Unilateral rhomboid intercostal and subserratus plane block application for analgesia after laparoscopic cholecystectomy surgery :a quasi-experimental study

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Running Title: RIIS in laparoscopic cholecystectomy

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Abstract

**Background:** Interfascial plane block applications can be used for postoperative pain after laparoscopic surgery. We aimed to investigate the effect of ultrasound-guided unilateral rhomboid intercostal and subserratus plane (RISS) block after laparoscopic cholecystectomy operations on the amount of analgesic use.

**Methods:** 50 patients underwent laparoscopic cholecystectomy were included in the quasi-experimental study. Patients meeting the criteria were analyzed in two groups as experimental group (RISS block with 20 ml %0.25 bupivacaine+intravenous patient-controlled analgesia (IV-PCA) tramadol; n = 25) and group Control (IV-PCA tramadol; n = 25). The primary outcome was the total amount of tramadol used over 24 hours. Secondary outcomes included the side effects, additional analgesic use and postoperative pain (during rest and activity) was at the 2nd, 6th, 12th, and 24th hours using the NRS scores.

**Results:** Postoperative tramadol consumption at the 24 hours was significantly lower in the Group RISS than the Group Control (p<0.001). The resting NRS scores at the 2nd and 6th hours were statistically significantly low in the Grup RISS. The NRS scores during movement in Grup RISS were significantly low at the postoperative 2nd, 6th, and 12th hours. There was no statistically significant difference in the rate of side effects and additional analgesic use between the groups (p>0.05).

**Conclusions:** In conclusion, unilateral RISS block is an effective method for pain management after laparoscopic cholecystectomy and can be used as a part of multimodal analgesia.

**Keywords:** Laparoscopic Cholecystectomy; Postoperative Pain; Nerve Block; Ultrasonography; Bupivacaine; Pain; Pain Management; Analgesia
Introduction

Laparoscopic gallbladder surgeries are the preferred techniques over open surgical procedures because of their various advantages, including reduced bleeding, lower surgical site infection rates, decreased costs, shorter hospital stay, earlier return to the daily routine, and enhanced recovery [1,2]. Despite all these advantages of laparoscopic surgeries, early postoperative pain is displeasing, even can lead to prolonged hospital stays [3]. Pain transmission after abdominal surgery is provided by the cutaneous branches of the thoracolumbar T6-L1 nerves in the anterolateral region [4,5]. Multimodal analgesia regimens are used for postoperative analgesia after abdominal surgery, including laparoscopic cholecystectomy. For this purpose, short-acting opioids, NSAIDs, and regional anesthesia techniques are used in combination.

The main causes of early pain after laparoscopic cholecystectomy are peritoneum and abdominal wall distension due to pneumoperitoneum and somatic pain in the trocar insertion sites [4,5]. The effective use of truncal blocks such as erector spinae plane or quadratus lumborum block has been demonstrated for postoperative pain management in laparoscopic cholecystectomy surgeries [6-8].

Rhomboid intercostal and subserratus (RISS) block provides analgesia from the third to 12th thoracic dermatomes and has been used in postoperative pain management for thoracic surgeries [7,8]. Although it is used for postoperative analgesia after upper abdominal surgery, there are no adequate studies on its use in laparoscopic cholecystectomy operations [7,8]. Theoretical target dermatomes (T3-T12) of the RISS block may include areas that cause pain in laparoscopic cholecystectomy operations, including trocar insertion sites. It has been suggested in several reports that incisional pain can be predominant than visceral pain during the postoperative 48 hours [1,9].
Therefore, in this study, we aimed to evaluate the effect of unilateral RISS block on postoperative analgesic consumption in laparoscopic cholecystectomy surgeries.
Material and Methods

Patient selection

The quasi-experimental study was conducted in 120 patients who underwent laparoscopic cholecystectomy between 2018-2020, following the approval of the institutional ethics committee (IEC # 2020-01-19). The patients aged 20 to 65 with American Society of Anesthesiology physical status I and II were included in the study. Patients with bleeding disorders, mental incapacity, known allergy to the local anesthetics, and body mass index ≥35 kg/m² were excluded from the study. Informed consent was obtained from all individual participants included in the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 2013 Helsinki declaration and its later amendments or comparable ethical standards.

Fifty patients meeting the study criteria were sampled as the experimental group (RISS block and (intravenous patient-controlled analgesia (IV PCA); tramadol administered; n = 25) and the control group (IV PCA only; tramadol; n = 25) using the non-probabilistic sampling method (Figure 1).

Anesthesia: After the routine monitoring in the operating room, general anesthesia was induced with fentanyl (1-2 µg/kg), propofol (1-2 mg/kg), and rocuronium (0.8-1 mg/kg). Anesthesia was maintained with inhaled sevoflurane 3-5% and air and oxygen mixture 2.5-3 L/min. Fentanyl 1-2 mg/kg was repeated during the surgery when needed.

Surgery: The surgical procedure was held with the same surgery team by using the four-port technique. The four ports were placed through the umbilicus, epigastric place (under the xiphoidal process), right lateral subcostal position (the intersection point of the costal arch and anterior axillary line), and right subcostal-midclavicular line. The intraabdominal pressure was never exceeded 14 mmHg.
Pain management: The patients in the preoperative RISS block group underwent procedures with a linear probe (10-18 MHz, MyLab30; Esaote, Florence, Italy) in the lateral decubitus position under standard monitoring (American Society of Anesthesiologists) in the block room, as previously described.

Rhomboid intercostal block: A high-frequency linear probe was placed in a sagittal plane to the medial border of the scapula and then rotated counter-clockwise to acquire a paramedian sagittal oblique image 1-2 cm medial to the scapular edge. A 22-gauge 100-mm block needle was inserted craniocaudally with an in-plane technique. After confirming the right placement of the needle tip by hydro-dissection, 10 mL of 0.25% bupivacaine was placed in the plane between the rhomboid major and intercostal muscles [7,8] (Figure 2).

Subserratus block: The ultrasound probe was slid down inferolateral to identify the serratus anterior muscle at the level of T6 to T9. After confirming the needle position, 10 mL of 0.25% bupivacaine was injected between the serratus anterior and intercostal muscles [7,8] (Figure 2). All patients received tenoxicam 20 mg intravenously 30 minutes before the end of the surgery. Postoperative pain management in the surgical ward was maintained with intravenous patient-controlled analgesia (PCA) device with the same setting for all patients. The PCA device gave a bolus dose of 25 mg tramadol on demand (max dose of 400 mg/day), with a lock-time of 30 minutes and no basal infusion. Paracetamol 1 g was administered as rescue analgesia. The pain was assessed on a 10-point Numeric Rating Scale (NRS) ranging from 0 (no pain) to 10 (worst pain imaginable).

Outcome measure:
The primary outcome measure of the study was to evaluate the total tramadol consumption at the end of the 24 hours. The secondary outcome measure were to assess the total amount of opioids administered intraoperatively, postoperative NRS scores at rest and during movement (2nd, 6th, 12th, and 24th hours), sensorial dermatomal block-level (30 minutes after the block administration.
and at the postoperative 2nd hour), rescue analgesic consumption, and postoperative nausea and vomiting. During movement, the postoperative NRS scores were evaluated while coughing or during in-bed movements at the 2nd hour and after taking five steps forward at the 6th hour. Patients were asked if they feel pain at the port sites at the postoperative 2nd hour.

Statistical analysis:

Statistical analyses were performed using the computerized statistical software IBM SPSS Statistics for Windows 2013, version 22.0 (Armonk, NY: IBM Corp.). The normality of the data distribution was evaluated using the Kolmogorov-Smirnov test. For the intergroup comparison of the categorical data, the Chi-square test was applied, and the Mann-Whitney U test was used for the continuous variables. A p-value <0.05 was considered statistically significant.

Power Analysis: In the results of previous studies, the postoperative 6th-hour tramadol consumption were found to be 59.7± 13.7 in the patients used IV PCA (tramadol) [10]. In this study a 20 % decrease in postoperative 6th hour tramadol consumption was expected in the RISS block group. In order to obtain a study power of 85% (α = 0.05), 25 patients per group for the required sample size, a total of 50 patients were calculated.
Results

The demographic variables were presented in Table-1. There were no statistically significant differences among groups in terms of age, BMI, and surgery duration. Postoperative tramadol consumption at the 24 hours was significantly lower in the Group-RISS 89 (50-175) mg than the Group-Control 142 (50-275) mg (p<0.001) (Figure 3). The resting NRS scores at the 2nd and 6th hours were statistically significantly low in the Group -RISS. There was no significant difference in the other measurements (Table 2). The NRS scores during movement in Group-RISS were significantly low at the postoperative 2nd, 6th, and 12th hours (Table 3). There were no differences between the study groups regarding intraoperative opioid requirement, postoperative nausea and vomiting, and paracetamol consumption (Table 4).

Evaluation of the RISS blocks levels: Preoperative sensory block level was tested with alcohol-soaked cotton swabs as the loss of sensation to cold 30 minutes after the RISS block. The loss of sensation was achieved at the T4-T12 dermatomes in 5 patients, T5-T10 in 13 patients, T6-T9 in 5 patients, and T7-T10 in 2 patients. Five patients had sensory blocks reaching the anterior midline (Figure 4). The postoperative evaluation revealed that ten patients felt discomfort on the umbilical port insertion site, and 13 patients felt pain on the epigastric port insertion site (Figure 4).
Discussion

This study investigating the analgesic effect of unilateral RISS block after laparoscopic cholecystectomy operation showed less tramadol consumption in the RISS block group during the postoperative 24-hour follow-up. The RISS block group was found to have low NRS scores at rest until the 6th hour and low NRS scores on movement in the 12-hour follow-ups.

Pain after laparoscopic cholecystectomy necessitates the use of multimodal analgesia methods due to its somatic and visceral components [1,9]. Visceral pain due to laparoscopic cholecystectomy emerges due to pneumoperitoneum and surgical manipulation of the gallbladder bed. Thus, visceral pain can be reduced with shorter surgery times and creating a pneumoperitoneum with lower pressures [11]. However, somatic pain due to the trocar entry incisions has been suggested to be the main cause of the early pain after laparoscopic gallbladder surgery [9].

The rhomboid intercostal block was previously used for pain management in thoracic wall surgery. However, it was later modified by Elsharkawy et al. and used together with the subserratus plane block in the treatment of post-abdominal surgery pain, and the combination of the two blocks was renamed as the RISS block [7,8,12]. The RISS block with 30mL of local anesthetic has been successfully used in transapical transcatheter aortic valve implantation [13]. In another report of the case series, RISS block with 20 mL of local anesthetic was used for pain management of multiple rib fractures, and the authors indicated that local anesthetic could spread to ventral and dorsal radices of the intercostal nerves [14]. Elsharkawy et al. presented their study in which RISS blocks were performed on six fresh unembalmed cadavers and 15 patients with different indications, including upper abdominal surgeries [7]. They demonstrated the lateral branches of the intercostal nerves were dyed from T4 to T8 in all cadavers, and in the clinical part of their study, they observed the most cephalocaudal extent of the sensory loss to cold was from T2 to T12 [7]. In a report of 21
patients undergoing abdominal surgery, the RISS blocks provided analgesia at the dermatomes varying from T3 to T12 with a high patient satisfaction rate [8].

The nerves targeted by the RISS block are basically the lateral cutaneous branches of the ventral branches of the thoracic intercostal nerves located between the rhomboid muscle and the intercostal muscles and deep into the scapula serratus anterior muscle. In addition, it has been reported that 2 different mechanisms may be effective in analgesia. The first of these is that local anesthetic agents may affect the dorsal rami of the thoracic intercostal nerves at the point where the erector spinae muscle originates from the thoracic transverse processes at T3-T9 levels through a medial spread in the tissue plane. Second, the authors hypothesized that local anesthesia may also spread into the paravertebral space due to its spread under the erector spinae muscle [8].

In our study, the dermatomal coverage of the RISS blocks performed was consistent with the literature. The most cephalad extent of the block was T4, and the most caudal extent was T12 dermatomes. The sensory loss was present at the medial and lateral areas, whereas only five patients had a sensory block at the midline of the abdominal wall. Limited studies are presenting the efficacy of unilateral regional blocks after laparoscopic abdominal surgeries. Binzer et al. revealed a significant decrease in pain scores after unilateral quadratus lumborum blocks for laparoscopic cholecystectomy surgeries [15]. In another study, subcostal transversus abdominis plane blocks were found to significantly lower postoperative opioid consumption than local anesthetic infiltration to port sites after laparoscopic cholecystectomy [16].

In the present study, unilateral RISS blocks were effective methods to reduce pain scores and opioid consumption after laparoscopic surgeries. The RISS blocks appear to be good choices as a part of multimodal analgesia for not only thoracic but also upper abdominal surgeries. Compared to central blocks, the RISS blocks are less invasive and associated with fewer complications such as nerve damage, hemodynamic instability or bleeding [8].
The broadest analgesic efficacy detected for RISS block is between thoracic 3 and thoracic 12 dermatomes. Trocar insertion sites for laparoscopic cholecystectomy surgery concern thoracic 6 and thoracic 10 dermatomes. It was thought that analgesia could be provided in these dermatomes with RISS block. Apart from this, we are of the opinion that potential mechanisms of action of RISS block such as the paravertebral spread of local anesthetics, ventral rami blockade of intercostal nerves, and neuronal structures in the anatomical structure of the fascia, which we have attempted to mention in the article, may be effective in analgesia. Several reports commented on the RISS block mechanism, but its paravertebral extension still has been a debate. The marked result of the present study is that five patients had sensory blocks extending to the abdominal midline. Nevertheless, except for these five patients in the RISS block group ten patients with no sensory block in the midline were not bothered by pain from the umbilical port site. We are of the opinion that this may be due to the anatomical structure of the fascia, which is considered for the efficacy of interfascial blocks. It is thought that, apart from the intercostal nerve block, the sensory innervation of the fascia and the presence of sympathetic nerve endings may play a particular role in the efficacy of interfascial blocks [17,18]. Animal studies have immunohistochemically demonstrated free nerve endings of Thoracolumbar fascia and the presence of Ruffini and Pacinian corpuscles [19]. Another animal study found that dorsal horn neurons became prominent with the stimulation of these receptors, and a different study on humans found that interfascial injection of saline (0.9%) created burning and throbbing-like symptoms known to be transmitted by A and C fiber nociceptors [20, 21]. Similar results and considerations have been shared in studies using the interfascial injection technique for the treatment of myofascial pain syndrome [22-24]. Stecco et al. also reported that the proprioception and nociception properties of the fascial system were shown through Aδ, C, and postganglionic sympathetic fibers. Despite the limited literature information, the
current data indicate that the anatomical structure of the fascia may play a role in the efficacy of interfascial blocks [25].

The lack of randomization and the small cohort of subjects are limitations of this study. Another limitation of this study is that no adjuvant drugs were used.

The RISS block procedures are new techniques and we think that long-term follow-up of these block techniques is not yet sufficient. Although there are studies using adjuvant in the literature, we did not add adjuvants to local anesthetic drugs in this study because we did not use them in our clinical practice.

In conclusion, unilateral RISS block is an effective method for pain management after laparoscopic cholecystectomy and can be used as a part of multimodal analgesia.
References


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<table>
<thead>
<tr>
<th></th>
<th>Group RISS (n = 25)</th>
<th>Group Control (n = 25)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (year)</strong></td>
<td>51.6(36-62)</td>
<td>51(35-65)</td>
<td>0.784</td>
</tr>
<tr>
<td><strong>BMI(kg/m^2)</strong></td>
<td>24.1(21.57-28.00)</td>
<td>23.4(21.3-27.3)</td>
<td>0.234</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>M/F 17(%68)/8(%32)</td>
<td>15(%60)/10(%40)</td>
<td>0.769</td>
</tr>
</tbody>
</table>

Median(Min-Max) values

BMI:body mass index M: male, F: female
Table 2. Comparison of NRS scores at rest between groups

<table>
<thead>
<tr>
<th>NRS (at rest)</th>
<th>Group RISS (n = 25)</th>
<th>Group Control (n = 25)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd hour</td>
<td>1.7(0-6)</td>
<td>2.68(1-6)</td>
<td>0.004</td>
</tr>
<tr>
<td>6th hour</td>
<td>1.6(0-5)</td>
<td>2.5(1-6)</td>
<td>0.022</td>
</tr>
<tr>
<td>12th hour</td>
<td>1.96(0-5)</td>
<td>2(1-6)</td>
<td>0.635</td>
</tr>
<tr>
<td>24th hour</td>
<td>0.96(0-6)</td>
<td>1 (1-6)</td>
<td>0.621</td>
</tr>
</tbody>
</table>

Median(Min-Max) values for abnormal distribution

NRS: numerical rating scale

Mann Whitney U test for the inter-group comparisons.

Bold and italic numbers indicates significance at p < 0.05
Table 3. Comparison of NRS scores at movement between groups

<table>
<thead>
<tr>
<th>NRS (at movement)</th>
<th>Group RISS (n = 25)</th>
<th>Group Control (n = 25)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2^{nd} hour</td>
<td>2.7 (0-6)</td>
<td>5.1 (3-7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>6^{th} hour</td>
<td>2 (0-5)</td>
<td>4 (0-7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>12^{th} hour</td>
<td>1.8 (0-3)</td>
<td>3.2 (0-6)</td>
<td>0.014</td>
</tr>
<tr>
<td>24^{th} hour</td>
<td>1.9 (0-4)</td>
<td>1.9 (0-5)</td>
<td>0.861</td>
</tr>
</tbody>
</table>

Median(Min-Max) values for abnormal distribution

NRS: numerical rating scale

Mann Whitney U test for the inter-group comparisons.

Bold and italic numbers indicates significance at p < 0.05
Table 4. Side effects, Additional Analgesic Requirement, Duration of surgery (min).

<table>
<thead>
<tr>
<th></th>
<th>Group RISS (n=25)</th>
<th>Group Control (n=25)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Effects nausea and vomiting</td>
<td>-</td>
<td>-</td>
<td>N</td>
</tr>
<tr>
<td>Additional Analgesic Requirement</td>
<td>1</td>
<td>3</td>
<td>0.186</td>
</tr>
<tr>
<td>Duration of surgery (min)</td>
<td>51 (40-67)</td>
<td>49 (40-60)</td>
<td>0.497</td>
</tr>
<tr>
<td>Amount of opioid given during operation (µg)</td>
<td>76 (60-110)</td>
<td>81 (60-150)</td>
<td>0.726</td>
</tr>
</tbody>
</table>

Median(Min-Max) values
Figure legends

**Fig 1:** Flow diagram

**Enrollment**
- Assessed for eligibility (n=120)
- Excluded (n=70)
  - Not meeting inclusion criteria (n=10)
  - Declined to participate (n=25)
  - Allergy to local anesthetics (n=35)
- Non-randomly allocated (n=50)

**Allocation**
- Experimental group
  - RISS block and intravenous patient-controlled analgesia
    - Allocated to intervention (n=25)
- Control group
  - Intravenous patient-controlled analgesia
    - Allocated to intervention (n=25)

**Follow-Up**
- Follow-up (n=25)
- Follow-up (n=25)

**Analysis**
- Analysed (n=25)
- Analysed (n=25)

**Fig. 1.** Flow Diagram
Fig. 2. Ultrasound image depicting the unilateral rhomboid intercostal and subserratus plane block. a: subserratus block, LDM: latissimus dorsi muscle. b: rhomboid intercostal block. ICM: intercostal muscle, white arrows: ultrasound visible block needle, white star: local anesthetic spread under the interfascial plane.
Fig. 3. Total tramadol consumption at the postoperative 24th hour.
**Fig. 4.** Dermatomal dispersion of sensorial block to the cold stimulus.

White triangle (light blue area): the widest area of the sensory extent of the block T4-T12 in 5 patients and anterior midline in 5 patients. White star (dark blue area): the most detected sensory level – T5-T10 in 13 patients. White circle: port insertion sites.