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Comparison of deep and combined serratus anterior plane block after video-assisted thoracoscopic surgery; a prospective randomized trial

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ABSTRACT

Aim: Ultrasound-guided plane blocks have been employed frequently in Video-assisted thoracoscopic surgery (VATS). The aim of this study was to evaluate the effect of deep and combined serratus anterior plane block (SAPB) after VATS.

Material and Method: The patients, in the age range of 18 to 65 years, with the American Society of Anesthesiologists (ASA) physical status of I-III, and body mass index (BMI) of 18-30 kg/m², and undergoing lung resection with VATS were included in the study. Patients were informed about the study, and their written consent was obtained. Patients were divided into Deep SAPB (DSAPB) (Group 1) and combined SAPB (CSAPB) (Group 2) groups according to the analgesia protocol.

Results: There was no statistically significant difference between the groups in terms of demographic characteristics and surgical features ($p>0.05$). When the groups were evaluated in terms of the block performance time, it was found to be statistically significantly longer in the CSAPB group than in the DSAPB group ($p<0.001$). When the groups were evaluated in terms of VAS resting scores, the 1st, 2nd, 4th, 8th, 16th, 24th, and 48th-hour VAS resting results were found to be statistically significantly higher in the DSAPB group than the CSAPB group ($p<0.05$). VAS cough scores were statistically significantly higher in the DSAPB group at the 1st, 2nd, 4th, 8th, 16th, 24th, and 48th-hour ($p<0.05$). When the groups were evaluated in terms of the side effects, additional analgesic use, and morphine consumption, they were found to be statistically significantly higher in the DSAPB group than in the CSAPB group (p: 0.026, p: 0.020, $p<0.001$, respectively).

Conclusion: CSAPB provided effective analgesia after VATS for 48 hours. In addition, morphine consumption and the need for additional analgesics were low in CSAPB. However, the duration of the block procedure was longer in the CSAPB application.

Keywords: Acute pain, deep serratus anterior plane block, superficial serratus anterior plane block, combined serratus anterior plane block, video-assisted thoracoscopic surgery, VATS

INTRODUCTION

Although thoracic surgery causes severe pain, the use of video ascites thoracoscopic surgery (VATS) methods has limited postoperative pain (1). However, pain is still a problem in VATS patients. Failure to control this pain is associated with postoperative complications (2). The causes of acute pain after VATS include soft tissue damage, incision line, and drain entry sites (3).

In recent years, regional anesthesia methods, multimodal analgesia techniques combined with nonsteroidal anti-inflammatory drugs (NSAIDs), and opioids have been preferred for postoperative analgesia (4). Thoracic epidural analgesia (TEA), thoracic paravertebral block (TPVB), and intercostal block are among the commonly used methods (5). However, with the widespread use of ultrasonography (USG) in recent years, fascial plane blocks (such as erector spinae plane block and serratus anterior plane block (SAPB)) in which local anesthetic (LA) is injected into a tissue plane have become very popular (6,7). Unlike peripheral nerve blocks, no nerve or plexus block is required. LA drugs reach the desired nerve by spreading along the muscle plane (8).

SAPB, which has just been applied after VATS, targets the lateral cutaneous branches of the intercostal nerves, which originate from the intercostal nerves and pass from the deep to the surface of the serratus anterior muscle (9). SAPB is one of the plane blocks that can provide analgesia between the levels of the second thoracic vertebra (T2) and the ninth thoracic vertebra (T9) and can be applied under the guidance of USG (10). This application can be applied in two ways as deep SAPB (DSAPB) or superficial SAPB

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(SSAPB) (11,12). Although both methods are easy to apply, it has been reported that the duration of action of SSAPB is longer than that of DSAPB. In addition, it has been reported that SAPB application has similar analgesic efficacy and morphine consumption to TPVB for thoracic surgery (13).

Possible side effects and complications that may develop due to other regional anesthesia techniques are more limited in SAPB (14). In contrast to neuraxial techniques, patients with coagulopathy have very limited contraindications and no sympathetic block resulting in hypotension. Theoretically, neurological complications are also not expected (15). Although there are studies on SSAPB and DSAPB blocks, we could not find any study combining these two blocks.

In this study, we hypothesized that more nerve blocks can be created with multisite injection and more effective postoperative analgesia can be provided. Therefore, we thought that the combination of deep and superficial SAPB could provide more effective analgesia than DSAPB. We determined the postoperative first 48-hour VAS scores as the primary outcome. We determined 24-hour morphine consumption, additional analgesia needs, and side effects as the secondary outcomes.

MATERIAL AND METHOD

Study Design

The randomized and prospective trial was conducted in a high-volume tertiary thoracic surgery center after obtaining approval from the Ankara City Hospital No:1 Clinical Researches Ethics Committee (Date: 20.10.2021, Decision No: E1/2066/2021). The trial was registered on clinicaltrials.gov (https://clinicaltrials.gov/) under the identifier NCT05106283. This study was conducted within the framework of the ethical rules stated in the Declaration of Helsinki and followed Good Clinical Practices. This manuscript adheres to the applicable Consolidated Standards of Reporting Trials (CONSORT) guidelines.

Patients

The patients, in the age range of 18 to 65 years, with the American Society of Anesthesiologists (ASA) physical status of I-III, and body mass index (BMI) of 18-30 kg/m², and undergoing lung resection with VATS were included in the study. Patients were informed about the study, and their written consent was obtained.

During the preoperative evaluation, the patients were informed about pain assessment and patient-controlled analgesia (PCA). Patients with preoperative acute or chronic pain and a history of opioid therapy were excluded. Moreover, patients with bleeding disorders, infection at the injection site, allergy to local anesthetics, and patients who underwent emergency surgery were excluded from the study.

Patients were divided into DSAPB (Group 1) and CSAPB (Group 2) groups according to the analgesia protocol. Randomization was achieved with computer-generated random numbers. Group assignments were kept in a sealed envelope known only to the physician who would perform the block procedures.

Anesthesia Protocol

Patients were monitored in the operating room following the ASA standards. Patients were administered 0.03 mg/kg midazolam for premedication. Following preoxygenation, anesthesia was induced with 2 mg/kg propofol, 1 mcg/kg fentanyl, and 0.1 mg/kg vecuronium. After intubation with a left-sided double-lumen endobronchial tube, tube localization was confirmed. Anesthesia was maintained with sevoflurane in a mixture of oxygen and air. Additionally, remifentanil infusion at a dose of 0.01-0.20 mcg/kg/min was administered.

Block Procedures

Block procedures were performed under general anesthesia before the skin incision to prevent anxiety and ensure patient comfort. Following the anesthesia induction, blocks were performed under US guidance when patients were in the lateral decubitus position. After strict skin antisepsis, the needle insertion area was covered with sterile drapes. A high-frequency 6–18 MHz linear probe (MyLab six, Esaote, Genoa, Italy) in a sterile cover and a US-compatible 22-gauge and 8-mm nerve block needle (Pajunk, SonoPlexSTIM, Germany) were used in all groups. Block performance times were noted based on the entry of the block needle into the skin and the exit of the needle after the block. The following procedures were performed in the study groups:

DSAPB group (n: 30): Following the visualization of the anatomical structures, the nerve block needle was advanced via the in-plane technique until reaching the fourth rib. Hydrodissection with 2 ml of normal saline was performed beneath the serratus anterior muscle, and a volume of 20 ml of 0.25% bupivacaine was injected into the area (**Figure 1**).

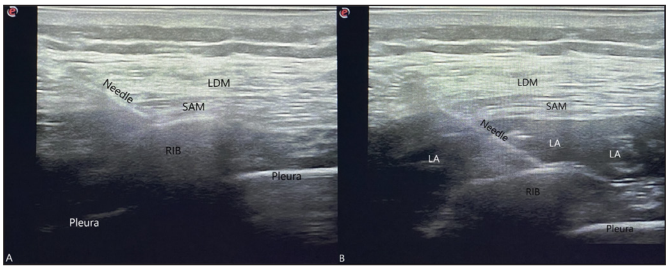

Figure 1. Deep serratus anterior plan block procedure. A: Anatomical scene before block B: Deep serratus anterior plan block; The local anesthetic spread beneath the serratus anterior muscle. SAM: serratus anterior muscle, LDM: Latissimus dorsi muscle, LA: local anesthetic.

CSAPB group (n: 30): After visualizing the anatomical structures, the needle was first advanced via the in-plane technique until reaching the fourth rib. Hydro dissection with 2 ml of normal saline was performed beneath the serratus anterior muscle, and a volume of 10 ml of 0.25% bupivacaine was injected into the area. Then, the needle was retracted 1–2 cm above the serratus anterior muscle; hydro dissection with 2 ml of normal saline was performed in the interfascial space, and a volume of 10 ml of 0.25% bupivacaine was injected into the area (**Figure 2**).

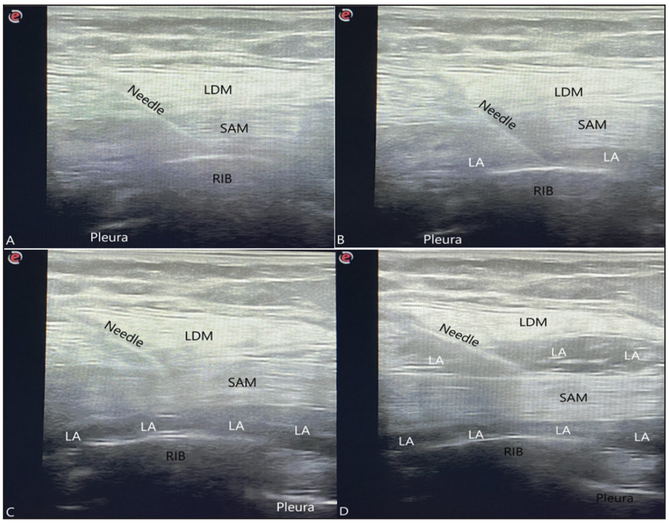

Figure 2. Combined serratus anterior plane block. A: Anatomical scene before the block. B: Deep serratus anterior plane block; The local anesthetic spread beneath the serratus anterior muscle. C: Anatomical scene before the superficial serratus anterior plane block after the deep serratus anterior plane block. D: Superficial serratus anterior plan block; The local anesthetic spread above the serratus anterior muscle. SAM: serratus anterior muscle, LDM: Latissimus dorsi muscle, LA: local anesthetic.

Analgesia Protocol

During the skin closure, patients received dexketoprofen and tramadol intravenously. Metoclopramide was administered intravenously to avoid nausea and vomiting. In the postoperative surgical intensive care unit, intravenous morphine was administered via PCA pump for 24 hours. Pain intensity was evaluated using a 10- point (0: No pain and 10: Unbearable pain) visual analog scale (VAS). The PCA pump's dose delivery was limited to administering a bolus dose of 1 mg morphine and delivering a maximum dose of 12 mg morphine in total within 4 hours with lockout intervals of 15 minutes. Paracetamol 1 g every 8 hours and dexketoprofen 50 mg twice daily were administered intravenously for multimodal analgesia. As a rescue analgesic agent, 0.5 mg/kg tramadol was given to patients intravenously when a score of VAS at rest was ≥ 4. The patients were transferred to the ward in the postoperative 24th hour. Paracetamol 500 mg tablets and tramadol 50 mg capsules every 8 hours and dexketoprofen 25 mg tablets every 12 hours were given after the postoperative second day. VAS scores at rest and while coughing were recorded in the postoperative 1st hour, 2nd hour, 4th hour, 8th hour, 16th hour, 24th hour, and 48th hour. The need for additional analgesics and side effects including allergic reactions, respiratory depression, sedation, hypotension, urinary retention, nausea-vomiting, and itching were recorded. In two groups, patients' hemodynamic data, age, BMI, gender, diagnosis, the type of surgery, intraoperative and postoperative complications, postoperative VAS scores, and postoperative additional analgesic use were recorded. The block was applied to all patients by the same attending anesthesiologist. The VAS score was followed up by the pain management nurse who was blinded to the type of block applied to the patient. All VATS procedures were applied by the same surgical team with sufficient experience in this regard in the third-level thoracic surgery center. A single polyvinylchloride chest tube was introduced, made of two openings, a camera port, and a utility.

Sample Size

The sample size was calculated using G*Power© software version 3.1.9.2 (Institute of Experimental Psychology, Heinrich Heine University, Dusseldorf, Germany). The sample size was calculated for the Mann-Whitney U-test, which was used for testing the main hypothesis of (VAS rest first hour) the present study. Depending on previous research results with two-sided (two tails) type I error 0.05 and power of 80% (1-β=0.8), effect size (d) factor 0.79, should involve ≥ 56 subjects.

Power Analyses

The post hoc power was calculated using G*Power© software version 3.1.9.2 (Institute of Experimental Psychology, Heinrich Heine University, Dusseldorf, Germany). The power was calculated for the Mann-Whitney U test, which was used for testing the main hypothesis of the present study (VAS rest first hour). Depending on previous research results with two-sided (two tails) type I error 0.05 and effect size (d) factor 1.07, post hoc power calculated as %97.96.

Statistical Analyses

Data analyses were performed by using SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, United States). Whether the distribution of continuous variables was normal or not was determined by the Kolmogorov Smirnov test. Levene test was used for the evaluation of homogeneity of variances. Unless specified otherwise, continuous data were described as mean±SD for normal distributions, and median (Q1: first quartile – Q3: third quartile) for skewed distributions. Categorical data were described as a number of cases (%). Statistical analysis differences in normally distributed variables between two independent groups were compared by Student's t-test, Mann Whitney U test was applied for comparisons of the not normally distributed data. Categorical variables were compared using Pearson's chi-square test or Fisher's exact test was accepted p-value <0.05 as a significant level on all statistical analysis.

RESULTS

66 patients were eligible for this study, and the data of 60 patients were analyzed (**Figure 3**). There was no statistically significant difference between the groups in terms of demographic characteristics and surgical features (p>0.05) (**Table 1**).

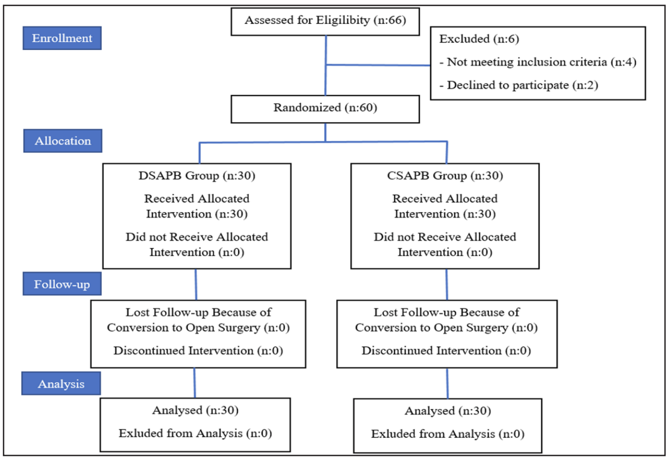

Figure 3. Flowchart of the patients. DSAPB: Deep serratus anterior plane block, CSAPB: Combined serratus anterior plane block

When the groups were evaluated in terms of the block performance time, it was found to be statistically significantly longer in the CSAPB group than in the DSAPB group (p<0.001) (**Table 1**).

Table 1. Demographic characteristics and surgical features of patients.

	DSAPB	CSAPB	p
Age, year β	51.5 (33-60)	52 (30-56)	0.569
Gender δ			
Female	4 (13.3%)	9 (30.0%)	0.117
Male	26 (86.7%)	21 (70.0%)	
BMI*	25.36±3.03	24.54±2.98	0.293
Diagnosis δ			
Pneumothorax	6 (20.0%)	7 (23.3%)	0.754
Lung Mass	24 (80.0%)	23 (76.7%)	
Operation δ			
Wedge	23 (76.7%)	25 (83.3%)	0.519
Lobectomy	7 (23.3%)	5 (16.7%)	
Block performance time (second)*	117.30±15.67	142.10±19.55	<0.001
Duration of anesthesia (minute) β	150 (120-180)	150 (120-180)	0.994
ASA δ			
ASA I	4 (13.3%)	3 (10.0%)	0.999
ASA I I	13 (43.3%)	13 (43.3%)	
ASA I I I	13 (43.3%)	14 (46.7%)	
Intraoperative remifentanil consumption (mcg) β	350 (300-450)	350 (275-450)	0.700

Continuous variables are expressed as either * the mean±standard deviation (SD) or β the median (Q1: first quartile – Q3: third quartile), and categorical variables are expressed as either δ frequency or percentage. Continuous variables were compared with a Student t-test or the Mann-Whitney U test, and categorical variables were compared using Pearson's chi-square test or Fisher's exact test. Statistically significant p-values are in bold. BMI: Body mass index. ASA: American Society of Anesthesiologists. DSAPB: Deep Serratus Anterior Plane Block, CSAPB: Combined Serratus Anterior Plane Block

When the groups were evaluated in terms of VAS resting scores, the 1st, 2nd, 4th, 8th, 16th, 24th, and 48th-hour VAS resting results were found to be statistically significantly higher in the DSAPB group than the CSAPB group (p<0.05) (**Table 2**). VAS cough scores were statistically significantly higher in the DSAPB group at the 1st, 2nd, 4th, 8th, 16th, 24th, and 48th-hour (p<0.05) (**Table 2**).

Table 2. Resting and coughing VAS scores of the patients during the postoperative 48 hours.

	DSAPB Med (Q1-Q3)	CSAPB Med (Q1-Q3)	p
VAS resting			
1st hour	3 (3-4)	3 (2-3)	<0.001
2nd hour	3 (3-3)	2 (1-3)	0.003
4th hour	2.5 (2-3)	2 (1-3)	0.016
8th hour	2 (2-3)	2 (1-2)	0.003
16th hour	2 (2-2)	1 (1-2)	0.002
24th hour	2 (1-2)	1 (0-2)	0.002
48th hour	2 (2-3)	1 (1-2)	<0.001
VAS coughing			
1st hour	5 (4-5)	4 (3-5)	0.006
2nd hour	4 (4-5)	3 (2-4)	0.001
4th hour	4 (3-4)	3 (2-3)	0.001
8th hour	3 (3-4)	3 (2-3)	0.035
16th hour	3 (3-3)	3 (2-3)	0.008
24th hour	3 (3-3)	2 (1-2)	<0.001
48th hour	3 (3-4)	3 (2-3)	0.001

Continuous variables are expressed as the median (Q1: first quartile – Q3: third quartile). Continuous variables were compared with the Mann-Whitney U test. Statistically significant p-values are in bold. DSAPB: Deep serratus anterior plane block, CSAPB: Combined serratus anterior plane block

When the groups were evaluated in terms of the side effects, additional analgesic use, and morphine consumption, they were found to be statistically significantly higher in the DSAPB group than in the CSAPB group (p: 0.026, p: 0.02, p<0.001, respectively) (**Table 3**).

Table 3. Morphine consumption during the postoperative 24-hours need for additional analgesics, and complication rates

	DSAPB (n:30)	CSAPB (n:30)	p
Morphine consumption (mg) *	30.30±9.52	18,27±4.53	<0.001
Additional analgesic use n (%) δ	14 (46.7%)	6 (23.3%)	0.028
Complication (Nausea) n (%) δ	8 (26.7%)	1 (3.3%)	0.026

Continuous variables are expressed as either * the mean±standard deviation (SD) and categorical variables are expressed as either δ frequency or percentage. DSAPB: Deep Serratus Anterior Plane Block, CSAPB: Combined Serratus Anterior Plane Block

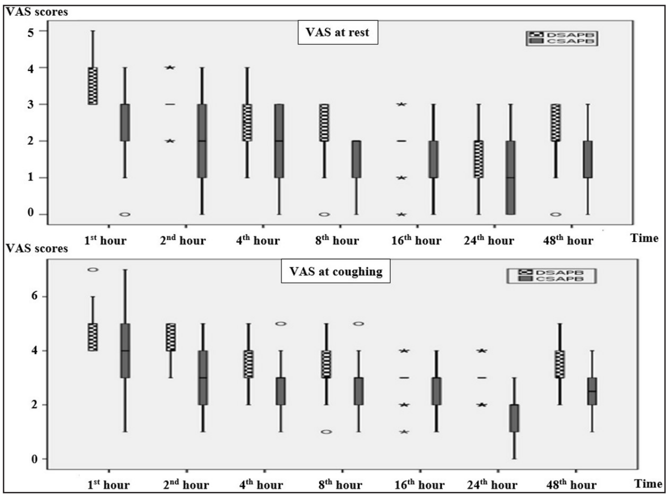

Figure 4. VAS scores at rest and VAS scores at coughing. Data are expressed as median (horizontal bars), interquartile range (boxes), and maximum and minimum values (whiskers) for the VAS scores in the 1st, 2nd, 4th, 8th, 16th, 24th hours, and 48th hours. DSAPB: Deep Serratus Anterior Plane Block, CSAPB: Combined Serratus Anterior Plane Block, VAS: Visual analog scale.

DISCUSSION

The results of this study comparing DSAPB and CSAPB applications showed that CSAPB provided effective analgesia for 48 hours postoperatively. However, morphine consumption and the need for additional analgesics remained very limited. However, the duration of the block procedure was longer in the CSAPB application. This study is special in terms of evaluating the combined block effectiveness in SAPB applications.

VATS, which is one of the developments in minimally invasive surgical techniques in recent years, provides more acceptable postoperative analgesia in patients with smaller incisions. This situation also ensures that complications are less common and therefore shortens the discharge time (16). However, severe pain in the acute postoperative period is still a problem that needs to be resolved in these patients. For this purpose, multimodal analgesia techniques are widely used and effective postoperative analgesia is provided in patients. One of the most important components of multimodal analgesia is regional and peripheral nerve blocks (17,18). For this purpose, plane blockers applied to the thoracic wall have been widely accepted in recent years. In addition, these blocks have become an indispensable part of the concept of acceleration of recovery after thoracic surgery (ERATS) due to the potential for thoracic epidural analgesia and less side effects compared to thoracic paravertebral blocks (19-22).

The analgesic effect of local anesthetics in thoracic plane blocks is still a controversial issue. The targeted area in SAPB application is the lateral cutaneous branches of the thoracic intercostal nerves, which originate from the anterior branches of the thoracic spinal nerves and extend as a neurovascular bundle just below each rib. In the midaxillary line, the lateral cutaneous branches of the thoracic intercostal nerve pass through the inner intercostal, outer intercostal, and serratus anterior muscles, which innervate the muscles of the lateral thorax (23). Local anesthetic spreading into these planes will spread along the lateral chest wall, resulting in paresthesia in the T2 to T9 dermatomes of the anterolateral thorax (23). SAPB, first described by Blanco et al. (9), has been evaluated by anatomical and radiological examination in fresh cadavers. SAPB containing the superficial plane has been reported to result in better drug diffusion and a longer duration of paresthesia (750-840 minutes) compared to SAPB containing the deep plane. It has been reported that the area of sensory loss in the pin-prick test is the same for superficial and deep SAPB injections. Moon et al. (11) found that the intraoperative analgesic efficacy is similar for deep and superficial SAPB in VATS lobectomy. Park et al. (4) evaluated the comparison of DSAPB and placebo, found that DSAPB provided effective analgesia after VATS. In a study comparing epidural analgesia and SAPB applications, Khalil et al. (15) found similar analgesic efficacy after thoracotomy and they also found that side effects were limited in the SAPB group. Baytar et al. (24) compared the DSAPB and TPVB applications reported that DSAPB and TPVB provided similar analgesic effects after VATS, and stated that DSAPB was safer. In present study is special in terms of comparing DSAPB and CSAPB applications, and according to the results of the study, more effective analgesia was provided in patients who underwent CSAPB with comparable side effects in both groups. Providing more effective analgesia in CSAPB can be explained by the more effective spread of local anesthetic applied to both deep and superficial areas by multisite injection and the compensation of a possible block failure with local anesthetic applied to the other area. Since this application is a new application and local anesthetic spread is still controversial in these blocks, new studies with different volumes may shed light on this issue.

Block implementation time is important both in terms of ease of application and easy learning. In this study, the duration of block application was longer in SSAPB than in DSAPB. This can be explained by the fact that rib imaging is performed faster in the DSAPB application since it is considered a landmark. In addition, in multisite injection, the application of injection to two points, even if it is a single needle entry, prolonged the time. However, providing more effective analgesia in CSAPB shows that this time difference is negligible.

Epidural, paravertebral, and intercostal blocks have been used in thoracic surgery for years. However, each of these blocks has some disadvantages. It includes unnecessary bilateral blockade, including the sympathetic nervous system, and various complications such as hypotension, epidural hematoma, abscess, and dural puncture (25,26). Although it has been recommended as a paravertebral block in recent years, it also has some disadvantages such as difficult technique, despite the use of pneumothorax and ultrasound (27). Intercostal nerve block also has some deficiencies such as pneumothorax, short duration of action, high plasma absorption of local anesthetics, and the need to block multiple nerve levels (25,27). Therefore, thoracic plane blocks are preferred because of their low incidence of side effects. In present study, only PONV was seen in the patients and the incidence of PONV in CSAPB group was quite low. This situation might be related to higher consumption of morphine and rescue analgesic requirements in DSAPB group.

There are some limitations in this study. First of all, since it is a single-center study, it may not be appropriate to generalize these results to the general population. Second, the long-term analgesic effects of these two blocks and their results on chronic pain could not be evaluated.

CONCLUSION

CSAPB provided effective analgesia after VATS for 48 hours. In addition, morphine consumption and the need for additional analgesics were low in CSAPB. However, the duration of the block procedure was longer in the CSAPB application. Large-scale prospective studies with different local anesthetics volumes and concentrations will be useful in evaluating the effectiveness of these two methods.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Ankara City Hospital No:1 Clinical Researches Ethics Committee (Date: 20.10.2021, Decision No: E1/2066/2021).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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