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Özgün Araştırma / *Original Article*

Ultrasound-Guided Erector Spinae Plane Block and Thoracic Paravertebral Block for Postoperative Analgesia Management Following Video-Assisted Thoracic Surgery: A Prospective, Randomized, Controlled Study

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Video Yardımcılı Torakal Cerrahi Sonrası Postoperatif Analjezi Yönetimi için Ultrasonografi Rehberliğinde Yapılan Erektor Spina Plan Bloğu ve Torakal Paravertebral Blok Etkinliği: Prospektif, Randomize, Kontrollü Çalışma

ABSTRACT

Objective: *Evaluation of the effectiveness of ultrasound (US)-guided erector spinae plane block (ESPB) and thoracic paravertebral block (TPVB) compared to no intervention control group for postoperative pain management in video assisted thoracic surgery (VATS) patients.*
Method: *Three groups - Group ESPB, Group TPVB and the control group (n=30 per group) were included in this prospective, randomized, controlled study. The US-guided blocks were performed preoperatively in the ESPB and TPVB groups. Intravenous patient-controlled postoperative analgesia via fentanyl was administered in all of the patients. The patients were evaluated using visual analogue scale (VAS) scores, opioid consumption, and adverse events.*
Results: *At all time intervals fentanyl consumption and VAS scores were significantly lower both in ESPB and TPVB groups compared to the control group (p<0.001). Block procedure time was significantly lower and success of one time puncture was higher in Group ESPB as compared with that in Group TPVB (p<0.001).*
Conclusion: *ESPB and TPVB provide more effective analgesia compared to control group in patients who underwent video-assisted thoracic surgery. ESPB had a shorter procedural time and higher success of single-shot technique compared to TPVB.*

Keywords: *Erector spinae plane block, thoracic paravertebral block, postoperative analgesia, video-assisted thoracic surgery*

ÖZ

Amaç: *Video yardımcılı torakal cerrahi yapılan hastalarda postoperatif analjezi yönetimi için ultrasonografi (US) eşliğinde yapılan erektor spina plan bloğu (ESPB) ve torakal paravertebral bloğun (TPVB) kontrol grubuna göre etkinliğinin değerlendirilmesi amaçlanmıştır.*
Yöntem: *Bu çalışmaya her grup için 30 hasta olmak üzere toplam 90 hasta dahil edilmiştir. Çalışma 3 gruptan oluşmaktadır; Grup ESPB, Grup TPVB ve Kontrol Grubu. ESPB ve TPVB gruplarındaki hastalara preoperatif olarak US eşliğinde blok yapıldı. Tüm gruplardaki hastalara fentanil içeren hasta kontrollü analjezi (HKA) uygulandı. Hastalar vizuel analog skala (VAS), opioid tüketimi ve yan etkiler kaydedilerek değerlendirildi.*
Bulgular: *Tüm zaman aralıklarında fentanil tüketimi ve VAS Grup ESPB ve Grup TPVB de kontrol grubuna göre anlamlı olarak daha düşüktü (p<0.001). Blok işlem süresi ESPB grubunda anlamlı olarak daha kısaydı ve iğne ile tek giriş başarısı ESPB grubunda TPVB grubuna göre anlamlı olarak daha yüksekti (p<0.001).*
Sonuç: *ESPB ve TPVB, video yardımcılı torakal cerrahi yapılan hastalarda kontrol grubuna göre etkili analjezi oluşturmaktadır. ESPB, TPVB'ye göre daha kısa işlem süresi ve tek iğne girişi ile daha yüksek başarı oranına sahiptir.*

Anahtar kelimeler: *Erektor spina plan bloğu, torakal paravertebral blok, postoperatif analjezi, video yardımcılı torakal cerrahi*

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INTRODUCTION

Video-assisted thoracic surgery (VATS) has become the standard procedure for minor and major lung surgeries. Compared with open thoracotomy, VATS has the advantages of lower postoperative pulmonary complications, shorter length of hospital stay, better short-term outcome, and milder postoperative pain [1,2]. However, patients may complain of moderate or severe postoperative and chronic pain [3]. For the management of postoperative pain, opioid-sparing multimodal analgesic approaches such as thoracic epidural analgesia (TEA), intercostal nerve block, thoracic paravertebral block (TPVB),and, more recently, erector spinae plane block (ESPB) have been preferred [3,4]. Among these, TEA has been a gold standard pain management approach. Since several studies have demonstrated comparable postoperative analgesia and fewer side effects (e.g., hypotension, urinary retention, and nausea and vomiting) with TPVB [5,6], ultrasound-guided TPVB for postoperative pain management after VATS has been more frequently performed [7,8]. However, TPVB has also some potential risks, such as hematoma, pneumothorax, neuraxial injury, and intercostal artery puncture [9,10]. Another promising analgesic approach after VATS is ESPB. In the literature, there are increasing number of case reports and a prospective randomized study demonstrating the analgesic efficacy of ESPB for pain management following thoracoscopy [4,11,12]. Therefore, this present study aimed to evaluate the analgesic effectiveness of TPVB and US-guided ESPB compared to no- intervention control group following VATS. The primary outcome was to compare perioperative and postoperative (48 h) opioid consumption. The secondary outcomes were to evaluate the patients' postoperative pain scores using Visual Analogue Scale (VAS), block performance time, success of one-time puncture, rescue analgesic usage, and adverse events related with opioid consumption (itching, nausea, and vomiting etc).

MATERIAL and METHOD

After approval of the local ethics committee was obtained (Istanbul Medipol University, ethics decision number: 66291034-604.01.01-E.4419), the Consolidated Standards of Reporting Trials (CONSORT) flow diagram was used for recording and distribution of patients (Figure 1). Written informed consent was obtained from all patients for the study. Ninety adult patients with American Society of Anesthesiologists (ASA) classification of I-II and aged between 18 and 65 years, and scheduled for VATS lobectomies/wedge resections were included in the study. The exclusion criteria for this study were bleeding diathesis, pregnancy or breastfeeding, receiving anticoagulant treatment, a known history of allergy to the study drugs (local anesthetic or opioids), infections at the region of the blocks, and refusal to take part in the procedure. The study included three groups of 30 patients each: an ESPB group, TPVB group and a control group. The patients were divided into these groups using a randomizing computer program. A pain nurse anesthetist, who was blinded to the study, evaluated and recorded the postoperative pain and opioid consumption.

All the patients were sedated with 2 mg of midazolam intravenously (IV) in the preoperative room. After a standardized ASA monitorization and performing aseptic conditions, the Vivid q US device (GE Healthcare, Wauwatosa, WI, USA), a high frequency 12 MHz linear probe, and a 22G, 50 mm block needle (Stimuplex Ultra 360; B. Braun, Melsungen, Germany) were used for the blocks. All the blocks were performed unilaterally, with the patients in a sitting position, at the level of the T5 vertebra. We did not perform any intervention in the control group.

ESPB technique

In the ESPB group, the probe was placed longitudinally at the level of the T5 transverse process, 2-3 cm lateral from the midline. The muscles were visualized superior to the transverse process (Figure 2); then, the needle was inserted in the craniocaudal direction using the in-plane technique. A dose of 2 mL normal saline were injected into the two layers of the interfacial area under the erector spinae muscle, and the proper injection site was confirmed. After visualizing the linear spread of saline in the fascial plane, 20 mL of 0.25% bupivacaine was injected there for the block.

TPVB technique

In the TPVB group, the probe was placed 2-3 cm

laterally and vertically of the T5 spinous process. Once the transverse process, corresponding paravertebral space, internal intercostal membrane, and pleura was identified (Figure 3), the needle was inserted in the lateromedial direction using the in-plane technique. After confirmation of pleural displacement with 2 mL saline, 20 mL of 0.25% bupivacaine was administered for the block.

General Anesthesia

In the operating room, all of the patients were monitored via ECG, measurements of noninvasive blood pressure, and SpO_2. General anesthesia and muscle relaxation were performed using IV propofol (2-2.5 mg kg^{-1}), fentanyl (1-1.5 µg kg^{-1}), and rocuronium bromide (0.6 mg kg^{-1}). A left-sided double-lumen tube was usually used for orotracheal intubation. The position of the double lumen tube was confirmed via a fiberoptic bronchoscopy. The patients were placed in a lateral decubitus position for the surgery. The mechanical ventilation was adjusted using a one-lung mechanical ventilation model. The maintenance of anesthesia was performed via gas inhalation (a mixture of sevoflurane, oxygen and fresh air) and a remifentanil infusion (0.01-0.1 µg kg^{-1} min). Additional analgesia during surgery was provided with 1 mcg kg^{-1} fentanyl if heart rate and mean arterial pressure of the patient could be raised 20% above the baseline. Invasive artery monitoring was performed through the radial artery with a 20 gauge cannula. A dose of 4 mg IV ondansetron was injected at the end of the surgery for preventing postoperative nausea and vomiting. VATS lobectomy/wedge resection was performed by the same surgical team using the same technique. A standard three-port VATS approach (at 5^{th}, 8^{th}, and 9^{th} intercostal space) was used and none of the incisions were required to be extended. A 24 F chest tube was placed at 8^{th} intercostal space in midaxillary line. A dose of 400 mg IV ibuprofen and 100 mg IV tramadol was administered at the end of the surgery. The patients were extubated after exhibiting sufficient spontaneous respiration and transferred to the intensive care unit (ICU) for further monitoring.

Standard postoperative analgesia protocol and measurements of pain

Management of postoperative analgesia was performed using classical IV PCA protocol of our department (2 mL-10 µg mL^{-1}-bolus dose of fentanyl, no infusion, 20-min lock out time, and 4-hour limit of 200 µg). At the PACU, a fentanyl PCA device was attached to the patients, and in the presence of pain (VAS score ≥ 4), the patient was asked to push the PCA button. As a part of multimodal analgesia, all patients received NSAID (400 mg ibuprofen in every 8 hours).

A nurse anesthetist blinded to the study evaluated and recorded the opioid consumption and the patients' pain scores using the visual analogue scale (VAS: 0 = no pain, 10 = the most severe pain). Pain at rest and during coughing (active and passive VAS scores) was assessed at postoperative 0, 2, 4, 8, 16, 24 and 48 hours. If the VAS was ≥ 4 despite the administraion of ibuprofen and fentanyl PCA bolus, IV meperidine (0.5 mg kg^{-1}) was administered as a rescue analgesic drug. Sedation levels were evaluated using the Michigan Sedation Scale (0 = awake and eyes open, 1 = sleepy but responds to verbal stimulus, 2 = hard to wake up, and 3 = sleepy and not aroused by shaking). The adverse effects, block procedure time, and success of single- shot technique were recorded. Our aim of comparing single-shot technique with the other method was to compare the easy applicability of both techniques. In this puncture technique block is performed through only a single entrance into the tissues to be blocked and the needle directly goes into the target.

Sample size and statistical analyses

In the power analysis performed with the total opioid consumption variable that was the primary outcome of the study, it was determined that the effect size was 1.97 in the 95% confidence interval and the power was 0.99 in the significance level. This result shows that the study sample is sufficient. Descriptive statistics was expressed as mean±SD and frequency. The Kolmogorov-Smirnov test was used to evaluate the distribution of data. Categorical data was compared between groups using the Pearson Chi-square test. We used the One-way ANOVA followed by Tukey's tests to check differences among groups, at a significance level of 5% for normally distributed continuous variables. Independent samples t-test was used to compare two groups. The statistical data was analyzed by the IBM SPSS 20.0 software.

RESULTS

The CONSORT flow diagram shows the enrollment of the patients for the study (Figure 1). This study comprised 90 patients, with 30 in each group. There were no statistical differences between groups in terms of age, weight, height, ASA status, duration of anesthesia, length of surgery, and the type of surgical procedure (wedge vs lobectomy) (p>0.05). The intraoperative opioid consumption was 258.17±49.83 µg in the ESPB group, 281.67±51.25 µg in the TPVB group, and 427.67±81.90 µg in the Control group.

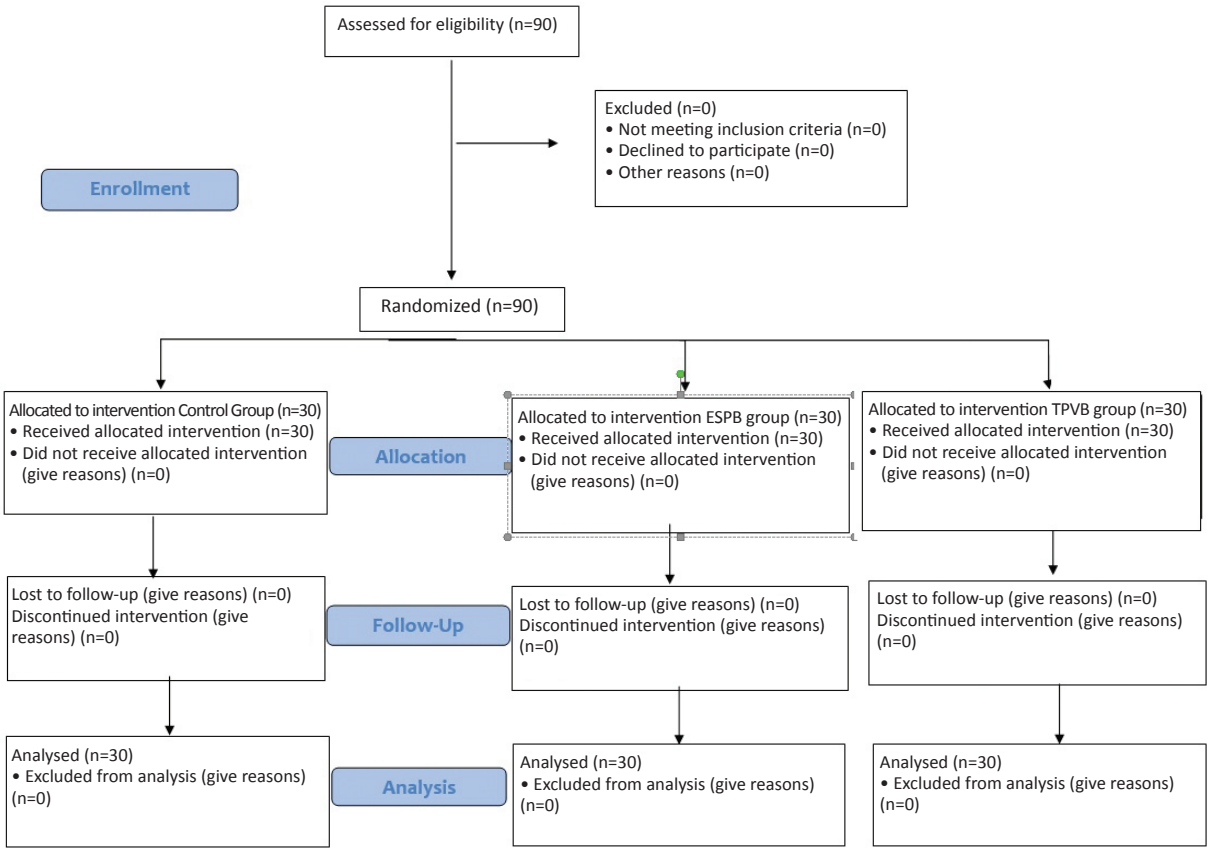

Figure 1. CONSORT flow diagram of the study

Table I. Demographic data, comparison of operative procedures, intraoperative opioid consumption and rescue analgesia between groups

	ESPB Group (n=30)	TPVB Group (n=30)	Control Group (n=30)	p
Age (years)	47.33±10.21	47.53±10.43	45.13±7.98	0.564[a]
Gender (m/f)	15/15	15/15	17/13	0.837[b]
Height (cm)	167.10±8.23	168.97±9.17	169.73±8.73	0.488[a]
Weight (kg)	72.13±8.42	76.47±8.61	75.67±8.99	0.127[a]
ASA (I/II)	16/14	11/19	17/13	0.252b
Duration of Surgery (min)	135.50±29.13	125.86±17.67	133.83±21.07	0.232[a]
Duration of Anesthesia (min)	169.66±29.62	175.33±20.54	164.33±21.12	0.216[a]
Surgery Type				
Wedge Resection	13	16	17	0.560[b]
Lobectomy	17	14	13	
Intraoperative Opioid Consumption (µg)	258.17±49.83	281.67±51.25	427.67±81.90	<0.001[c]
Rescue Analgesia (Yes/No)	10/20	12/18	30/0	<0.001[d]

Values are expressed mean ± standard deviation or frequency, ASA; American Society of Anesthesiologist, m; male, f; female, cm; centimeter, kg; kilogram, min; minutes,
[a]One Way ANOVA between groups
[b]Chi-square test between groups.
[c]One Way ANOVA, between ESPB & TPVB and Control group
[d]Chi-square test was used, between ESPB & TPVB and Control group

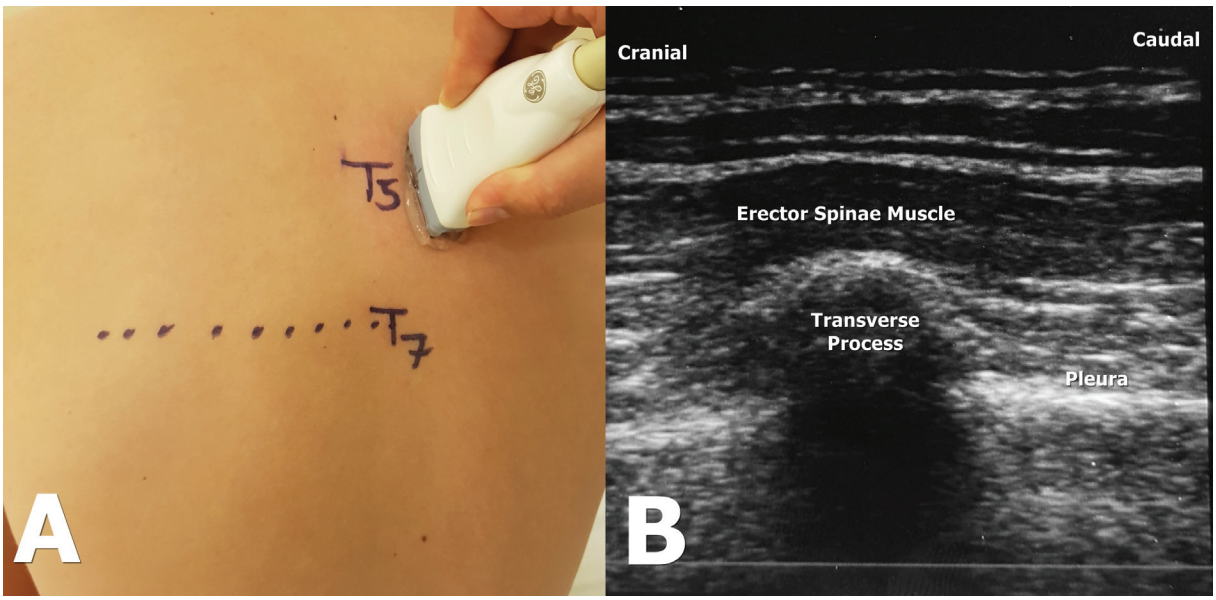

Figure 2A. Probe localization in a longitudinal direction during ESPB performing at 2-3 cm lateral to the T5 transverse process. The patient is in sitting position during the procedure.The bold black lines indicate the vertebral column. 2B. Corresponding sonographic anatomy of the block. The erector spinae muscle, transverse process and pleura are seen

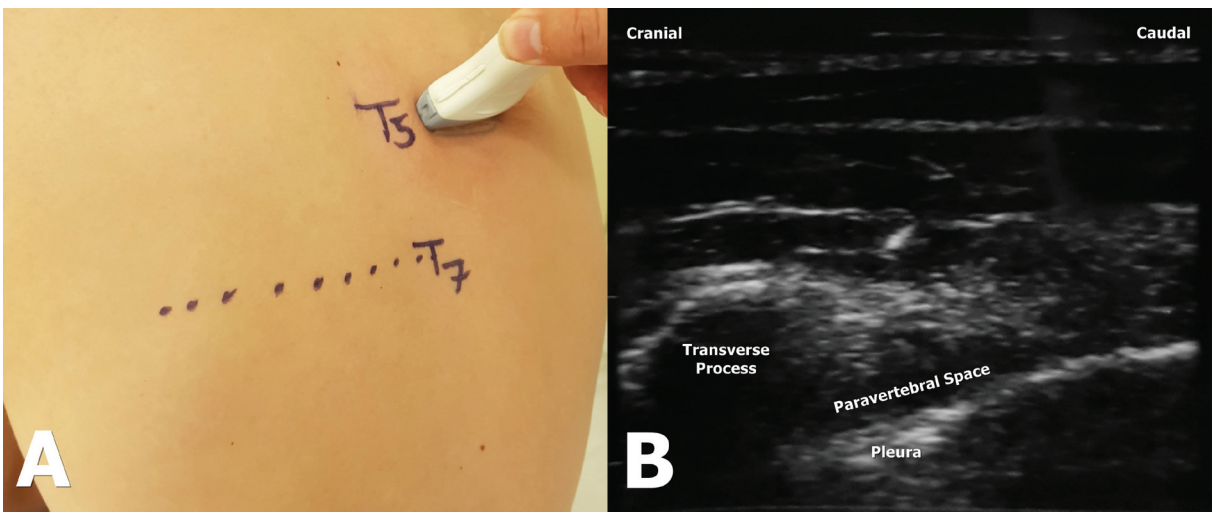

Figure 3A. Patient position and probe localization during TPVB performing at T5 vertebrae level. 3B. Corresponding sonographic anatomy of the block. The paravertebral space, transverse process and pleura are seen

There was a significantly difference between ESPB, TPVB and Control groups ($p<0.001$), however there was no difference between the ESPB and TPVB groups ($p>0.05$). Rescue analgesia (meperidine) was used in 10 patients in the ESPB group, 12 patients in the TPVB group, and 30 patients in the Control group. The use of rescue analgesia was significantly lower in ESPB and TPVB groups compared to the control group ($p<0.001$) (Table I).

Postoperative mean total fentanyl consumption was 178.66±129.39 µg in the ESPB group, 224.66±134.59 µg in the TPVB group, and 859.33±198.99 µg in the Control group. There was a significantly difference between ESPB/TPVB and Control groups ($p<0.001$), however there was no difference between the ESPB and TPVB groups ($p>0.05$) in terms of postoperative total fentanyl consumption. The fentanyl consumption at all time intervals was significantly lower both in ESPB and TPVB groups compared to the control

group. There were no statistical difference between the ESPB and TPVB groups for fentanyl consumption at any time interval (Figure 4).

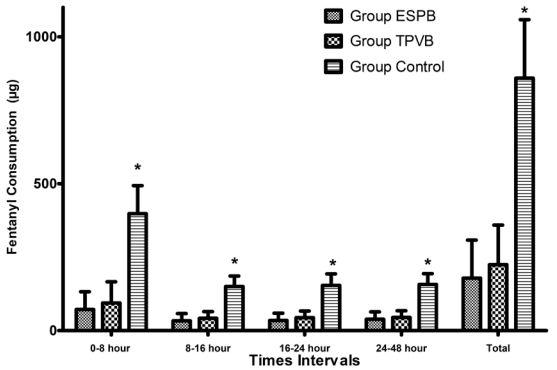

Figure 4. The Comparison of opioid consumption in time intervals between groups

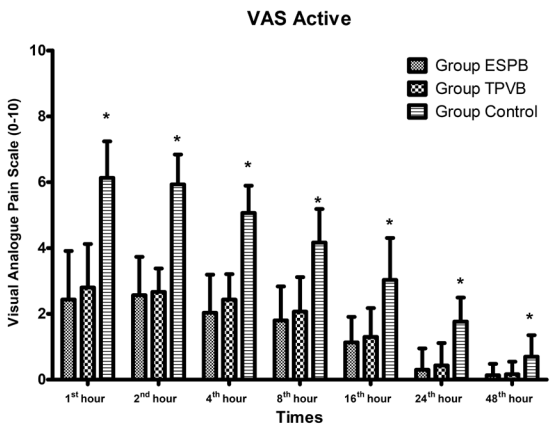

Figure 5. Comparisons of passive VAS assessment between groups

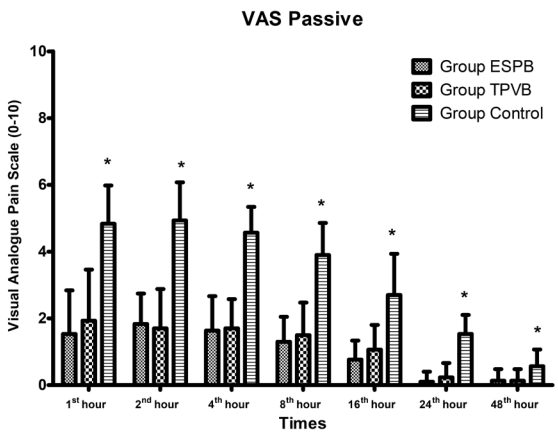

Figure 6. Comparisons of active VAS assessment between groups

There was no statistical difference between the ESPB and TPVB groups in terms of the active and passive VAS scores in any time interval (p>0.05 for each interval). The active and passive VAS was significantly higher in Control group compared to the ESPB and TPVB groups at all time intervals (p<0.001) (Figure 5 and 6).

Five patients in the ESPB, six patients in the TPVB and 18 patients in the Control group had postoperative nausea (p<0.001). Six patients in the ESPB group, seven patients in the TPVB group and 17 patients in the Control group had postoperative itching (p=0.002). There was no significant difference between groups in terms of the other adverse effects (Table II). No block related complications such as pneumothorax, vascular or neuraxial injury were seen in both of the groups.

Block procedure time was significantly lower in the ESPB group (7.13±1.59 min) compared to the TPVB group (13±2.49 min) (p<0.001) (Table III). Success of single- shot technique was significantly higher in the ESPB group than in the TPVB group (in 25 vs 10 patients (p<0.001) (Table III).

Table II. Comparison of the adverse effect incidences between groups

	ESPB Group (n=30)	TPVB Group (n=30)	Control Group (n=30)	p
Respiratory depression	0	0	0	-
Sedation/Confusion	0	0	0	-
Nausea	5	6	18	<0.001[a]
Vomiting	4	5	7	0.587
Itching	6	7	17	0.004[a]
Constipation	0	0	0	-
Dyspepsia	0	0	0	-

Values are expressed as frequency. Chi-square test was used
[a]Control group was significant than other groups

Table III. Comparison of the block procedure time and success of one time puncture between group ESPB and TPVB

	Group ESPB (n=30)	Group TPVB (n=30)	p
Block procedure time (min)	7.13± 1.59	13 ±2.49	<0.001[a]
Success of one time puncture (yes)	25	10	<0.001[b]

[a]Independent samples t test was used.
[b]Chi-square testwas used.

DISCUSSION

This study was designed to evaluate the analgesic

efficacy of US-guided TPVB with US-guided ESPB compared to control group following thoracoscopic surgery. The results showed that both single-shot ESPB and TPVB provided similar effective analgesia compared to the control group during the first 48 hours. ESPB and TPVB significantly reduced the intraoperative and postoperative opioid consumption with lower VAS scores than the control group. However, ESPB had a shorter performance time and higher success of single-shot technique compared to TPVB.

The US-guided ESPB was described by Forero et al. [13] in 2016 for the treatment of thoracic neuropathic pain. With increasing number of case reports and randomized controlled trials, the application area of the ESPB has been widened from cervicothoracic region to lumbar spine [14-18]. Based on its injection site (over the vertebral transverse process) and the spread of injectate, ESPB is a type of paraspinal block [14], and it is described as "paravertebral block by proxy" [19,20]. In this respect, the ESPB is similar to TPVB, but it offers the benefit of lesser technical difficulty with comparable efficacy [18]. Local anesthetic spread to the paravertebral space in ESPB has been also shown in some cadaveric studies [19,21,23], and the analgesic effectiveness of ESPB for thoracic surgery as an alternative to TPVB and TEA has been shown in numerous case reports [12,24-29]. The first randomized, controlled study comparing the efficacy of ESPB and TPVB for postoperative analgesia was performed in patients undergoing breast surgery. In this study, the authors demonstrated that both TPVB and US-guided ESPB reduced 24-hour postoperative morphine consumption without any statistically significant differences between the two groups [30]. In another randomized clinical trial, Chen et al. [31] investigated US-guided intercostal nerve block, single-shot ESPB, and multiple-shot TPVB after thoracoscopic surgery. While they reported superior analgesia with multiple-injection TPVB over intercostal nerve block and single-shot ESPB, intercostal nerve block and single injection ESPB were equally effective in reducing pain after thoracoscopic surgery. However they compared single-shot ESPB with multiple-shot TPVB which may not indicated that TPVB has a superiority over ESPB in terms of analgesia after VATS. To reach this conclusion it would be better to compare multiple- shot ESPB with multiple-shot TPVB. Single level ESPB provided good analgesia in our current study. In a study comparing US-guided, preoperative, single-dose ESPB with TPVB after thoracotomy, Fang et al. [32] found that ESPB provided similar, satisfying postoperative pain control in the first postoperative 48 hours. It also offered advantages as technical simplicity, a shorter puncture time, a higher success of one-time puncture, and higher patient satisfaction, which resemble the results of the present study. Fang et al. [32] also demonstrated that, in the TPVB group, the incidence of adverse events, such as bradycardia and hypotension, were higher than in the ESPB group. In the present study, there were no differences between both groups in terms of adverse events. Although the volumes used for TPVB were the same (20 mL), this may be due to the difference in degree of sympathetic blockage for TPVB in both studies. Of course, ESPB is not without complications. In the literature, local anesthetic spread to the epidural space and the pneumothorax have been reported [33]. ESPB has a technical simplicity and a better risk profile compared to TPVB. However, ESPB may also be risky if the needle tip is not seen during procedure. In addition, it may be risky if the procedure is being done by less skilled hands [21].

As VATS is a widespread surgical technique, and since fast-track surgery is also an important issue for thoracoscopy, multimodal, opioid-sparing analgesic techniques should become part of this fast-track program. Therefore, peripheral nerve blocks may be preferred for this procedure [3]. The analgesic effectiveness of TPVB and its role in fast-track surgery has already been proven [7]. With increasing number of case reports and studies about ESPB, this block may be a good option for fast-track thoracoscopic surgery. ESPB is performed on the same side of surgery, which involves a chest tube placement. This makes ESPB quite safe. In the literature, randomized studies about ESPB are limited. Therefore, meta-analyses and further studies with larger sample sizes are necessary.

This study did have some limitations. First, dermatomal sensory testing could be done to explore the dermatomal distribution of these two blocks. Second, the researchers utilized 20 mL of 0.25% bupivacaine, as in other studies. Therefore, it is still unknown

whether 20 mL of local anesthetic is the minimum effective dose. In our previous study we evaluated the efficacy of single-shot ESPB for VATS and found single shot ESPB with 20 mL volume as an effective analgesic technique [4]. In this study we wanted to compare this effectiveness with TPVB. May higher volumes or different concentrations have longer analgesic effects? Lastly, a block catheter may be used, but we didn't use it to see the effectiveness of the single-shot blocks.

CONCLUSION

To summarize, the results of the trial showed that US-guided, single-shot ESPB and TPVB provided more effective analgesia than IV fentanyl PCA after VATS. In addition, single-shot ESPB offers the advantages of technical simplicity that ESPB had a shorter performance time and higher success of single-shot technique compared to TPVB.

Ethics Committee Approval: Ethics decision number: 66291034-604.01.01-E.4419
Conflict of Interest: The authors report no conflicts of interest.
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Informed Consent: Written informed consent was obtained from all patients for the study

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