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Original Research Article

A Randomized Trial to Compare Serratus Anterior Plane Block and Erector Spinae Plane Block for Pain Management Following Thoracoscopic Surgery

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Abstract

Objective. Comparison of ultrasound (US)-guided erector spinae plane block (ESPB) and serratus anterior plane block (SAPB) in video-assisted thoracic surgery (VATS) patients. The primary outcome was to compare perioperative and postoperative (48 hours) opioid consumption. **Methods.** A total of 60 patients were randomized into two groups (N = 30): an ESPB group and an SAPB group. All the patients received intravenous patient-controlled postoperative analgesia and ibuprofen 400 mg intravenously every eight hours. Visual analog scale (VAS) scores, opioid consumption, and adverse events were recorded. **Results.** Intraoperative and postoperative opioid consumption at 0–8, 8–16, and 16–24 hours and rescue analgesic use were significantly lower in the ESPB group ($P < 0.05$). Static/dynamic VAS scores were significantly lower in the ESPB group ($P < 0.05$). There was no significant difference between static VAS scores at the fourth hour. There were no differences between adverse effects. Block procedure time and one-time puncture success were similar between groups ($P > 0.05$ each). **Conclusion.** US-guided ESPB may provide better pain control than SAPB after VATS. **Question.** Even though there are studies about analgesia management after VATS, clinicians want to perform the technique that is both less invasive and more effective. **Findings.** This randomized trial showed that US-guided ESPB provides effective analgesia compared with SAPB. **Meaning.** Performing single-injection ESPB reduces VAS scores and opioid consumption compared with SAPB.

Key Words: Erector Spinae Plane Block; Serratus Anterior Plane Block; Video-Assisted Thoracic Surgery; Postoperative Analgesia

Introduction

Serratus anterior plane block (SAPB) is a type of interfascial plane block that was defined by Blanco in 2013 [1]. SAPB blocks the lateral branches of the intercostal nerves (T2–T9) so that it can provide analgesia in the chest wall [2]. It has been reported that SAPB may be used to provide postoperative analgesia after thoracoscopic surgery [3,4].

Erector spinae plane block (ESPB) is an interfascial plane block that was defined by Forero and colleagues in 2016 [5]. ESPB has a wide indication range for pain management of the thoracic, abdominal, lumbar, hip, and even shoulder areas [5,6]. ESPB is a paraspinal block that targets the dorsal and ventral rami so that it can provide analgesia in the anterolateral and posterior chest wall [5,6]. It has been reported that ESPB may be used to provide effective analgesia management following video-assisted thoracoscopic surgery (VATS) [7].

VATS is a minimally invasive procedure; a small incision allows a video camera to enter the thoracic cavity.

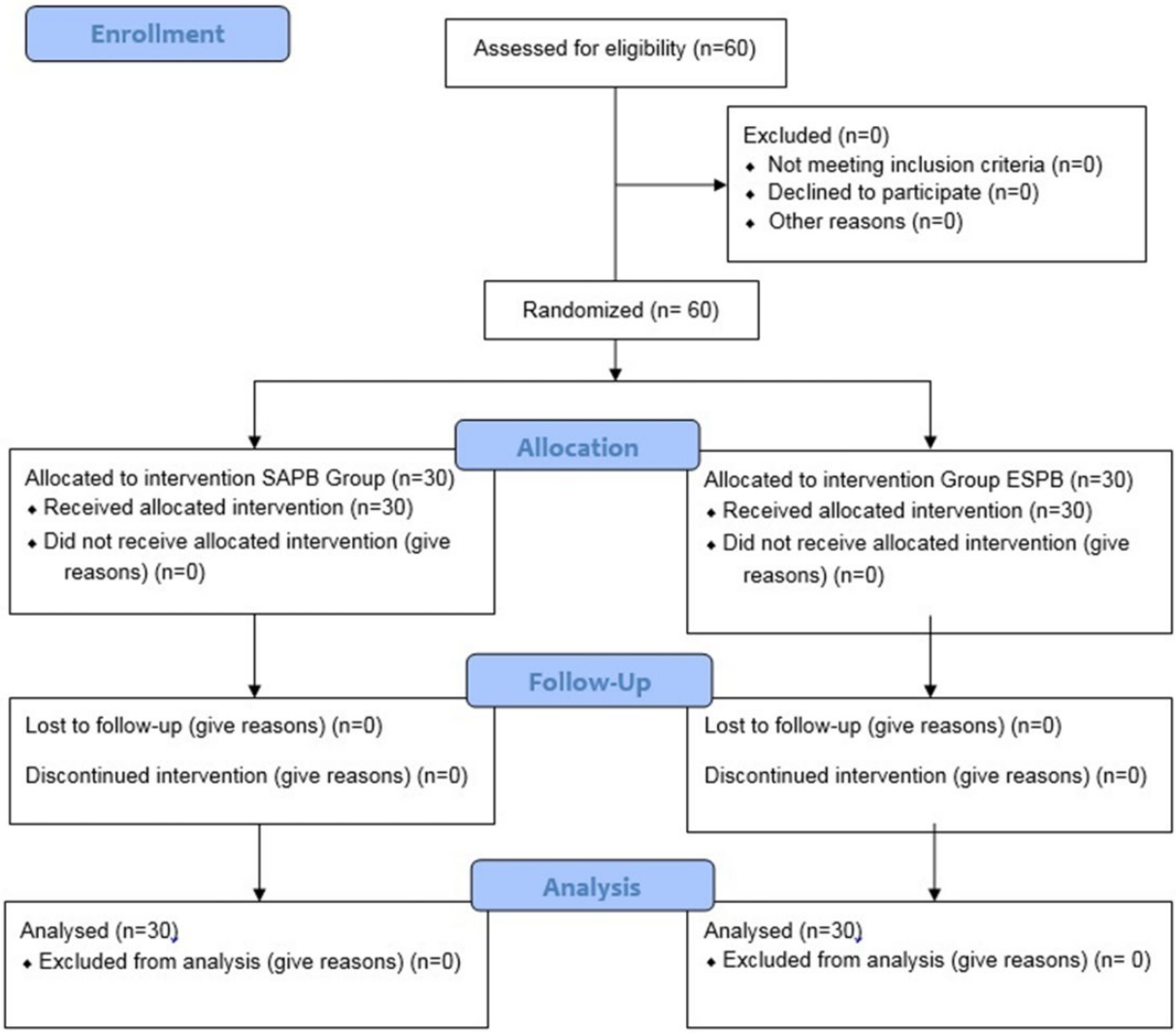

Figure 1. CONSORT flow diagram of the study.

This procedure allows for rapid recovery and improved pulmonary function [8,9]. Enhanced recovery after surgery (ERAS) is a multimodal treatment that aims to improve the quality of recovery following surgery. The role of pain management in ERAS pathways is important because effective pain management reduces surgical stress, reduces pain-related complications, and allows for rapid recovery following VATS [8].

The aim of the present study was to compare the effectiveness of two alternative techniques, SAPB and ESPB, following thoracoscopic surgery. The primary outcome was a comparison of perioperative and postoperative (48 hours) opioid consumption. Secondary outcomes included evaluations of the patients' postoperative pain scores as measured by the visual analog scale (VAS), block performance time, one-time puncture success, rescue analgesic usage, and adverse events related to opioid consumption (e.g., itching, nausea, vomiting, etc.).

Methods

The present randomized prospective trial was approved by the local ethics and research committee of Istanbul Medipol University. Following approval by the ethics committee, this study was registered at ClinicalTrials.gov (registration number: NCT03960762). The Consolidated Standards of Reporting Trials (CONSORT) guidelines were used (Figure 1), and written informed consent was obtained from all patients during the procedures of this study. This study was performed at the Medipol Mega Hospital Complex between November 2018 and September 2019.

Participants for the present study included American Society of Anesthesiologists (ASA) class I and II patients aged 18–65 years who had undergone unilateral thoracoscopic lobectomies/wedge resection. Sixty patients were included in this study (N = 30 in each group). Patients with histories of bleeding diathesis, anticoagulant

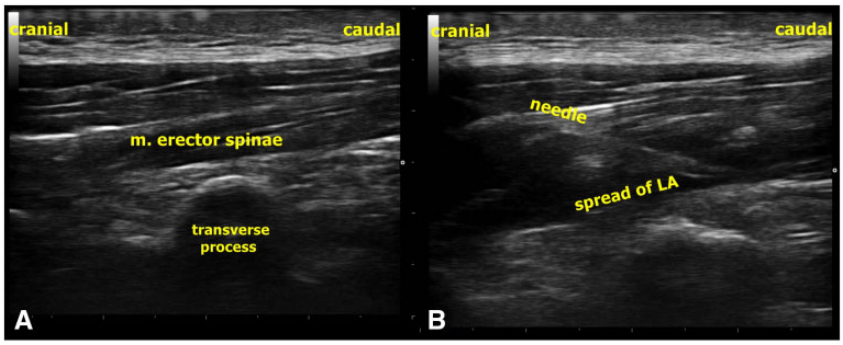

Figure 2. A) Sonographic anatomy of the erector spinae plane block. The erector spinae muscle and transverse process are seen. B) Needle direction, craniocaudal spread of local anesthetic during erector spinae plane block.

treatment, pregnancy, lactation, known allergies to the drugs used in the study (i.e., local anesthetics or opioids), or local tissue infections at the block procedure area were excluded from the study, as well as those who refused to participate in the block procedure or the overall study. The patients were randomly selected using the closed envelope method to receive single-shot, US-guided ESPB (N = 30) or SAPB (N = 30). Sixty sealed envelopes were prepared for this randomization technique before the beginning of the trial. Either ESPB or SAPB was written inside each envelope as the technique for each participant. On arrival to the preoperative regional room, the investigators randomly selected a sealed envelope. Then the procedure was explained to the patient whether ESPB or SAPB was performed to him/her.

Block Procedure

All procedures were performed by the same investigators, ME and BC. On arrival to the preoperative regional room, the patients were monitored using standardized ASA monitoring procedures including electrocardiography (ECG), noninvasive blood pressure measurement, and pulse oximetry (SPO_2). Following placement of a peripheral intravenous catheter, a 2-mg dose of midazolam was performed intravenously (IV) for sedation. Under aseptic conditions, US-guided ESPB and SAPB were performed unilaterally with a Vivid q US device (GE Healthcare, Wauwatosa, WI, USA) and a high-frequency, 12-MHz linear US probe covered by a sterile sheath. A 22-g, 50-mm block needle (Stimuplex Ultra 360; B. Braun, Melsungen, Germany) was used to create the puncture.

US-Guided ESPB

For patients in the sitting position, ESPB was performed at the level of the T5 vertebrae. The probe was placed longitudinally, 2–3 cm lateral from the midline. The sonographic anatomy was visualized above the transverse process shadow (Figure 2A). The needle created a puncture in the cranial-caudal direction with an in-plane technique. For correction of the injection site, a 2-mL volume of normal saline was injected into the interfascial area below the erector spinae muscle with real-time visualization. After the injectate had spread deeply throughout the interfascial area, a 20-mL volume of 0.25% bupivacaine was administered for ESPB (Figure 2B).

US-Guided SAPB

SAPB was performed for patients in the lateral position. The probe was placed in a sagittal plane over the midaxillary line of the thoracic wall. Then, the fourth and fifth ribs were identified in the midaxillary line, and the serratus muscle was identified over these ribs (Figure 3A). The needle was inserted, using an in-plane technique, into the interfascial area between the serratus anterior muscle and the rib. A 2-mL volume of saline was injected here for correction. Following confirmation of the correct needle position, a 20-mL volume of 0.25% bupivacaine was administered for SAPB (Figure 3B).

General Anesthesia

Following the block procedure, the patients were transferred to the surgery room. The same general anesthesia protocol was performed for all patients. The patients were monitored with ECG, noninvasive blood pressure measurement, and SpO_2. A propofol (2–2.5 mg/kg), fentanyl (1–1.5 μg/kg), and rocuronium bromide (0.6 mg/kg) IV was used for anesthesia induction. Intubation was generally performed using a left-sided, 35–37 French double-lumen endotracheal tube. The tube's position was corrected using a fiberoptic bronchoscopy. The radial artery was cannulized with a 20-gauge cannula for invasive blood pressure monitoring. The patients were placed in a lateral decubitus position for the surgery. A mechanical, one-lung protective ventilation model was used via a tidal volume of 5–6 mL/kg, an end tidal CO_2 pressure of 30–35 mmHg, and a peak airway pressure of 30 cmH_2O. Anesthesia was maintained with sevoflurane in a 50% air–oxygen mixture, in a 2–3-L fresh gas flow. Remifentanil was infused at a rate of 0.01–0.1 μg/kg/min during surgery. A 4-mg dose of ondansetron IV was administered to prevent postoperative nausea and vomiting. Thoracoscopic lung surgery was performed via the same technique by the same surgical team. At the end of

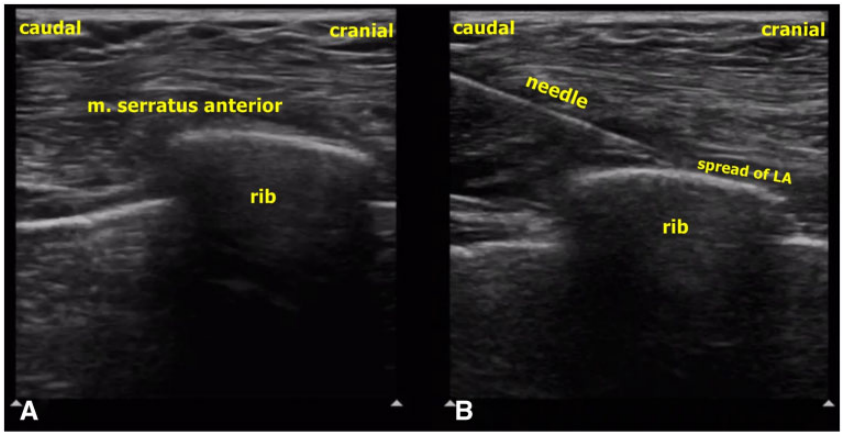

Figure 3. A) Sonographic anatomy of the serratus anterior plane block. The serratus anterior muscle and the rib are seen. B) Needle direction, craniocaudal spread of local anesthetic during serratus anterior plane block.

surgery, the patients with sufficient spontaneous respiration were extubated then transferred to the intensive care unit (ICU) for clinical observation.

Postoperative Analgesia Management

A standardized postoperative pain control protocol was administered to all patients. Twenty minutes before the end of the operation, a 400-mg dose of ibuprofen and a 100-mg dose of tramadol IV were administered for postoperative pain treatment. Ibuprofen 400 mg IV was performed every eight hours for postoperative analgesia. A patient-controlled analgesia (PCA) device was prepared with fentanyl and connected to each patient. The PCA protocol included a 10-μg/mL dose of fentanyl and the following settings: a 2-mL dose of bolus without an infusion dose, a lockout time of 20 minutes, and a four-hour time limit. Static (i.e., at rest, with normal breathing) and dynamic (i.e., while coughing) pain scores were evaluated using the VAS (0 = no pain, 10 = the most severe pain). VAS scores were recorded 1, 2, 4, 8, 16, 24 and 48 hours into the postoperative period. A meperidine (0.5 mg/kg) IV was administrated for rescue analgesia if the VAS was ≥4. Sedation levels were evaluated according to a four-point sedation scale (0 = awake, 1 = sleepy, 2 = hard to wake up, and 3 = not aroused by shaking). Outcomes were evaluated and recorded by a single pain nurse anesthetist who was blinded to the study protocol. Adverse effects (itching, nausea, vomiting, etc.) were recorded as well.

Statistical Analysis

The power analysis was calculated according to total 0–48-hour postoperative opioid consumption, which is the primary outcome of the study (36 ± 26.9 μg in the ESPB group, 95 ± 47.4 μg in the SAPB group). According to these data, it was determined that the power was 0.99 in the significance level in the 95% confidence interval. The following statistical analyses were performed using IBM SPSS Statistics for Windows (version 20.0; IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to analyze the data distribution, and Pearson's chi-square test was used to compare the categorical data between groups. A Student *t* test was used to check for differences between the groups, and analysis of variance was used to analyze repeated measures (VAS scores and fentanyl consumption) at a significance level of 5% for the normally distributed continuous variables. The descriptive statistics were expressed as means ± standard deviations.

Results

This study included 60 patients who received either single-injection US-guided ESPB or SAPB in a 1:1 ratio. There were no significant differences between the two groups in terms of demographic data, durations of surgery and anesthesia, or the types of surgical procedures they underwent ($P > 0.05$ each) (Table 1). Figure 1 shows the CONSORT flow diagram chart of this trial.

Intraoperative (239.33 ± 54.59 vs 275.33 ± 39.25, respectively) and postoperative opioid consumption at 0–8 (30.22 ± 22.7 vs 68.66 ± 30.48 μg, respectively), 8–16 (3.3 ± 7.5 vs 14.66 ± 13.8 μg, respectively), and 16–24 hours (1.33 ± 5.07 vs 9.33 ± 13.62 μg, respectively) and rescue analgesic use (9 ± 14.46 vs 29.33 ± 25.72 mg, respectively) were all significantly lower in the ESPB group compared with the SAPB group ($P < 0.05$). At 24–48 hours, postoperative opioid consumption was similar between groups (1.33 ± 5.07 vs 2.66 ± 6.91 μg, $P > 0.05$) (Table 2). Total postoperative 48-hour opioid consumption was significantly lower in the ESPB group (36 ± 26.9 μg) than the SAPB group (95 ± 47.4 μg, $P < 0.001$) (Table 2). At all times, static/dynamic VAS scores were significantly lower in the ESPB group compared with the SAPB group. However, there was no significant difference between the static VAS scores of the two groups at hour 4 ($P < 0.05$) (Figures 4 and 5). There were also no differences between the adverse effect

Table 1. Comparison of demographic data and duration times of surgery and anesthesia between the ESPB and SAPB groups

	Group ESPB (N = 30)	Group SAPB (N = 30)	*P*
Gender (M/F)	14/16	12/18	0.795*
Age, y	45.67 ± 9.7	45.93 ± 10.3	0.919†
Weight, kg	71.87 ± 8.6	75.8 ± 8.05	0.68†
Height, cm	166.1 ± 8.06	168.5 ± 8.3	0.264†
ASA I/II	16/14	11/19	0.299*
Types of surgery (wedge resection/lobectomy)	17/13	20/10	0.596*
Duration of surgery, min	133.83 ± 30.41	126.03 ± 14.97	0.213†
Duration of anesthesia, min	168.16 ± 29.08	157.66 ± 14.84	0.083†
Block procedure time, min	6.96 ± 1.8	7.1 ± 1.7	0.661†
One-time puncture success (yes/no)	21/9	26/4	0.209*

Values are expressed mean ± SD or No.
ASA = American Society of Anesthesiologists; ESPB = erector spinae plane block; SAPB = serratus anterior plane block.
*$P > 0.05$, chi-square test between groups.
†$P > 0.05$, independent Student *t* test between groups.

Table 2. Comparison of postoperative fentanyl consumption, intraoperative remifentanyl consumption, and the use of rescue analgesia (meperidin) between the ESPB and SAPB groups

	Group ESPB (N = 30), μg	Group SAPB (N = 30), μg	*P*
0–8 h	30.22 ± 22.7	68.66 ± 30.48	<0.001*
8–16 h	3.3 ± 7.5	14.66 ± 13.8	<0.001*
16–24 h	1.33 ± 5.07	9.33 ± 13.62	0.004*
24–48 h	1.33 ± 5.07	2.66 ± 6.91	0.398
Total postoperative fentanyl consumption, 0–48 h	36 ± 26.9	95 ± 47.4	<0.001†
Rescue analgesic using (yes/no)	9/21	19/11	0.019‡
Rescue analgesic dose, mg	9 ± 14.46	29.33 ± 25.72	<0.00†
Intraoperative remifentanyl consumption, mcg	239.33 ± 54.59	275.33 ± 39.25	0.005†

Values are expressed mean ± SD or No.
ESPB = erector spinae plane block; SAPB = serratus anterior plane block.
*$P < 0.05$, one-way analysis of variance.
†$P < 0.05$, independent Student *t* test between groups.
‡$P < 0.05$, chi-square test between groups.

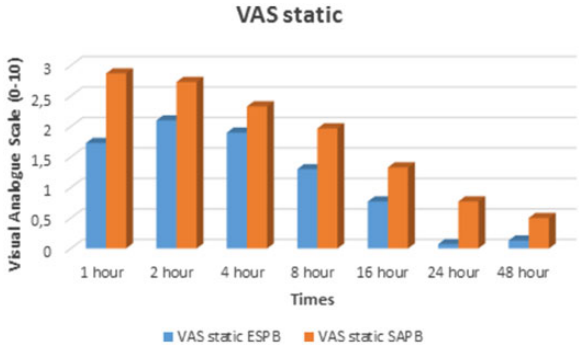

Figure 4. Static visual analog scale.

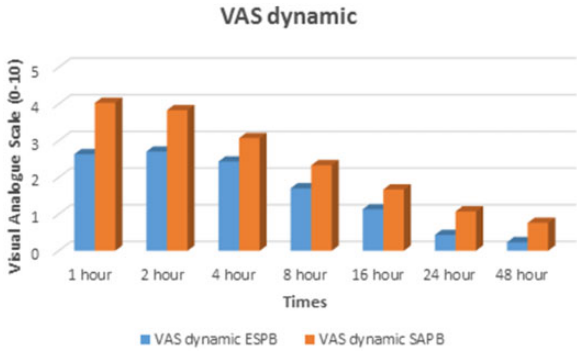

Figure 5. Dynamic visual analog scale.

profiles of the two groups (Table 3). Both block procedure time and one-time puncture success were similar between groups ($P > 0.05$ each) (Table 1).

Discussion

The results of the present study showed that the ESPB technique provided more effective pain control compared with the SAPB technique following thoracoscopic lung surgery. ESPB resulted in a decrease in intraoperative and postoperative opioid consumption at hour 24, lower rescue analgesic usage, and lower active/passive VAS scores compared with SAPB. Block procedure time, one-time puncture success, and opioid consumption at 24–48 hours were all similar between groups.

Moderate to severe postoperative pain may occur following VATS [10,11]. The sources of this pain often

Table 3. Comparison of incidence of adverse effects between the ESPB and SAPB groups

	Group ESPB (N = 30)	Group SAPB (N = 30)	*P*
Breathing depression	0	0	1*
Sedation/confusion	0	0	1*
Urinary retention	0	0	1*
Nausea (Y/N)	4/26	6/24	0.731*
Vomiting (Y/N)	3/27	5/25	0.706*
Itching (Y/N)	4/26	7/23	0.506*
Constipation	0	0	1*

ESPB = erector spinae plane block; SAPB = serratus anterior plane block.
*$P > 0{,}05$ chi-square test between groups.

include the entry sites of ports, lobectomy or wedge resection of the lung, and the surgical drain [5]. It has been reported that this pain may be acute and may transform into chronic pain at a rate of 22–63% [12]. Thus, both anesthesiologists and surgeons want to determine the best option for acute pain management following VATS. ERAS is a treatment strategy that aims at rapid recovery with fewer adverse effects. According to our results, there was a significant difference between groups in terms of analgesic efficacy; however, there was no statistical difference in terms of adverse effects.

Several techniques may be preferred for pain management, including interfascial plane blocks. These block techniques may be performed easily and safely under US guidance. SAPB is an interfascial plane block that may provide analgesia in patients who have undergone thoracoscopic surgery [3,4]. This technique blocks only the lateral braches of the intercostal nerves so that it can provide analgesia in the hemithorax and axilla. The serratus anterior muscle stretches from the first eight ribs to the medial side of scapula. Thoracic intercostal nerves are present under the serratus anterior muscle; the lateral braches penetrate the muscle and provide sensational innervation for the anterolateral chest wall [2]. Thus, we performed the SAPB deep in the serratus anterior muscle in our study.

ESPB is a novel interfascial plane block. However, it is different from other types of interfascial plane blocks in that it is a paraspinal block and may also act as a neuraxial block [5,6]. ESPB targets the dorsal and ventral rami of the spinal nerves. The thoracic spinal nerves divide into dorsal and ventral rami after transversing the intervertebral foramina. The ventral rami transform into the intercostal nerve, which provides innervation for the anterolateral chest wall. The dorsal rami spread into the paravertebral space above the transverse process and innervate the paravertebral tissues and the posterior thorax [2,5,6]. In the present study, ESPB provided superior analgesia compared with SAPB. ESBP blocks both dorsal and ventral rami, as well as the rami supplying the sympathetic chain, whereas SAPB blocks only the lateral branches of the intercostal nerves, which are part of the ventral rami [2].

In the literature, it has been reported that both SAPB [3,4,13] and ESPB [7,14–18] provide effective analgesia after thoracoscopic surgery. However, a limited number of studies have attempted to compare these two blocks. Further investigations are needed to determine the best regional analgesic technique for pain control following VATS. In another pilot randomized trial that compared the analgesic effectiveness of SAPB and ESPB after VATS, it was reported that ESPB provided superior analgesia compared with SAPB [19]. Our results were similar to the results of this study. However, there were differences between these two studies. First, in the prior study, patients were observed postoperatively for 24 hours. In the present study, patients were observed for 48 hours. The results of the present study showed that rates of opioid consumption were similar between groups, although VAS scores were lower in the ESPB group for hours 24–48. Second, local anesthetic infiltration to the port entry sites was performed by surgeons intraoperatively, but we did not perform infiltration to the port sites for better standardization.

The present randomized trial has some limitations. First, we did not perform dermatomal sensory testing; this could be used to better understand the differences in efficacy areas between the two blocks. Second, a block catheter could have been used for continuous infusion to provide pain control postoperatively. These points may be investigated in future studies. Lastly, the present study did not have a control group.

Conclusions

In conclusion, clinicians could develop a preference for either ESPB or SAPB for pain control after VATS based on their clinical experiences and personal choices. However, our study showed that US-guided ESPB may provide better pain control than SAPB.

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