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The Effect of the Port Numbers Used in Video-assisted Thoracoscopic Surgery on the Success of Ultrasound-Guided Erector Spinae Plane Block; A Single Center Retrospective Study

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Abstract: Video-assisted thoracoscopic surgery (VATS) is a minimally invasive procedure with lower pain scores and less morbidity than thoracotomy. However, it is necessary to provide adequate pain control in VATS. For this purpose, blocking visceral and somatic nerve fibers results in successful pain management. This retrospective study evaluated the effect of using different numbers of ports on the success of erector spinae plane block (ESPB) for postoperative analgesia management in patients undergoing VATS. We conducted a retrospective, single-center study between Sep 2020 and Aug 2021. According to the number of ports used, seventy-three patients were assigned to three groups (single port, dual port, and three-port). Preoperative ultrasound-guided ESPB was performed on all patients. The primary outcome was the numerical rating scale (NRS) score assessed for pain severity at different periods after surgery. The secondary outcome was the postoperative cumulative opioid consumption, and the exploratory outcomes were to determine the length of hospital stay and the incidence of opioid-related side effects. Static and dynamic NRS scores were significantly higher in the three-port group in the first 12-hour postoperative period after admission to the post-anesthesia care unit ($p<0.05$). After the first 12-hour period after surgery, static and dynamic NRS scores did not differ significantly between the groups ($p=0.158$ and $p=0.125$, respectively). Cumulative opioid consumption in the first 24 hours postoperatively was considerably higher in the three-port group than in the other groups (33.04±21.35 mg, $p=0.001$). Rescue analgesia consumption was similar between all groups ($p=0.341$). Preoperative single-shot ESPB injection may be associated with better analgesia and less opioid consumption in the first 12 hours postoperatively in patients undergoing single or two-port VATS compared to the multi-port technique.

Keywords: Video-Assisted Thoracoscopic Surgery; Erector Spinae Plane Block; Multiport; Single Port; Ultrasound.

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1. Introduction

Video-assisted thoracoscopic surgery (VATS) is increasingly used for primary lung cancer surgery and helps to reduce postoperative pain (1, 2). VATS is also accepted as a standard technique for many types of lung surgery. The main advantages of the procedure can be summarized as reducing the postoperative pain and incidence of pulmonary dysfunction, shorter chest tube duration, and reduced hospital stay (3). However, it is a fact that the pain can be severe and long-lasting after VATS. Therefore, it is essential to apply multimodal analgesic methods in postoperative pain control. Rocco et al. first reported single-port video-assisted thoracoscopic surgery in 2004 after wedge resection (4). Studies have reported that the single-port VATS technique results in less postoperative pain. However, the data obtained belong to the studies that compared the surgical technique regardless of the analgesic method applied. No study in the literature compares the success of thoracic wall blocks according to the number of ports.

Different drugs and doses have been studied and defined for regional analgesia methods, patient-controlled analgesia, and regional techniques, regardless of the number of ports in studies conducted regarding analgesic efficacy after VATS. Thoracic epidural analgesia (TEA) is a classic regional method with proven effectiveness in reducing postoperative pain following VATS surgery (5). Similarly, the thoracic paravertebral block (TPVB) is the first described chest wall block widely used in thoracic surgery (6, 7). Erector spinae plane block (ESPB) was first described by Forero et al. in 2016 (8). ESPB is achieved by injecting LA into the fascial plane between the erector spinae muscle and the transverse process. Therefore, it is far from the pleura and neuraxial structures. However, ESPB penetrates the paravertebral space with intertransverse connective tissues. Thus, in addition to the dorsal and ventral branches of the spinal nerve, it also blocks the lateral cutaneous branches of the intercostal nerves (9).

Some clinical research studies have reported that ESPB can provide adequate analgesia in the thoracic region after thoracotomy and VATS in thoracic surgery (10, 11). However, the effect of the number of ports used in VATS on the success of ESPB has not been evaluated until now. Therefore, we think that the number of ports used in VATS may create different results in the success of ESPB for postoperative analgesia management.

2. Material and Methods

2.1. Patients and Study Design

This retrospective study was conducted by the Declaration of Helsinki (as revised in 2013) and was approved by the institutional ethics committee (Bakırköy Dr. Sadi Konuk Training and Research Hospital, Institutional Review Board, Istanbul, Republic of Turkey; approval number: 2019-10-34/2019-251). The files of patients aged between 18-80 years, with American Society of Anesthesiologists (ASA) physical status 1-3, and who had undergone unilateral lobectomy and segmentectomy with VATS technique with different numbers of trocar ports for lung cancer between 1 Sep 2020 and 31 Aug 2021 were retrospectively reviewed. Patients with abnormal coagulation hemostatic test results, receiving anticoagulant therapy, a history of allergy to local anesthetic agents, using chronic opioids (at least three months), undergoing thoracotomy, and obese (body mass index >35 kg/m^2) were excluded from the study. A total of 73 patients were enrolled in this study. The patients were known to the anesthesiologist since the applied block was performed by a single clinician (GS). However, the persons on duty at the statistical and writing stage did not know which patients belonged to which group. Likewise, post-anesthesia care unit nurses tasked with evaluating the results, such as postoperative pain severity, were independent of the study and were blinded by the port numbers used. In addition, separate from the study, each patient was informed about the procedure to be done, and their consent was obtained.

2.2 Ultrasound-Guided ESPB Block

ESPB was performed with the patient in the lateral decubitus position before induction of general anesthesia under standard monitoring (Figure 1A). Before the procedure, the patient was sedated with midazolam at a dose of 0.03-0.05 mg/kg, and the back area was sterilized with 10% povidone-iodine. The 5–12 MHz linear ultrasound transducer probe (Esaote MyLabSeven / Esaote S.p.A, Genoa-Italy) was covered in a sterile sheath. Ultrasound-guided ESPB was performed at the T5 vertebral level. First, musculus (m) trapezius, m. rhomboid major, and m. erector spinae were visualized by moving the probe approximately 2-3 cm lateral to the midline with the in-plane technique. Next, a 20 gauge 100 mm peripheral nerve block needle (Stimuplex Ultra 360 30 ° - BRA-04892510-01 / B. Braun Melsungen AG, Japan) was advanced towards the interfascial plane between the erector spinae muscle and the transverse process of the vertebra. After confirming the location of the interfascial plane with the hydrodissection method using 3 mL of physiological saline solution, a paramedian longitudinal block was performed by injecting 20 mL of 0.25% bupivacaine (Marcaine 0.5 %, 5 mg/mL) (Figure 1B).

2.3. General Anesthesia

General anesthesia was provided with propofol (2-3 mg/kg) and fentanyl (1-2 μg/kg) in both groups. Before tracheal intubation with a double-lumen tube, the procedure was facilitated by providing muscle relaxation with rocuronium (0.6-1 mg/kg). Anesthesia was maintained with sevoflurane (1-2 %) and remifentanil infusion (0.05-0.1 mcg/kg/min). Hemodynamic data such as electrocardiography, peripheral oxygen saturation (SpO_2), invasive arterial pressure, exhaled CO_2 (end-tidal capnography), and

body temperature were monitored in the perioperative period. At the end of the surgery, anesthetic agents were discontinued, and the muscle relaxant effect was reversed with sugammadex (1-2 mg/kg). In addition, 8 mg ondansetron as a prophylactic antiemetic and 20 mg tenoxicam, and 100 mg tramadol hydrochloride as an analgesic were given. All patients were transferred to the post-anesthesia care unit (PACU) for close hemodynamic monitoring for the first 24 hours after extubation.

2.4. Postoperative Pain Management

Postoperative pain management was performed in all three groups according to our clinical protocol. During the postoperative period, intravenous patient-controlled analgesia (IV PCA) device (CADD-Legacy PCA Ambulatory Infusion Pump, Model 6300/Smiths Medical/USA) was connected to the patient, and morphine infusion was started. Morphine solution (0.5 mg/mL) was prepared in 100 mL isotonic saline; the PCA was adjusted as 1 mg bolus, lockout interval of 10 minutes, 1-hour limit dose of 4 mg, and no basal infusion. In addition, 25 mg meperidine was administered intravenously as rescue analgesia to patients with an NRS score of 4 and above. The evaluation of postoperative of pain and opioid consumption was done by a nurse on the PACU team who was independent of the study. Numerical rating scale (NRS) scores of all patients at 1-6-12-24 hours were recorded in the pain follow-up form. Furthermore, side effects such as nausea, vomiting, itching, sedation, urinary retention, and constipation due to postoperative opioid consumption were recorded.

2.5. Outcome Measurements

The primary outcome included NRS scores for pain at rest and coughing to assess the quality of analgesia at 1, 6, 12, and 24 hours post-surgery, while the secondary outcome included cumulative opioid consumption in the first 24 hours postoperatively. Additionally, intraoperative opioid requirement, postoperative rescue analgesic requirement, and postoperative adverse effects related to opioid consumption were evaluated.

2.6. Statistical Analysis

Based on our preliminary retrospective study, sample size was calculated based on the NRS mean difference between the 3 ESPB-treated groups. Data were collected retrospectively from 73 consecutive cases. We estimated that 73 subjects per group would be needed to provide a type I error of 0.05, a power of 90 %, and an estimated dropout rate of 20 % to detect a difference of 1 point between the 3 groups considered clinically significant.

The G*Power 3.1.9.2 program was used to calculate the sample size of the study. Data were analyzed using SPSS 22 for Windows (IBM Corp., Armonk, NY, USA). The normal distribution of the data was evaluated using the Kolmogorov-Smirnov test. The normally distributed variables were presented as the mean ± standard deviation, while the non- normally distributed variables were presented as the median. Categorical variables were presented as numbers and percentages. ANOVA test (post-hoc: Bonferroni and Dunnett Test) was used for the group comparison of the normally and homogeneous distributed variables and Welch test was used for non-homogeneous group comparisons of numerical variables. Kruskall Wallis Test (post-hoc: Mann Whitney U Test) was used for the intergroup comparison of the non-normally distributed variables. The Chi Square Test was used for the intergroup comparison of the categorical variables.

3. Results

After exclusion criteria, data from seventy-three patients for the study were collected and analyzed retrospectively. When the demographic data of the patients and the duration of surgery and anesthesia were compared, no statistically significant difference was found between the groups (Table 1). Repeated measurements of NRS scores at rest and during coughing revealed that static and dynamic NRS scores were significantly higher in the three-port group until the first 12 hours postoperatively ($p<0.05$). There was no significant difference between the single port and two port groups in terms of pain scores.

In the postoperative period after 12 hours, it was determined that static and dynamic NRS scores did not differ between the groups ($p=0.158$ and $p=0.125$, respectively) (Figure 2). PCA demand dose, delivered dose, and cumulative opioid consumption (mg) were significantly higher in the three port group in the first 24 hours postoperatively ($p=0.010$, $p=0.034$, and $p=0.001$, respectively). The need for postoperative rescue analgesia was similar between the groups ($p=0.341$). There was no significant difference between all three groups regarding the length of stay in PACU and hospital ($p=1.000$ and $p=0.269$, respectively) (Table 2). While vomiting developed in the patients in the single port group and the three port group in the postoperative period, no such complication was found in the two port group ($p=0.347$) (Table 3). All three groups had no complications related to the block procedure such as pneumothorax, local anesthetic systemic toxicity, or hematoma.

Table 1: Comparison of the demographical and surgical data between groups.

	Single Port Group (*n*=24)	Two Port Group (*n*=24)	Three Port Group (*n*=25)	*P* Value
Age	30.08±14.16	35.70±17.49	31.00±12.80	0.379
Gender				
Male	17 (70.8 %)	21 (87.5 %)	23 (92.0 %)	0.111
Female	7 (29.2 %)	3 (12.5 %)	2 (8.0 %)	
Height	174.08±11.85	175.58±7.01	174.16±8.46	0.821
Weight	64.45±9.23	68.91±9.23	62.04±10.87	0.053
BMI	21.45±3.99	22.42±3.40	20.27±2.91	0.100
ASA				
I	8 (33.3 %)	1 (4.2 %)	4 (16 %)	0.077
II	16 (66.7 %)	21 (87.5 %)	19 (76 %)	
III	0 (0.0 %)	2 (8.3 %)	2 (8 %)	
Surgery type				
Lobectomy	24 (100.0 %)	22 (91.7 %)	23 (92.0 %)	0.354
Segmentectomy	0 (0.0 %)	2 (8.3 %)	2 (8.0 %)	
Duration of Anesthesia	100.79±40.06	103.7±28.77	110.6±58.52	0.675
Duration of Surgery	63.04±33.92	73.25±28.22	64.40±44.61	0.111

Data are presented as mean±standard deviation (SD) or number (%).
BMI: body mass index, ASA: American Society of Anesthesiologists.

Table 2: Comparison of perioperative data between groups.

	Single Port Group (*n*=24)	Two Port Group (*n*=24)	Three Port Group (*n*=25)	*p* Value
Mean Remifentanil Use (μg/kg/min)	0.033±0.016	0.036±0.014	0.039±0.025	0.533
Total Remifentanil Use (mcg)	211.1±138.7	186.3±111.7	325.5±360.3	0.132
Intraoperative Hemodynamic Parameters and Complications				
HR	71.95±9.65	74.25±12.28	69.68±10.78	0.350
MAP	72.54±9.54	74.75±10.01	69.16±12.70	0.200
Bradycardia (Y/N)	1/23	1/23	2/23	0.792
Tachycardia (Y/N)	5/19	4/20	5/20	0.927
Hypotension (Y/N)	18/6	19/5	19/6	0.938
Hypertension (Y/N)	3/21	5/19	7/18	0.406
Chest tube Removal (day)	3.42±1.31	4.28±1.59	5.00±4.29	**0.048**
Length of PACU Stay (day)	1 (100.0%)	1 (100.0%)	1 (100.0%)	1.000
Length of Hospital Stay (day)	4.79±1.44	5.75±2.67	5.20±1.80	0.269

Data are presented as Mean±Standard Deviation (SD) or number (%).
PONV: postoperative nausea and vomiting, PPC: postoperative pulmonary complication, PACU: post-anesthesia care unit.

Table 3: Comparison of morphine consumptions and NRS scores between groups.

	Single Port Group (*n*=24)	**Two Port Group (*n*=24)**	**Three Port Group (*n*=25)**	***P* Value**
Postoperative Pain Scores at Rest				
PO 1 h	2.5 (0-6)	2 (0-5)	4 (0-5)	**0.002**
PO 6 h	2 (0-5)	2 (0-4)	3 (0-5)	**0.005**
PO 12 h	2 (0-6)	3 (0-5)	4 (0-6)	**0.023**
PO 24 h	2 (0-5)	2 (0-4)	3 (0-7)	0.158
Postoperative Pain Scores While Coughing				
PO 1 h	2.5 (1-6)	3 (1-4)	4 (1-8)	**0.028**
PO 6 h	3 (2-6)	3 (2-5)	5 (2-7)	**0.001**
PO 12 h	4 (0-7)	3 (1-7)	5 (2-7)	**0.003**
PO 24 h	3 (1-7)	4 (1-6)	5 (1-7)	0.125
PCA Demand Dose	16.75±18.43	18.20±9.84	33.04±21.35	**0.010**
PCA Delivered Dose	9.08±6.15	10.88±6.11	13.75±6.13	**0.034**
Cumulative Opioid Consumption (mg)	15.18±10.03	17.75±13.5	28.74±13.62	**0.001**
Rescue Analgesia Requirement	5 (20.8%)	7 (29.2%)	10 (40.0%)	0.341
Opioid Related Complications				
Nausea (Y/N)	6/18	6/18	4/21	0.678
Vomiting (Y/N)	2/22	0/24	1/24	0.347
Itchiness (Y/N)	0/24	1/23	0/25	0.355
Sedation (Y/N)	2/22	3/21	2/23	0.839
Constipation (Y/N)	0/24	1/23	1/24	0.604
Urinary retention (Y/N)	0/24	0/24	0/25	N/A

Data are presented as mean±standard deviation (SD).
PCA: patient-controlled analgesia, PO: postoperative, S-NRS: static numerical rating scale, D-NRS: dynamic numerical rating scale, h: hour.

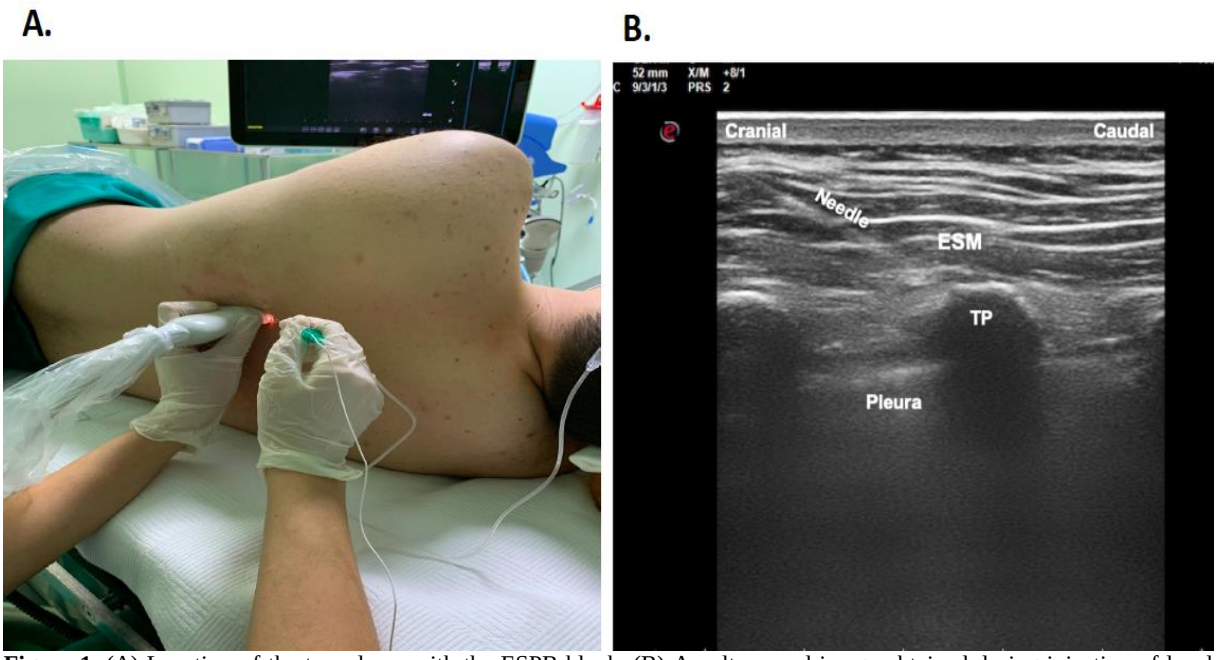

Figure 1. (A) Location of the transducer with the ESPB block, (B) An ultrasound image obtained during injection of local anesthetics. ESPB: Erector spinae plane block, ESM: erector spinae muscle, TP: transverse process, LA: local anesthetics.

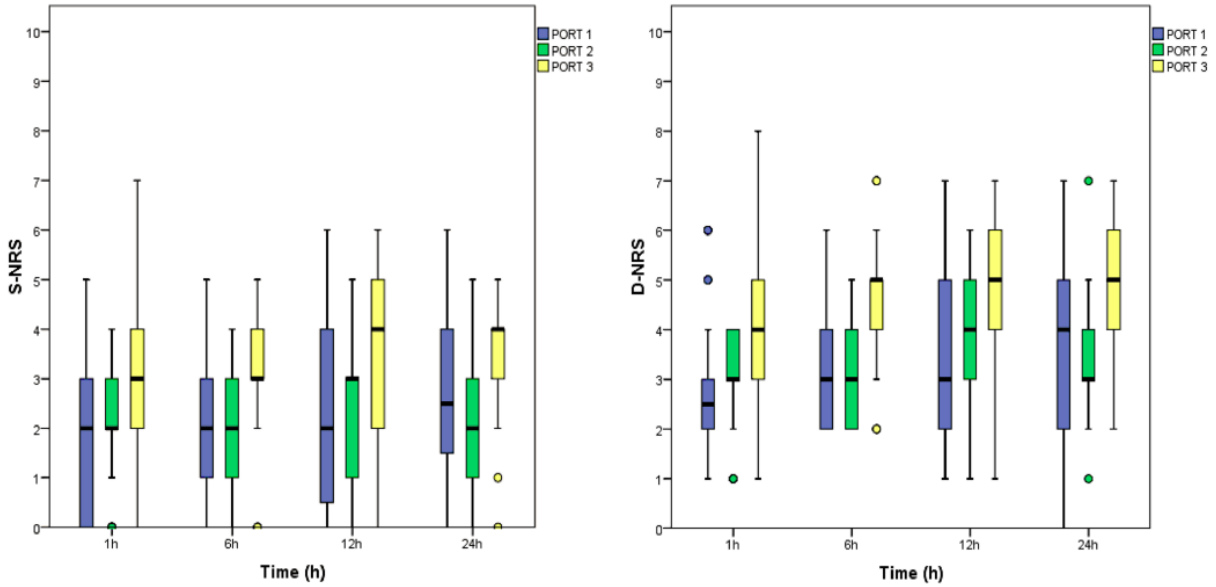

Figure 2. Postoperative static and dynamic NRS scores at the 1, 6, 12 and 24 hour follow-ups. NRS: Numerical rating scale.

4. Discussion

Our study showed that ultrasound-guided single-shot ESPB performed before anesthesia induction in VATS patients significantly reduced NRS scores and opioid consumption in the first 12 hours postoperatively in the single and two-port groups compared to the three-port group. ESPB similarly helped reduce pain and opioid consumption in patients in the single and dual port groups after 12 hours. Although it was stated in previous studies that reducing opioid consumption in the first 24 hours postoperatively could reduce the length of hospital stay and the development of postoperative pulmonary complications, we did not reach such a result in our study (12).

TEA or TPVB has been used for many years in pain management after thoracic surgery. However, with the widespread use of ultrasound in daily anesthesia practice, thoracic wall blocks have become more preferred. ESPB is primarily used as an alternative to TPVB and is considered to be safer due to the area in which it is applied (13). Because the TPVB application area is close to the pleura and the epidural distance, complications such as pneumothorax, widespread epidural spread, and total spinal block can be seen (14). Furthermore, clinical and cadaveric studies have shown that ESPB can spread to the epidural and intercostal areas at the T5-T9 level (15, 16). In addition, clinical research studies have reported that ESPB can reduce somatic and visceral pain in the chest region (10, 17, 18). Therefore, analgesia obtained with ESPB may also play a role in the relief of visceral pain originating from port entry sites.

In different clinical studies comparing ESPB with the control group and other truncal blocks, its effectiveness in reducing postoperative pain has been demonstrated (14, 19). Apart from VATS, studies in thoracotomy have also reported that ESPB effectively reduces pain and opioid consumption. (20, 21). In addition, different studies in the literature report that the single-port technique causes less postoperative pain, regardless of the analgesic method applied after VATS surgery (22, 23).

In these studies, shorter hospital stays and fewer pulmonary complications were determined as advantages of the single port technique. However, these studies only examined the results of the applied surgical procedure on pain. Therefore, the data obtained are independent of analgesic methods. However, regional analgesic techniques may have different effects depending on the number of ports. Unfortunately, there is no study in the literature examining the relationship between any regional technique applied for analgesia and the number of ports.

Although previous clinical studies reported that patients experienced less pain after single-port VATS, the analgesic method applied in most of the studies was not specified (22-24). However, different analgesic techniques may produce different results. In our study, results supporting this hypothesis were obtained. There was a significant difference between the groups after ESPB in both NRS scores and opioid consumption in the first 12 hours. As the reason for this, as stated in previous studies, it was assumed that the local anesthetic could act in an area up to three levels below the application point. Another finding is that when using three ports, there is a distance of four costa distance between the ports according to the placement technique, and a local anesthetic volume of 20 ml may have been insufficient for the spread over this distance. In the present study, it can be understood that the applied local anesthetic dose was inadequate after the postoperative 12th hour, with the disappearance of the statistical difference in NRS scores between the groups. If a longer duration of analgesia is preferred, local anesthetic infusion with catheterization may be considered.

The study has some limitations. The most important limitation of retrospective analysis is its ability to

identify associations without being able to assess causality. Furthermore, since it was a retrospective study, randomization could not be performed, and the patients were included in the study consecutively according to the admission order. In addition, the results of this study may not be generalizable to patients treated in healthcare centers with different dosing protocols. In addition, dermatomal evaluation could not be performed after the blocks. Still, the spread of local anesthetic to the correct area was confirmed by ultrasound guidance.

5. Conclusion

Ultrasound-guided ESPB may be associated with better analgesic efficacy and less opioid consumption, especially in the first 12 hours postoperatively for the single and two-port VATS technique. However, due to the decrease in the analgesic effect of single shot ESPB after 12 hours, patients' pain scores may be similar regardless of port numbers.

Limitations of the Study

The main limitations of this study are that it is a retrospective study and the number of patients included in the groups are small.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this article. The authors have no sources of funding to declare for this manuscript.

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Author Contributions

All authors contributed to the study conception and design. Conception and design, Provision of study materials, Data collection or management, Manuscript writing, Critical Review, Literature Review, Final approval: GS, Study design, Manuscript preparation, Critical Review, Literature Review, Statistical analysis: GOY. Study design, Manuscript preparation, Language editing, Critical Review, Literature Review,: İB. Study design, Manuscript preparation, Language editing, Statistical analysis, Final approval: ZÇ. Conception and design, Manuscript preparation, Language editing, Statistical analysis, Final approval: GOH. All the authors contributed to the interpretation of the results and the proof reading of the manuscript.

Ethical Approval

The trial was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Bakirkoy Dr. Sadi Konuk Training and Research Hospital. (approval number: 2019-251, approval date: 20/05/2019).

Data sharing statement

Data and statistical analysis plan will be shared if requested.

Consent to participate

Consent was obtained from all patients for the use of data and photographs under ethical conditions.

Informed Consent

Informed consent forms were obtained from all patients that preoperatively the patient data could be used in the retrospective studies.

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