui X, et al. Transmuscular quadratus lumborum block for postoperative pain and recovery after laparoscopic adrenalectomy: a randomized controlled trial. BMC Anesthesiol. 2021;21:274. https://doi.org/10.1186/s12871-021-01494-4.

8. Dam M, Hansen C, Poulsen TD, et al. Transmuscular quadratus lumborum block reduces opioid consumption and prolongs time to first opioid demand after laparoscopic nephrectomy. Reg Anesth Pain Med. 2021;46:18–24. https://doi.org/10.1136/rapm-2020-101745.

9. 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; 41:621–7. https://doi.org/10.1097/AAP.0000000000000451

10. Carline L, McLeod GA, Lamb C. A cadaver study comparing spread of dye and nerve involvement after three different quadratus lumborum blocks. Br J Anaesth. 2016;117:387–94. https://doi.org/10.1093/bja/aew224.

11. Dam M, Moriggl B, Hansen CK, Hoermann R, Bendtsen TF, Børglum J. The pathway of injectate spread with the transmuscular quadratus lumborum block: a cadaver study. Anesth Analg. 2017;125:303–12. https://doi.org/10.1213/ANE.0000000000001922.

12. Jadon A, Ahmad A, Sahoo RK, Sinha N, Chakraborty S, Bakshi A. Efficacy of transmuscular quadratus lumborum block in the multimodal regimen for postoperative analgesia after total laparoscopic hysterectomy: a prospective randomised double-blinded study. Indian J Anaesth. 2021;65:362–8. https://doi.org/10.4103/ija.IJA_1258_20.

13. Schulz KF, Altman DG, Moher D. Consort 2010 statement: updated guidelines for reporting parallel group randomised trials. Trials. 2010;11:32. https://doi.org/10.1186/1745-6215-11-32.

14. Finnerty DT, McMahon A, McNamara JR, Hartigan SD, Griffin M, Buggy DJ. Comparing erector spinae plane block with serratus anterior plane block for minimally invasive thoracic surgery: a randomised clinical trial. Br J Anaesth. 2020;125:802–10. https://doi.org/10.1016/j.bja.2020.06.020.

15. Blichfeldt-Eckhardt MR, Ording H, Andersen C, Licht PB, Toft P. Early visceral pain predicts chronic pain after laparoscopic cholecystectomy. Pain. 2014;155:2400–7. https://doi.org/10.1016/j.pain.2014.09.019.

16. Ely EW, Truman B, Shintani A, et al. Monitoring sedation status over time in ICU patients: reliability and validity of the Richmond Agitation-Sedation Scale (RASS). JAMA. 2003;289:2983–91.

17. Stark PA, Myles PS, Burke JA. Development and psychometric evaluation of a postoperative quality of recovery score: the QoR-15. Anesthesiology. 2013;118:1332–40. https://doi.org/10.1097/ALN.0b013e318289b84b.

18. Choi JY, Lee HS, Kim JY, et al. Comparison of remimazolam-based and propofol-based total intravenous anesthesia on postoperative quality of recovery: a randomized non-inferiority trial. J Clin Anesth. 2022;82: 110955. https://doi.org/10.1016/j.jclinane.2022.110955.

19. Abu Elyazed MM, Mostafa SF, Abdelghany MS, Eid GM. Ultrasound-guided erector spinae plane block in patients undergoing open epigastric hernia repair: a prospective randomized controlled study. Anesth Analg. 2019;129:235–40. https://doi.org/10.1213/ANE.0000000000004071.

20. Jaeger P, Baggesgaard J, Sørensen JK, Ilfeld BM, Gottschau B, Graungaard B, et al. Adductor canal block with continuous infusion versus intermittent boluses and morphine consumption: a randomized, blinded, controlled clinical trial. Anesth Analg. 2018;126:2069–77. https://doi.org/10.1213/ANE.0000000000002747.

21. Frassanito L, Zanfini BA, Catarci S, Sonnino C, Giuri PP, Draisci G. Erector spinae plane block for postoperative analgesia after total laparoscopic

hysterectomy: case series and review of the literature. Eur Rev Med Pharmacol Sci. 2020;24:3892–7. https://doi.org/10.26355/eurrev_202004_20855.

22. Singh N, Rao PB, Elayat A. Ultrasound-guided anterior and posterior quadratus lumborum block for analgesia after laparoscopic hysterectomy. Pain Manag. 2021;11:5–8. https://doi.org/10.2217/pmt-2020-0008.

23. Rosato C, Santonastaso DP, de Chiara A, et al. Erector spinae plane block for pain management in laparoscopic hysterectomy and bilateral oophorectomy. J Clin Anesth. 2021;70: 110184. https://doi.org/10.1016/j.jclinane.2021.110184.

24. Chen N, Qiao Q, Chen R, Xu Q, Zhang Y, Tian Y. The effect of ultrasound-guided intercostal nerve block, single-injection erector spinae plane block and multiple-injection paravertebral block on postoperative analgesia in thoracoscopic surgery: a randomized, double-blinded, clinical trial. J Clin Anesth. 2020;59:106–11. https://doi.org/10.1016/j.jclinane.2019.07.002.

25. Ziesenitz VC, Vaughns JD, Koch G, Mikus G, van den Anker JN. Pharmacokinetics of fentanyl and its derivatives in children: a comprehensive review. Clin Pharmacokinet. 2018;57:125–49. https://doi.org/10.1007/s40262-017-0569-6.

26. Saari TI, Ihmsen H, Mell J, et al. Influence of intensive care treatment on the protein binding of sufentanil and hydromorphone during pain therapy in postoperative cardiac surgery patients. Br J Anaesth. 2014;113:677–87. https://doi.org/10.1093/bja/aeu160.

27. Pehora C, Pearson AM, Kaushal A, Crawford MW, Johnston B. Dexamethasone as an adjuvant to peripheral nerve block. Cochrane Database Syst Rev. 2017;11:CD011770. https://doi.org/10.1002/14651858.CD011770.pub2.