The effect of deep and superficial serratus anterior plane block on postoperative acute pain for thoracoscopic surgery patients; a prospective randomized trial

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ABSTRACT

Aims: In recent years, video-assisted thoracoscopic surgery (VATS) is increasingly preferred over open thoracotomy. Serratus anterior plane block (SAPB) is the preferred analgesic technique in VATS interventions. This study, it was aimed to compare the postoperative analgesic efficacy of superficial SAPB (SSAPB) and deep SAPB (DSAPB) in patients undergoing lung resection with VATS.

Methods: The study was conducted with a prospective, randomized, single-blind design. The ethics committee approval was obtained for the study. 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 assigned to DSAPB (Group 1) and SSAPB (Group 2) groups according to the analgesia protocol.

Results: After obtaining ethical committee approval, 60 patients were included in the study. Eight patients who converted from VATS to thoracotomy were excluded from the study. There was no statistically significant difference between the groups in terms of demographic characteristics, surgical features, side effects, morphine consumption, and additional analgesic use (p>0.05). When the groups were evaluated in terms of the duration of the block procedure, it was found to be statistically significantly longer in the SSAPB group than in the DSAPB group (p<0.001).

Conclusion: Both DSAPB and SSAPB were effective and had similar analgesic actions. The shorter block procedure time in DSAPB may be an advantage when considering similar analgesic effects.

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

INTRODUCTION

In recent years, video-assisted thoracoscopic surgery (VATS) is increasingly preferred over open thoracotomy. The popularity of VATS has gradually increased due to the widespread use of applications defined as enhanced recovery after surgery (ERAS), the preference of less invasive surgical techniques, and less associated with postoperative complications.1,2 Although it is performed via a smaller incision compared to thoracotomy, pain after VATS is still a problem that needs to be resolved. Postoperative severe pain; by making it difficult for the patient to cough, it may cause accumulation of secretions, decrease in functional residual capacity and, as a result, increase in morbidity.3 Since the formation of postoperative pain depends on tissue damage, preemptive analgesia applications remain on the agenda in the treatment of pain.4 Although the application of thoracic epidural analgesia (TEA) is considered the gold standard for the treatment of pain in thoracic surgery, in recent years, considering the serious complications associated with TEA application, regional interfacial nerve blocks under ultrasound (US) guidance have been preferred.5,6 Nowadays, erector spinae plane block (ESPB) and serratus anterior plane block (SAPB) are the most preferred techniques in VATS interventions. The application of such regional blocks is technically easier than TEA or even thoracic paravertebral block (TPVB) and is supported by ERAS protocols besides having lower complication rates.7

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SAPB is a new technique that provides an analgesic effect by blocking the lateral branch of the intercostal nerve. This block has become a popular analgesic modality as it is easy to administer and relatively safe. SAPB has two different methods as a deep and superficial application. While blocking is applied to the plane between the latissimus dorsi and serratus anterior muscles in superficial SAPB (SSAPB); it is applied to the deep plane between the serratus anterior muscle and the rib/external intercostal muscle in deep SAPB (DSAPB). There are still controversial results about the superiority of these blocks. In VATS applications, publications are showing that SSAPB has a longer and wider blockage area than DSAPB, and there are also publications in the literature showing that these two methods are not superior to each other.

We hypothesized that SAPB may be effective in reducing postoperative pain in patients undergoing VATS and that SSAPB or DSAPB methods may exhibit different properties. It was aimed to compare the postoperative analgesic efficacy and application times of SSAPB and DSAPB in patients undergoing lung resection with VATS. The VAS pain scores during the first 48 hours after surgery were determined as the primary outcome. The 24-hour morphine consumption, additional analgesic requirements, and block performance time were of the patients were determined as the secondary outcome.

**METHODS**

The randomized and prospective trial was conducted in a high-volume tertiary thoracic surgery center after obtaining approval from Ankara City Hospital Ethics Committee (Date: 22.10.2021, Decision No: E1-21-2067). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. 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, or allergy to local anesthetics, and patients who underwent emergency surgery were excluded from the study. In addition, patients who converted from VATS to thoracotomy were also excluded from the study.

Patients were divided into DSAPB (Group 1) and SSAPB (Group 2) groups according to the analgesia protocol. Randomization was achieved with computer-generated random numbers.

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.

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.

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 (interquartile range). 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.

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 man Whitney u-test, which was used for testing the main hypothesis of VAS scores at rest in the first postoperative 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 0.88, should involve ≥ 44 subject.

RESULTS

After obtaining ethical committee approval, 60 patients were included in the study. Eight patients who converted from VATS to thoracotomy were excluded from the study. (Figure 3).

There was no statistically significant difference between the groups in terms of demographic characteristics, surgical features, side effects, morphine consumption, and additional analgesic use (p>0.05) (Table 1).

When the groups were evaluated in terms of block performance time, it was found to be statistically significantly longer in the SSAPB group than in the DSAPB group (p<0.001) (Table 1). No statistically significant difference was observed between the groups in terms of hemodynamic parameters and SpO2 (p>0.05).

There was no statistically significant difference between the groups in terms of all VAS resting and VAS coughing (p>0.05) (Figure 4) (Table 2).
Studies comparing the analgesic efficacy of DSAPB and SSAPB after VATS are very limited. Blanco et al. argued that SSAPB has a wider block area in their study. While Piracha et al. found that DSAPB could offer better analgesia compared to superficial injection in four patients undergoing breast surgery, Abdallah et al. found similar analgesic effects with both plane blocks after breast surgery. On the other hand, a study by Qui et al. showed that superficial SAPB is more effective. The widespread use of local anesthesia in the deep or superficial block is still controversial. Biswas et al. in a cadaver study, with a high-volume injection technique, provided widespread and consistent dye distribution in the anterior chest wall and axilla, regardless of superficial or deep application. However, they stated that its distribution in the posterior area is more limited. Qui et al. showed in their study that SSAPB creates a more effective block compared to DSAPB. The authors argued that this situation may be related to complete or partial blockage of the long thoracic nerve innervating the serratus anterior muscle with SSAPB. It was evaluated as this blockade provided more effective analgesia by blocking the anterior branches of the intercostal nerves.

In this study, we observed similar analgesic actions with both SSAPB and DSAPB in the postoperative 48-hour period. There is no consensus on the ideal local anesthetic injection volume for SAPB. Major studies on this subject have been increasing the use of local anesthesia with TPV and DSAPB. However, some studies have revealed that similar results in terms of postoperative analgesia are obtained with TPV and DSAPB applications. Anatomically, the serratus anterior muscle originates on the surface of the first 8 ribs and attaches to the medial border of the scapula and posterior aspect of the latissimus dorsi. Intercostal nerves pierce the muscle and pass through the deep and anterior planes of the serratus anterior muscle in transition to the subcutaneous tissue. This anatomical location may provide adequate analgesia at T2 to T9 levels in patients undergoing SAPB. Another advantage of SAPB applications is that they are easier to view and easier to implement than TPV and DSAPB.

In the current study, the block areas for DSAPB and SSAPB were compared and showed similar analgesic effects in both gating and coughing. The results of this study showed that both DSAPB and SSAPB provided effective postoperative analgesia in patients who underwent VATS. Although their analgesic effects are similar, the shorter block performance time in DSAPB can be considered as an advantage of this practice.

In recent years, VATS has become an increasingly preferred method in lung resections because it is a less invasive treatment method. Although the pain is more limited compared to thoracotomy, severe pain may be encountered, especially in the first 24 hours postoperatively, and this may last longer. Poorly controlled postoperative pain may limit the patient's effective coughing function, resulting in pulmonary infections and delayed recovery. Various analgesic methods are used to relieve pain after VATS, techniques such as TPVB, ESPB, SSAPB, and DSAPB have been increasingly used recently. These applications are also one of the most important elements of multimodal analgesia, which is a component of ERAS protocols, the main concept of which aims to accelerate the surgical process with the least invasive intervention possible. In addition, TPVB, ESPB, and SAPB have recently been recommended by the European Society of Regional Anaesthesia (ESRA) as methods of choice for postoperative analgesia after VATS (recommendation grade: A, for all 3 techniques). SAPB application seems to be more practical and safe due to the relative difficulty of TPV and ESP application, and the proximity to the pleura and vascular structures, especially in TPV. In addition, studies have revealed that similar results in terms of postoperative analgesia are obtained with TPV and DSAPB applications. Anatomically, the serratus anterior muscle originates on the surface of the first 8 ribs and attaches to the medial border of the scapula and posterior aspect of the latissimus dorsi. Intercostal nerves pierce the muscle and pass through the deep and anterior planes of the serratus anterior muscle in transition to the subcutaneous tissue. This anatomical location may provide adequate analgesia at T2 to T9 levels in patients undergoing SAPB.

In this study, we observed similar analgesic actions with both SSAPB and DSAPB in the postoperative 48-hour period. There is no consensus on the ideal local anesthetic injection volume for SAPB. Major studies on this subject are at the level of cadaver or imaging studies. Kunigo et al. compared SABP applications using 20 mL and 40 mL of ropivacaine for postoperative analgesia after breast cancer surgery, and found that higher volume produced a better analgesic effect and that the blocking effect could be sufficient and safer with lower doses also. In this study where we kept the local anesthetic volume constant at 20 mL, we achieved sufficient analgesic effect.

### DISCUSSION

The results of this study showed that both DSAPB and SSAPB provided effective postoperative analgesia in patients who underwent VATS. Although their analgesic effects are similar, the shorter block performance time in DSAPB can be considered as an advantage of this practice.

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### Table 2: Resting and coughing VAS scores during the postoperative 48 hours.

<table>
<thead>
<tr>
<th></th>
<th>DSAPB (n:26)</th>
<th>SSAPB (n:26)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS at rest</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st hour</td>
<td>3 (2)</td>
<td>3 (1)</td>
<td>0.430</td>
</tr>
<tr>
<td>2nd hour</td>
<td>2.5 (2)</td>
<td>2 (1)</td>
<td>0.726</td>
</tr>
<tr>
<td>4th hour</td>
<td>2 (2)</td>
<td>2 (2)</td>
<td>0.832</td>
</tr>
<tr>
<td>8th hour</td>
<td>2 (2)</td>
<td>2 (1)</td>
<td>0.977</td>
</tr>
<tr>
<td>16th hour</td>
<td>1 (1)</td>
<td>1 (1)</td>
<td>0.530</td>
</tr>
<tr>
<td>24th hour</td>
<td>1 (1)</td>
<td>1 (2)</td>
<td>0.520</td>
</tr>
<tr>
<td>48th hour</td>
<td>2 (2)</td>
<td>2 (2)</td>
<td>0.748</td>
</tr>
<tr>
<td>VAS at cough</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st hour</td>
<td>4 (2)</td>
<td>4 (2)</td>
<td>0.468</td>
</tr>
<tr>
<td>2nd hour</td>
<td>4 (2)</td>
<td>3 (2)</td>
<td>0.748</td>
</tr>
<tr>
<td>4th hour</td>
<td>3 (2)</td>
<td>3 (2)</td>
<td>0.895</td>
</tr>
<tr>
<td>8th hour</td>
<td>3 (2)</td>
<td>3 (1)</td>
<td>0.682</td>
</tr>
<tr>
<td>16th hour</td>
<td>2 (1)</td>
<td>2.5 (1)</td>
<td>0.938</td>
</tr>
<tr>
<td>24th hour</td>
<td>2 (1)</td>
<td>2 (2)</td>
<td>0.621</td>
</tr>
<tr>
<td>48th hour</td>
<td>3 (1)</td>
<td>3 (2)</td>
<td>0.621</td>
</tr>
</tbody>
</table>

Continuous variables are expressed as median (interquartile range). Continuous variables were compared with the Mann-Whitney U test. Statistically significant p values are in bold.

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, SSAPB: Superficial Serratus Anterior Plane Block, VAS: Visual analog scale.
Block performance times are important in terms of showing the easy applicability of the block. This is important not only for limiting the time spent on the block but also for the convenience of the process. In studies on SAPB applications, the block procedure duration has not come to the fore. However, Edwards et al. evaluated DSAPB and SSAPB in terms of the duration of the block procedure in patients who underwent breast surgery and found the duration of block application to be shorter in patients who underwent DSAPB. In our study, the DSAPB application was completed in a shorter time than the superficial application. This can be explained by the rapid acquisition of the ultrasound image due to the rib and the fact that the deep serratus region is less mobile due to its proximity to the rib during application. In addition to providing similar analgesic effects with SSAPB, we think that DSAPB, which can be administered in a shorter time, may be a good alternative to SSAPB. Moreover, we think that since the area where DSAPB is applied is directly above the rib and away from the pleura, it will not pose a problem in terms of safe block application.

Qiu et al. found that the number of patients who developed nausea and vomiting in patients who underwent SSAPB was higher without significance after VATS. In this study, we observed only nausea as a side effect in the DSAPB and SSAPB groups. However, although this rate was higher in the SSAPB group, there was no significant difference between the groups. Considering that many factors are effective in the development of PONV after surgery, it may not be possible to evaluate whether the applied blocks may be related to PONV.

The present study has some limitations. The study was conducted at a single center. In the study, the block was applied using the same local anesthetic volumes in both blocks. Studies with different volumes may be useful in evaluating the analgesic effect of these two blocks. However, they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

CONCLUSION
In this study comparing DSAPB and SSAPB in patients who underwent VATS lung resection, safe and effective analgesia was obtained with both blocks. Although their analgesic effects are similar, the shorter block procedure time in DSAPB can be considered as an advantage of this practice.

ETHICAL DECLARATIONS
Ethics Committee Approval: The study was carried out with the permission of Ankara City Hospital Ethics Committee (Date: 22.10.2021, Decision No: E1-21-2067).
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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