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Rhomboid Intercostal and Serratus Anterior Interfascial Plane Blocks for the Treatment of Post-Operative Pain after Video-Assisted Thoracoscopic Surgery: A Retrospective Propensity-Matched Study

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Abstract

Objective: Video-assisted thoracoscopic surgery (VATS) techniques are commonly used for surgical procedures within the thoracic cavity with smaller incisions. There are very few regional anesthesia methods used to achieve this goal. This study aimed to investigate the effect of two fascial plane block technique rhomboid intercostal block (RIB) and serratus anterior plane block (SAPB) administered on pain scores after VATS.

Methods: A total of 90 patients who underwent VATS were included in this study. Patients were divided in three groups: Group R (intravenous patient-controlled analgesia (IV. PCA) +RİB with (25 mL 0.25% bupivacaine; n=30), Group S (IV. PCA + SAPB with (25 mL 0.25% bupivacaine; n=30), and Group C (IV. PCA). The primary outcome was determined as a tramadol consumption amount (at hours 6, 12, and 24). Postoperative pain was evaluated using the VAS (at the 30th minute, 2nd, 6th, 12th, and 24th hours) scores. Secondary outcomes included the side effect profile and additional analgesic use.

Results: VAS scores of the Group R were found to be statistically significantly lower to those of Group S and Group C ($p<0.05$). A comparison of Groups R and S with Group C in terms of tramadol consumption amounts, at all measurement time points, revealed statistically significantly lower values ($p<0.005$).

Conclusion: As per the results of this study, we believe that RİB and SAPB administration for pain palliation after VATS is an effective analgesia technique.

Keywords: Bupivacaine, nerve block, post-operative pain, VATS, ultrasound

Introduction

Video-assisted thoracoscopic surgery (VATS) is applied for surgical procedures within the thoracic cavity with smaller incisions.[1] Today, several surgical procedures requiring a thoracotomy can be carried out using this less invasive method, which is considered to offer advantages in terms of post-operative pain and complications given the associated smaller incisions. Although it is less invasive, post-VATS pain requires multimodal analgesia.[2, 3] For this purpose, the most commonly used methods are the intravenous route and regional anesthesia. Despite the established efficacy of thoracic epidural analgesia (TEA) and paravertebral block (PVB) for post-VATS pain, there is as yet a lack of consensus on the optimum regional anesthesia technique.[4] Anesthesiologists tend to opt for interfascial plane blocks as an appropriate alternative to TEA and PVB, which have been associated with serious risks of complications related to the neuraxial structures.[5, 6]

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Among the interfascial blocks that have been suggested as analgesic techniques for thoracic wall-related surgical procedures, the main ones considered appropriate for thoracic surgery are Serratus anterior plane (SAP), Erector spinae, and Rhomboid intercostal block (RIB). Ultrasound-guided interfascial block techniques (RIB, SAP) include the injecting of local anesthetics between muscles, aiming to provide analgesia to the thoracic wall by blocking the lateral cutaneous branches of the thoracic intercostal nerves located in this area.[6, 7] SAP blocks are applied to the lower and upper planes of the serratus muscle. It has been proven that it provides analgesia between the dematomal levels of Thoracic 2 and Thoracic 9 and has been used as an analgesia following different operations.[5, 8] RIB, in turn, is a plane block that has been introduced more recently. Performed in the triangle of auscultation between rhomboid major muscle and intercostal muscle, RIB has been reported to provide for the distribution of local anesthetics beneath the serratus muscle at the anterior, and to the erector spina muscle at the posterior of the site of application.[6] The most notable advantage of this technique is its coverage of the lateral cutaneous branches of the thoracic nerves and also the dorsal rami.[6]

This study aims to establish the effect of the SAP and RIB block techniques on post-operative pain following VATS, for which the analgesic consumption amounts of the patients are evaluated.

Methods

Upon obtaining the approval of the Bursa Yuksek Ihtisas Training and Research Hospital Ethics Committee (decision number 2011-KAEK-25 2019/10-06), this propensity-focused retrospective cohort study examined the files of 550 patients who had undergone a VATS operation between June 2016 and October 2019. All patients had provided written consent for the block procedure to be performed. The study was conducted following the principles of the Declaration of Helsinki.

The study included patients aged 18-70 who had undergone VATS by the same surgical team of American Society of Anesthesiologists (ASA) class I-III. Excluded from the study were patients undergoing a second operation in the same region or emergency surgical operations, coagulation disorder, known allergy to study drugs, and those using pre-operative chronic opioids.

Main Points:

- Post-VATS pain requires multimodal analgesia.
- Interfascial block techniques can be used for pain control after thoracic surgery.
- RİB and SAPB administered for pain palliation after VATS is an effective analgesia technique.

Anesthetic Management: After premedication with IV Midazolam: 0.03 mg kg^{-1}, the patients were taken into the operating theater and subjected to routine anesthetic monitorization (non-invasive blood pressure, Electrocardiography, heart rate, and peripheral oxygen saturation), with propofol and rocuronium bromide used for induction. The patients were intubated with a double-lumen tube of an appropriate size (35–37 French), and general anesthesia was maintained through sevoflurane (at a concentration of 1–2.5%), O_2 and air (50% - 50%) mixture with a flow of 3 L min^{-1}. Intraoperative analgesia needs were met with 1 µg kg^{-1} fentanyl. Approximately 30 minutes before the end of the operation, first, 20 mg of Tenoxicam was administered intravenously. At the end of the operation, after suturing the skin, a SAPB or Rhomboid intercostal block was applied under the US. After monitoring for 1 hour in the post-operative recovery room, the patients were transferred to the patient ward.

Pain management: IV PCA protocol: a tramadol-saline solution of 1 mg ml^{-1} was prepared for all patients. The device was adjusted to a 30-minute locking interval and an 8-mg demand dose. The daily maximum dose was 400 mg, and the allowable dose per six hours was planned as 100 mg.

Rhomboid intercostal block: Following surface dysinfection, a linear USG probe (10–18 MHz, MyLab30; Esaote, Florence, Italy) was placed vertically into the inferior medial scapula in the craniocaudal direction in a sagittal position. By advancing the probe toward the caudal direction, the rhomboid major muscle was identified at the levels of the Thoracic 5 and Thoracic 6 vertebrae, below the trapezius muscle. After the location was confirmed through hydro dissection with 3 mL of local anesthetic, 25 mL of bupivacaine (at a concentration of 0.25%) was injected to the plane between the rhomboid major muscle and the intercostal muscle using the in-line technique via a 22-gauge 100 mm ultrasound-visible peripheral nerve block needle.[6]

Serratus anterior plane blocks: Were performed with the patient in a lateral position, with the upper arm raised over the head. Following appropriate surface dysinfection, the first and second ribs were identified via the linear probe in the midclavicular line. By advancing the USG probe in a caudal direction, the fourth and fifth ribs were visualized in the sagittal plane; after which, the US probe was forwarded to the posterior, and the serratus, latissimus dorsi, and intercostal muscles were visualized on the mid-axillary line. Then, 25 mL of bupivacaine (at a concentration of 0.25%) was injected into the lower plane of the serratus muscle using the in-line technique with an USG-guided 22-gauge 100 mm ultrasound-visible peripheral nerve block needle.[5] All block procedures were performed by the same anaesthesiology and reanimation specialist (KÖ). For both groups, paracetamol 1 gr at 8-hour intervals at a maxi-

mum of three times/per day was ordered for the need for additional analgesia when VAS (Visual analog scale) was >5.

The RIP group patients, SAPB block patients, and non-block group patients were matched 1:1:1 using propensity score matching.[9] This matching was made to match the different factors with potential effects on the post-operative pain levels of the three groups. Propensity scores were calculated using a non-parsimonious multivariable logistic regression model, in which the mode of analgesia was used as a dependent variable. The propensity scores were calculated using a logistic regression model, which uses the mode of analgesia as a dependent variable. Independent variables were established as thoracic surgical procedures and 5 risk factors, considered to be producers of post-operative pain after surgical procedures. The risk factors were: (1) Age, (2) Gender, (3) Type of surgery performed, (4) Duration of surgical procedure, and (5) Intraoperative analgesic amount.[10, 11] Propensity matching, 1: 1: 1 was carried out using the nearest-neighbor algorithm. Matchings with propensity score logits within the range of a standard deviation of 0.2 were included.[12]

All analyses were limited to patients compatible with this propensity set. Following propensity score matching, we were left with three groups with containing 30 patients each. The groups of patients were determined as serratus anterior plane block, rhomboid intercostal block, and non-block (Figure 1).

Outcome measures

The primary outcome was determined as a tramadol consumption amount (at hours 6, 12, and 24). Secondary outcomes were determined as the VAS score (at post-operative min: 30, post-operative hours: 2, 6, 12, and 24), the distribution of sensory block level, the side effects (nausea and vomiting, itching, and hypotension), the need for additional analgesia, and distribution of the sensory block.

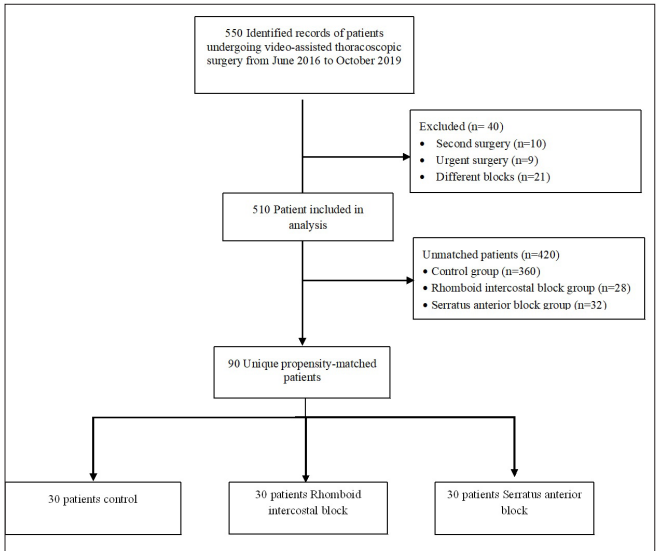

Figure 1. Flow diagram of case selection

Statistical analysis

The data were analyzed using the IBM Statistical Package for the Social Sciences version 23.0 (IBM SPSS Corp.; Armonk, NY, USA) software package. The study data were assessed using descriptive statistics (frequency, percentage, mean, standard deviation, median, and min-max), and the qualitative data were compared with a Chi-square (c^2) test. Shapiro-Wilk tests were used to evaluate the normality of the distribution of data. A multiple regression analysis was used for propensity score matching. In case of abnormal distribution and non-homogenous distribution, a Kruskal-Wallis test was used for between-group comparisons. To establish the time point of the difference, the ANOVA posthoc test was used.

Values with a probability (*P*) less than $\alpha=0.05$ were considered significant and there was a difference between groups, higher values are considered insignificant and there is no difference between groups.

The sample size was calculated considering the tramadol consumption amounts at post-operative hour 24.[13] Analgesic consumption was estimated in the RIB patient group at an amount at least as much as the amount for the SAPB group. For a power of 85% ($\alpha=0.05$), this was calculated as 81 patients. In order to increase the effect size of the study, a grouping of 30 patients was made for each group; a total of 90 patients.

Results

A total of 90 post-matched patients who underwent VATS between June 2016 and October 2019 were evaluated retrospectively within the scope of the study (Figure 1). The Patient Characteristics after Propensity Score Matching are presented in Table 1.

When the total tramadol consumption in each group was compared, the highest consumption was identified in the Control group, with an average of 223 mg, and the lowest consumption was 68.5 mg in the RIB group. A comparison of Groups R and S with Group C in terms of tramadol consumption amounts at all measurement time points revealed statistically significantly lower values ($P < 0.005$) (Table 2).

The between-group VAS scores were found to be statistically significantly higher at all measurement time points in Group C than in Group R ($P < 0.005$). In a comparison of the R and S Groups, the VAS score was found lower in the rhomboid intercostal block group at hours 12 and 24 (Table 3).

The use of paracetamol as a recovery analgesia was required in 10 patients, with 1 in Group R, 2 in Group S and 7 in

Group C. There was no statistical difference between the groups ($P < 0.005$). The distribution of the sensory block at 30 minutes after the local anesthetic injection is presented in Figures 2 and 3.

Table 1. Comparison of the Demographic Characteristics of the Patients

	Group R (n=30)	Group S (n=30)	Group C (n=30)
Age (year)	45.6±10.8	46.3±11.2	45.9±10.6
BMI (kg/m^2)	25.3±3.6	25.9±3.4	26±3.7
Gender			
M/F	26/4	24/6	25/5
Amount of opioid given during operation (µg)	110±27	111.1±30	108.1±26
Duration of surgery (min)	99±22.7	103±32.7	102±27.6
Surgical side (L/R)	21/9	22/8	23/7
ASA status (I/II/III)	4/21/5	5/22/3	5/21/4
Surgical procedures			
Wedge resection	23	24	22
Lobectomy	6	4	6
Other	1	2	2

Median (Min; Max) values, BMI: body mass index; M: male; F: female; ASA: American Society of Anesthesiologists; µg: microgram; min: minute

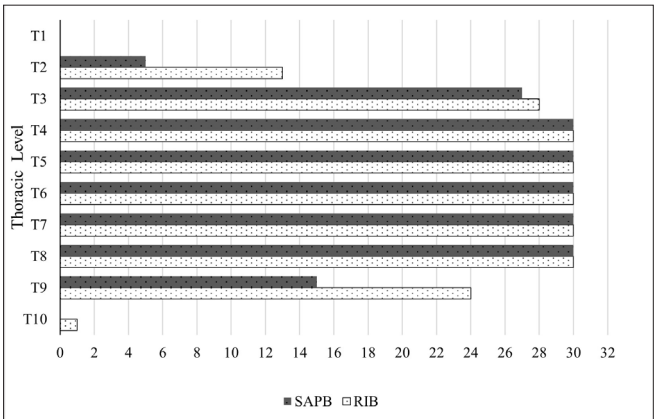

Figure 2. Cranio-Caudal sensory block spread

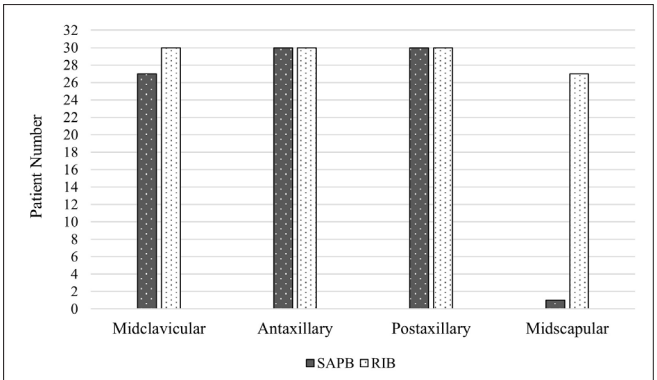

Figure 3. Postero-Anterior sensory block spread

Table 2. Tramadol Consumption in the first 24 h After Surgery, Side Effects, and Additional Analgesic Requirement

Tramadol consumption (mg)	Group R (n=30)	Group S (n=30)	Group C (n=30)	*P* Group R&S	*P* Group R&C	*P* Group S & C
6th hour	52.4 (32-76)	54.8 (32-96)	68.5 (48-96)	0.935	<0.001	0.004
12th hour	81.8 (48-144)	99.4 (40-192)	54.8 (32-96)	0.130	<0.001	<0.001
24th hour	122 (64-192)	151.3 (40-316)	223.2 (144-378)	0.165	<0.001	<0.001
Side Effects (patients)						
Nausea and vomiting	-	1 (3.3%)	1 (3.3%)	0.663	0.663	N/A
Pruritus	1 (3.3%)	-	-	0.442	0.442	N/A
Hypotension	1 (3.3%)	-	4 (13.3%)	0.835	0.205	0.63
Additional Analgesic Requirement	1 (3.3%)	2 (6.7%)	7 (23.3%)	0.057	0.085	0.322

Median (Min; Max), mg: miligram

Table 3. Comparison of VAS Scores for Different Groups

VAS	Group R (n=30)	Group S (n=30)	Group C (n=30)	*P* Group R&S	*P* Group R&C	*P* Group S & C
30th minute	2.3(0-5)	2.2(0-4)	4(3-5)	0.936	<0.001	<0.001
2nd hour	2.2(0-4)	2.5(1-4)	3.6(2-5)	0.493	<0.001	<0.001
6th hour	2.4(1-3)	2.6(1-4)	3(2-4)	0.968	<0.001	<0.001
12th hour	2(1-3)	2.7(1-5)	3.3(2-4)	0.002	<0.001	0.021
24th hour	1.86 (0-2)	2.93(1-4)	3(1-5)	<0.001	<0.001	0.205

VAS: Visual Analogue Scale; Median (Min; Max) values

Discussion

This study reports on a retrospective examination of the outcomes of the SAPB, RIB, and intravenous (IV PCA) tramadol infusion techniques that are used for post-operative analgesia in patients undergoing VATS procedures. The amount of tramadol consumption and the VAS score were found to be statistically significantly lower in the SAP+IV PCA and RİB+IV PCA groups when compared to the tramadol alone group. There was no difference in the tramadol consumption of the SAPB and RIB groups during their 24-hour follow-up, whereas the VAS scores at hours 12 and 24 were statistically significantly lower in the RIB group.

Although VATS is a less invasive method, and post-operative pain following VATS is lower than that associated with thoracotomy, analgesia is still an important issue.[14] For post-VATS analgesia, regional anesthetic techniques, such as thoracic epidural analgesia, paravertebral block, and intercostal block are used alone or intravenously as a part of a multimodal analgesia approach.[15] With the increased use of ultrasound in regional anesthesia, the fields of application for interfascial plane blocks have extended and different methods have emerged. Blanco et al.[5] described a new regional block technique for thoracic wall analgesia in 2013. To date, SAPB has been used in several studies related to the thoracic wall (breast surgery thoracotomy, VATS, etc.), as a part of a multimodal analgesia approach.[8] There are several studies in the literature investigating the use of SAPB for post-VATS analgesia. Although the results of such studies designed as a randomized-controlled trial (RCT) appear to be similar, the block techniques and local anesthetic doses are different.[13,16,17] In a placebo-controlled study by Kim et al.[16], lower VAS scores and opioid consumption were reported in block-performed patients at the first post-operative 6-hour follow-up, while the VAS scores of the SAPB group patients were similar to those of the control group at the 24-hour follow-up, although opioid consumption was lower. Similar to the study by Kim et al.[16], a study of 42 patients identified lower VAS scores at the first 6-hour follow-up, and the authors reported that the opioid consumption was lower in the serratus anterior block group at the 24-hour follow-up.[17] Both studies garnered similar results, although there was a difference in the injection sites of the local anesthetic. The local anesthetic injection can be administered beneath the area between the serratus muscle and intercostal muscle, although some studies have used the fascial area between the serratus muscle and the latissimus dorsi muscle.[8,13,16,17] Another RCT involving an injection beneath the serratus anterior muscle provided no details of the level of sensory block, but reported lower opioid consumption and VAS scores in the SAPB group in all of the 24-hour follow-up results.[13] Although serratus anterior plane block applications have been used for post-operative analgesia in various surgical procedures in literature, some factors are limiting the discussion of the subject. The first of these is the difference in the fascial planes to which the injection was administered in the studies. In a review by Chong et al.[8], it was reported that it is possible to obtain similar outcomes from injections above or below the serratus muscle. Secondly, the local anesthetic agent used may be different in terms of dose and the contain adjuvant.[16] It is apparent that medications administered in different doses provided similar analgesic effects in similar surgical procedures. In this study, 25 ml LA was injected into the fascia between the serratus muscle and the intercostal muscle. Previous studies in the literature reported lower 24-hour opioid consumption in the serratus anterior block group than in the control group.[13,16,17] Unlike our study, two studies established a difference in VAS scores at the measurement points after the first 6 hours when compared to the control groups.[16,17] We believe that these differences may be attributed to such factors as the use of additional analgesics other than PCA, and the type and duration of the surgical procedure.[16,17]

The RIB block, which was introduced more recently than the serratus anterior plane block as a thoracic wall analgesia, has been reported to provide wider analgesia than SAPB[6]. In SAPB, the local anesthetic is distributed along the plane through which the lateral branches of the intercostal nerves between serratus muscle and intercostal muscle pass. Accordingly, SAPB may provide analgesia more to the lateral thoracic wall, and to a lesser extent, to the anterior and posterior wall[6]. RIB, in turn, is administered to the fascial area between the rhomboid major muscle and the intercostal muscle–known as the triangle of auscultation[6]. With a local anesthetic injection, it has been reported to provide a wider sensory block to the lateral and posterior thoracic wall relative to SAPB.[6]

The literature contains several case series, case reports, and randomized controlled study (RCT) seeking to establish the efficacy of RIB. In a series of five diseases, patients undergoing a thoracotomy were fitted with a catheter after an RIB, and the approach was concluded to be applicable based on post-operative pain scores.[18] In another case report, analgesia was provided after scapular surgery to the posterior thorax.[19] The analgesia provided at the dermatomal levels of Thoracic 2 and Thoracic 10 after this block, and the ability to provide analgesia to the anterior, lateral, and posterior thorax, were the outcomes of the case reports.[20-22] In the RCT by Altıparmak et al.[23], rhomboid intercostal block (RIB) was used for analgesia after radical mastectomy operation. In this study of 56 cases, it was reported that it caused improved healing quality and lower opioid use when used as part of multimodal analgesia.

In this study, analgesia was provided at the dermatomal levels of T3 and T10, covering the lateral and posterior thorax, in the RIB group. It was observed that analgesia was provided in more areas than in the SAPB group. We believe that RIB, which we concluded provided wider analgesia.

Since the sources of pain after thoracic surgery are not limited to the surgical incision (muscle pain due to the surgical position, pain due to the chest tube, etc.), RIB is likely to result in lower VAS scores at postoperative 12 and 24 hour follow-up.

Study limitations

This retrospective study has some limitations. Although the use of propensity score matching reduced the risk of bias and increased the validity of the analysis, psychological factors that have a potential impact on post-operative pain were not excluded. Furthermore, the data garnered from the study is limited to a specific operation, VATS, and cannot be generalized to other operations involving the thoracic wall. One of the major complications associated with SAPB and RIB fascial plane blocks is pneumothorax. The presence of a chest tube in all patients after the operation was a limiting factor in the establishment of complications. In addition, another limitation of our study is that the sensory block evaluation is limited to the post-operative 30th minute.

Conclusion

This study found lower opioid consumption at 24-hour follow-up in the RIB and SAPB groups when compared to the non-block group. Although both methods seem applicable for post-VATS pain palliation, we believe future studies will increase the levels of response, especially to RIB and SAPB.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Bursa Yuksek Ihtisas Training and Research Hospital Ethics Committee (decision number 2011-KAEK-25 2019/10-06).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – K.Ö.; Design – K.Ö., M.K.; Supervision – K.Ö., M.K.; Resources – K.Ö., M.K.; Materials – K.Ö., M.K.; Data Collection and/or Processing – K.Ö.; Analysis and/or Interpretation – K.Ö., M.K.; Literature Search – K.Ö.; Writing Manuscript – K.Ö.; Critical Review – K.Ö., M.K.; Other – K.Ö., M.K.

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

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