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Analgesic effect of combined transversus abdominis plane block and rectus sheath block in laparoscopic cholecystectomy: prospective randomized study

Ibrahim Hakki Tor¹, Erkan Cem Çelik^{2*}  and Muhammed Enes Aydın²

Abstract

Background: We aimed to investigate the combination of the subcostal transversus abdominis plane block and rectus sheath block (ScTAP-RS) versus wound infiltration on opioid consumption and assess effects on pain scores in laparoscopic cholecystectomy (LC). One hundred patients scheduled for LC were included in this study following the local ethics committee approval. Patients were randomized and divided into two groups as group ScTAP-RS and wound infiltration group (group I). After the surgical intervention, in group ScTAP-RS, ScTAP-RS block with 30 ml 0.25% bupivacaine solution was administered by ultrasound, and in group I, 20 ml 0.25% bupivacaine solution was injected in three port incision sites. Patient-controlled analgesia with tramadol was programmed for 24 h postoperatively. Tramadol consumptions and visual analog scale (VAS) scores were evaluated.

Results: Compared to the infiltration group, total tramadol consumption was significantly lower in the ScTAP-RS group between 4 and 12 h. There was no statistically significant difference between the groups in other time intervals. VAS scores were significantly lower in the ScTAP-RS group in the 4th and 8th hours at rest and ambulation. There was no statistically significant difference between the groups for VAS scores at other time intervals.

Conclusion: ScTAP-RS blocks decrease the opioid consumption and pain scores compared to the local infiltration after LC.

Keywords: Laparoscopic cholecystectomy, Postoperative pain, Infiltration anesthesia, Transversus abdominis plane block, Rectus sheath block

Background

Laparoscopic cholecystectomy (LC) is the gold standard in many health centers as it is less invasive compared to open cholecystectomy (Amreek et al., 2019). In the USA, 90% of the cholecystectomies are implemented with the laparoscopic technique (Csikesz et al., 2010). Postoperative pain, length of stay, and other surgical complications are minimized by laparoscopic surgery (Prasad & Foley,

1996; Qu et al., 2019). Even though the size of the incisions is relatively small, severe somatic pain may emerge in the anterior abdominal wall following LC. This pain may change its character depending on the number and sites of the ports (Bisgaard et al., 2001). Besides, peritoneal distention and diaphragm irritation because of high intra-abdominal pressure and insufflations cause visceral pain (Tulgar et al., 2018).

After LC, non-steroidal anti-inflammatory drugs, gabapentinoids, intravenous patient-controlled analgesia (PCA), central analgesic interventions, local infiltration analgesia, and regional blocks are usually performed for

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the control of the postoperative pain (Mitra et al., 2012). Current rational analgesia management guidelines recommend opioids only if needed and encourages the usage of multimodal analgesic methods, which can decrease the use of postoperative opioids (Wick et al., 2017).

Transversus abdominis plane block (TAP) is one of the preferred analgesia methods in abdominal anterolateral wall surgeries (Jakobsson et al., 2015). The TAP block is administered between the internal oblique muscle and the transverse abdominal muscle. It provides adequate analgesia in the anterior abdominal wall through the ventral branches of the nerve roots, which is divided into the ventral and dorsal rami after originating from the medulla spinalis (Chin et al., 2017). Compared to the TAP implemented between the costal margin and iliac crest in the sidewall of the abdomen, the analgesic effect can be increased in the interventions at upper levels like cholecystectomy with the subcostal TAP (ScTAP), which is performed at the junction of the costal arch and midclavicular line (Chin et al., 2017; Khan & Khan, 2018). Several studies demonstrated that the ScTAP block decreased the pain scores and the analgesic consumption and improved patient satisfaction in the postoperative period (Tolchard et al., 2012; Shin et al., 2014; Bhatia et al., 2014). On the other hand, the rectus sheath (RS) block is administered between the rectus muscles, which form the middle wall of the abdomen, and the posterior rectus sheath. This technique provides adequate analgesia in the middle wall of the abdomen through the block of the terminal branch of the ventral ramus (Jeong et al., 2019). Clinical studies showed that the combination of RS block and ScTAP or conventional TAP provides adequate analgesia in LC (Abdelsalam & Mohamdin, 2016; Ramkiran et al., 2018).

In this study, our primary aim was to investigate the effects of the rectus sheath and unilateral subcostal TAP block versus trocar site injection on the opioid consumption in patients undergoing laparoscopic cholecystectomy. Our secondary objective was to investigate the pain scores, rescue analgesia, and side effects.

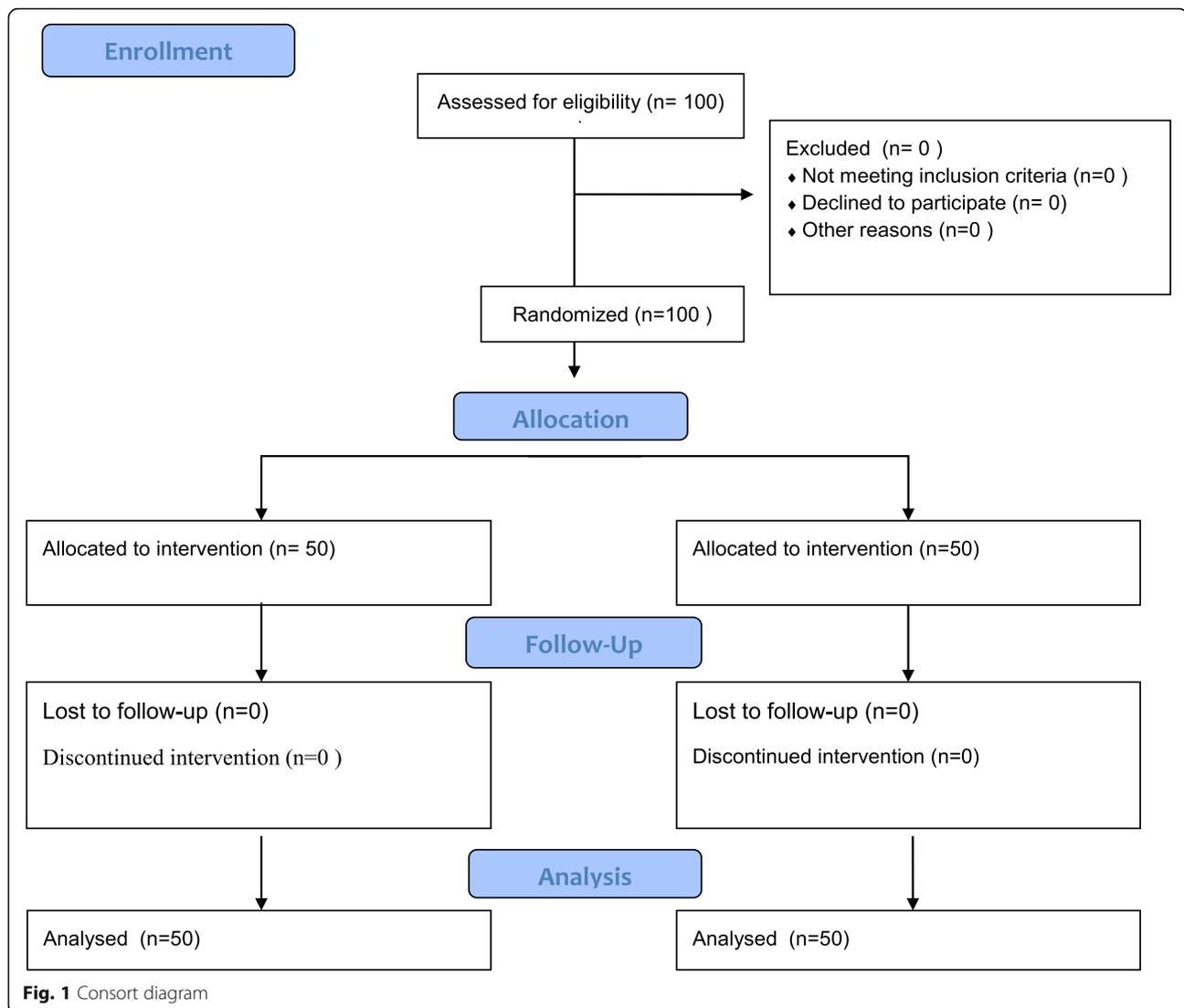
Methods

One hundred patients between the age of 18 and 65 years, ASA I-II scheduled for elective LC, were included in the study following the approval of the local ethics committee. Patients with known cardiac, renal, hepatic and hematological diseases, peptic ulcer, gastrointestinal bleeding, chronic pain, chronic use of analgesic agents, central or peripheral neurological disorder, use of anti-coagulant agents, allergy to the medication used in the study, and pathological obesity (BMI > 35) and poor cooperation were excluded from the study. Demographic data were recorded including age, body mass index

(BMI), gender, ASA score, the duration of surgery, duration of anesthesia, duration of pneumoperitoneum, and pathologic diagnosis (Fig. 1).

Institutional ethical committee approval number BEAH KAEEK 2018/20-210 was obtained from local ethics committee of a Regional Training and Research Hospital in east of Turkey, on December 17, 2018. A written informed consent was obtained from each participating patient and written informed consent was obtained from patients' legal guardian(s) after the description of the procedure and its potential complications. Patients were recruited between January and April in 2019 in a regional training and research hospital in the east of Turkey. The included patients were randomized and divided into two groups as subcostal transversus abdominis plane block and rectus sheath block (group ScTAP-RS) and wound infiltration group (group I) by a computer program. Both groups received propofol (2 mg/kg), fentanyl (1–2 mcg/kg), and rocuronium (0.6 mg/kg) for the induction of anesthesia. A mixture of sevoflurane, 50% O₂, and 50% air was used for the anesthesia management at MAC 1. In both groups, three trocar incisions were carried out for a total of 3 ports (umbilical port, subxiphoid port, and right subcostal port). LC was performed with the same technique in all patients. LC was performed with CO₂ pneumoperitoneum at 12 mmHg pressure with three trocar techniques. After the surgical intervention, in group ScTAP-RS, right unilateral ScTAP block and bilateral RS plane block were administered using a high-frequency linear ultrasound (US) probe (MyLabOne, Esaote Co., Genova, Italy). A 22-G 100-mg ultrasound-visible block needle (Stimuplex® B-Braun medical, Melsungen, Germany) was inserted at the junction of the right costal arch and midclavicular line under ultrasonographic guidance. The space between the internal oblique muscle and transverse abdominal muscle was visualized, and 20 ml of the 0.25% bupivacaine solution was injected. Besides, bilateral rectus muscles were scanned with the US probe, which was placed on the linea alba above the umbilicus, and 10 ml of the 0.25% bupivacaine solution was bilaterally injected between the rectus muscle and posterior rectus sheath following the access to the right and left rectus muscles with the in-plane technique on the lateral side (Hebbard, 2015). In group I, a total of 20 ml of the 0.25% bupivacaine solution was injected in three incision sites, which were opened for the umbilical, subxiphoid, and right subcostal ports, for the wound infiltration analgesia after surgery. Granisetron 3 mg was infused over 5 min and 30 min before the completion of the surgical process.

After surgery, 0.04 mg/kg neostigmine and 0.02 mg/kg atropine were injected to antagonize the muscle-relaxing effect of anesthesia. Following the extubation, patients



were referred to the post-anesthetic recovery unit. In all patients, LC was performed by the same surgical team with the same technique.

Postoperative analgesia

In both groups, 50 mg tramadol and 800 mg ibuprofen were administered 30 min before the completion of the surgical process. During the postoperative period, patient-controlled analgesia with tramadol (PCA) was programmed (tramadol concentration: 2 mg/ml; 20 min lockout interval, and 15 mg bolus, maximum 400 mg) for 24 h without basal infusion. Tramadol consumption in the PACU, 1st, 2nd, 4th, 8th, 12th, and 24th hours, and visual analog scale (VAS) scores were evaluated and recorded at rest and ambulation. VAS with ambulation was evaluated by a semi-sitting movement. Patients were evaluated in the PACU for only half an hour. Then, they were transferred to the

related ward. Intravascular 25 mg meperidine was administered to patients with a VAS > 4 as rescue analgesia. In PACU, patients with a modified Aldrete score > 8 were referred to the related ward. The postoperative follow-up and evaluations were done by an investigator who was blind to the treatments performed to the groups.

Sample size

The sample size calculation was done with the G*Power version 3.1.9.2 (Kiel University, Kiel, Germany) software with Student's *T* tests post hoc analysis. The power analysis performed with postoperative total opioid consumption variable, which was the primary outcome of the study showed that the effect size was 0.56 in the alpha of 0.05 and the power of 0.80 with 50 patients for groups. This result indicated that the study sample size was sufficient.

Table 1 Demographic datas and comparison of duration times between group ScTAP-RS and group I

| | Group ScTAP-RS (n, 50) | Group I (n, 50) | p |
|---------------------------------|------------------------|-----------------|--------------------|
| Age (years) | 46.68 ± 12.46 | 45.78 ± 10.50 | 0.697 ^a |
| BMI | 28.26 ± 3.51 | 27.99 ± 3.62 | 0.704 ^a |
| Gender (M/F) | 24/26 | 25/25 | 1.000 ^β |
| ASA (I/II) | 40/10 | 37/13 | 0.635 ^β |
| Surgery duration (min) | 45.34 ± 17.48 | 49.94 ± 17.75 | 0.195 ^a |
| Anesthesia duration (min) | 62.28 ± 19.14 | 64.06 ± 17.82 | 0.631 ^a |
| Pneumoperitoneum duration (min) | 16.62 ± 2.35 | 17.03 ± 2.40 | 0.183 ^a |
| Pathologic diagnosis | | | |
| Chronic cholecystitis | 37 | 30 | |
| Gallbladder polyp | 3 | 4 | 0.323 ^β |
| Cholelithiasis | 10 | 16 | |

Values are expressed mean ± standard deviation or number, BMI body mass index, M male, F female, ASA American Society of Anesthesiologist, min minutes

^ap > 0.05 Student's *T* test between groups

^βp > 0.05 chi-square test between groups

Statistical analysis

Statistical analysis was performed with IBM SPSS v20.0 (SPSS Inc., Chicago, IL, USA) software package. The normality distribution of variables was checked with the Kolmogorov-Smirnov and histogram tests. Descriptive data were expressed as mean ± standard deviation (SD) or median [min–max]. Categorical variables were analyzed using the chi-square test. Normally distributed data comprising continuous variables were analyzed using the Student's *t* test. For the statistical analysis, *p* < 0.05 was considered statistically significant.

Results

A total of 100 patients were included in this study (50 patients in each group). There were no drop-outs during the study. There was no statistically significant difference between the groups regarding the demographic characteristics (*p* > 0.05) (Table 1).

Compared to the infiltration group, total tramadol consumption was significantly lower in the ScTAP-RS group (176.20 ± 143.90 vs. 112.80 ± 69.54 *p* = 0.006, respectively). When the tramadol consumptions in time intervals were evaluated, there were statistically significant differences between the groups only 4–12 h (*p* = 0.002). There was no statistically significant difference between the groups in other time intervals (*p* > 0.005) (Table 3).

The VAS scores were recorded in the PACU, 1st, 2nd, 4th, 8th, 12th, and 24th hours at rest and ambulation, and the results showed that VAS scores were significantly lower in the ScTAP-RS group in the 4th and 8th hours at rest and ambulation compared to group I (*p* < 0.05). There was no statistically significant difference between the groups for VAS scores at other time intervals (*p* > 0.05) (Table 2).

Rescue analgesia was needed in 8 and 17 patients in the ScTAP-RS and control groups, respectively, but the difference was not statistically significant (*p* > 0.005) (Table 3).

We also evaluated the postoperative complications, and there were no side effects such as respiratory depression, sedation/confusion, somnolence, and pruritus. Besides, there was no complication related to regional anesthesia and surgery intervention too. Nausea occurred in 9 and 17 patients in ScTAP-RS and control groups, respectively, while vomiting emerged in 4 and 12

Table 2 The comparison of postoperative VAS values in rest and ambulation between group ScTAP-RS and group I

| | Group ScTAP-RS (n, 50) | Group I (n, 50) | p |
|-------------------|------------------------|-----------------|--------------------------|
| Rest | | | |
| PACU | 2 [0–6] | 2 [0–8] | 0.279 ^a |
| 1st hours | 2 [0–6] | 2 [0–6] | 0.556 ^a |
| 2nd hours | 0 [0–4] | 1.5 [0–4] | 0.262 ^a |
| 4th hours | 0 [0–6] | 2 [0–4] | 0.014^β |
| 8th hours | 0 [0–4] | 2 [0–6] | 0.006^β |
| 12th hours | 0 [0–2] | 0 [0–6] | 0.296 ^a |
| 24th hours | 0 [0–4] | 0 [0–2] | 0.724 ^a |
| Ambulation | | | |
| PACU | 4 [0–6] | 4 [0–8] | 0.085 ^a |
| 1st hours | 2 [0–6] | 2 [0–6] | 0.480 ^a |
| 2nd hours | 2 [0–6] | 2 [0–4] | 0.845 ^a |
| 4th hours | 2 [0–6] | 2 [0–6] | 0.038^β |
| 8th hours | 2 [0–6] | 2 [0–6] | 0.017^β |
| 12th hours | 0 [0–4] | 1 [0–4] | 0.256 ^β |
| 24th hours | 0 [0–4] | 0 [0–4] | 0.725 ^a |

Values are expressed median [min–max], VAS visual analog pain scale

^ap > 0.05 Student's *T* test between groups

^βp < 0.05 Student's *T* test between groups

Table 3 The comparison of tramadol consumption between group ScTAP-RS and group I

| | Group ScTAP-RS (n, 50) | Group I (n, 50) | p |
|------------------------|------------------------|-----------------|--------------------------|
| 0–4 h (mg) | 45.20 ± 24.59 | 61.00 ± 53.91 | 0.062 ^a |
| 4–12 h (mg) | 39.40 ± 36.61 | 67.20 ± 50.26 | 0.002^b |
| 12–24 h (mg) | 28.20 ± 39.72 | 48.00 ± 81.96 | 0.127 ^a |
| Total consumption (mg) | 112.80 ± 69.54 | 176.20 ± 143.90 | 0.006^b |
| Rescue analgesia (Y/N) | 8/42 | 17/33 | 0.063 ^c |

Values are expressed mean ± standard deviation or numbers, h hours, mg milligram, Y yes, N no

^ap > 0.05 Student's *T* test compared between groups

^bp < 0.05 Student's *T* test compared between groups

^cp > 0.05 chi-square test compared between groups

patients in the ScTAP-RS and control groups, respectively ($p > 0.005$) (Table 4).

Discussion

The study results showed that subcostal transversus abdominis plane block and rectus sheath block decreased opioid consumption and pain scores compared to the local anesthetic infiltration in the trocar sites after laparoscopic cholecystectomy.

After laparoscopic cholecystectomy, patients suffer from severe pain, especially in the first 24 h (Wu et al., 2013). The trocar incision sites on the anterior abdominal wall are one of the reasons for pain after laparoscopic cholecystectomy (Alexander, 1997). Three incisions for a total of 3 ports (umbilical, subxiphoid, and right subcostal ports) are performed during the conventional laparoscopic cholecystectomy (Justo-Janeiro et al., 2014). In our hospital, as the routine port openings are carried out on the right side of the abdomen and bilateral middle quadrants, we performed a unilateral right subcostal transversus abdominis plane block (ScTAP) and bilateral rectus sheath (RS) block.

The TAP block was first described in 2001 for postoperative analgesia after abdominal surgery (Rafi, 2001). Then, different ultrasound-guided block variations were described, and different TAP block types such as upper subcostal, lower subcostal, and lateral and posterior TAP were developed. The rectus sheath block was first described and implemented by Schleich in 1899 (Hebbard, 2015). Currently, it is widely adopted in the interventions of the middle abdominal wall (Jeong et al., 2019).

Regarding the literature, ScTAP and RS blocks used for the anterior abdominal wall analgesia might seem to be effective solutions to the problem (Chin et al., 2017; Ramkiran et al., 2018).

To our best knowledge, there is no randomized controlled study in the literature focused on the implementation of unilateral ScTAP and bilateral RS blocks in laparoscopic cholecystectomy. Pain after laparoscopic cholecystectomy may depend on different factors. Visceral pain is originating from the liver related to the stitching or staples; pain in the trocar port sites depending on the increased tissue inflammatory response secondary to the sympathetic nervous system activation is related to the diaphragmatic stretching and hypercarbia and insufflation during laparoscopic surgery (Guo et al., 2015). In this study, we demonstrated that the pain relief only in the trocar incisions in the postoperative period decreases significantly postoperative pain, and the ScTAP and RS block combination provided better analgesia compared to the infiltration analgesia at the trocar opening sites during the postoperative period.

A case report showed that unilateral subcostal TAP and bilateral rectus sheath blocks, which were performed for analgesia, provided an adequate analgesic activity in a patient with Becker muscular dystrophy (Iwata et al., 2017). Similar to our study, this case report confirmed that unilateral ScTAP and bilateral RS blocks could provide adequate analgesia for the trocar incision pain. Although there are some studies focused on the combined use of ScTAP and RS blocks, these blocks were administered unilaterally in these studies. These studies

Table 4 The comparison of incidence of side effects between group ScTAP-RS and group I

| | Group ScTAP-RS (n, 50) | Group I (n, 50) | p |
|------------------------|------------------------|-----------------|--------------------|
| Respiratory depression | 0 | 0 | 1.000 ^a |
| Sedation/confusion | 0 | 0 | 1.000 ^a |
| Nausea (Y/N) | 9/41 | 17/33 | 0.068 ^a |
| Vomiting (Y/N) | 4/46 | 12/38 | 0.054 ^b |
| Pruritus | 0 | 0 | 1.000 ^a |

Values are expressed as a number, Y yes, N no

^ap > 0.05 chi-square test compared between groups

^bp > 0.05 Fisher's exact test compared between groups

showed—similar to our study—that the combined implementation of ScTAP and RS blocks decreased the opioid consumption and pain scores compared to the infiltration analgesia in the trocar incision sites (Ramkiran et al., 2018; Okamoto et al., 2017). In our study, the RS block was performed bilaterally to increase the analgesic activity, as the trocar entry site was on the abdominal middle line above the umbilicus. We believe that the unilateral RS block will be insufficient, as we assume that the unilateral RS block will be effective only on one side of the body and will not affect pain on the other body side. In another study, it was shown that bilateral ultrasound-guided TAP and RS blocks decreased opioid consumption (Xu et al., 2018).

In our study, although we did not determine any difference between the local infiltration analgesia and unilateral ScTAP and bilateral RS blocks in the first 4 h and between 12 and 24 h for opioid consumption and VAS scores, we found a statistically significant difference between the groups for opioid consumption and VAS scores between 4th and 8th hours. Regarding the total opioid consumption, there is a significant decline in the ScTAP-RS group. This result confirmed that local infiltration analgesia has a short duration, and its effect declined significantly after 4 h. It was also found out that ScTAP and RS blocks were effective through 8 h, and their effects declined in the following hours. This duration of the activity provided adequate analgesia in the early postoperative period and was quite effective in the decrease of the total opioid consumption. As the same medications have different duration of analgesia in different regions, we believe that the analgesic agents used for the infiltration analgesia enter faster the blood circulation compared to the plane blocks, and local anesthetics are stored between the fasciae and thus their activity declines in a shorter time. Besides, we suggest that in the plane blocks, the solutions of local anesthetics are stored between the fasciae, and this storage maintains the analgesic activity for a relatively long time. As there is no study found in the literature focused on the duration of the analgesic activity, there is a need for further studies to determine the duration of activity of the local anesthetics in different compartments.

Even though the efficacy of the ScTAP and RS blocks in laparoscopic cholecystectomy had been demonstrated in several studies, there are also studies with conflicting results. In a study, in which bilateral ScTAP and RS blocks were compared with local anesthetic infiltration anesthesia in the trocar incision sites in laparoscopic cholecystectomy patients, it was shown that ScTAP and RS blocks provided adequate analgesia. In contrast, patient satisfaction was significantly higher in the local anesthetic infiltration group (Wu et al., 2019). In another study conducted with patients, who had undergone

subcostal TAP block, the authors did not determine any difference between the saline and bupivacaine groups for the analgesic efficacy (Houben et al., 2019).

Although there was no significant difference between the groups in terms of adverse effects in this study, it was observed that the number of nausea and vomiting was high in the infiltration group. The increase in the number of nausea and vomiting can be attributed to general anesthesia, cholecystectomy surgery, opioid consumption, etc. (Ma et al., 2019). Reducing opioid consumption, which is the only parameter whose exposure can be reduced from these parameters, can be an effective treatment in reducing postoperative nausea and vomiting (Doleman et al., 2015).

Our study had certain limitations. Firstly, only pain scores and opioid consumptions were assessed for both analgesia techniques. There was no difference between the groups for the rescue analgesia and side effects. Therefore, the investigation of the effects on patient satisfaction and evaluation as a different goal may contribute to the comparison of these two analgesia methods. Secondly, we believe that the results would be more reliable if the study had a double-blind design. Thirdly, comparative studies are required to the different blocks such as quadratus lumborum/erector spinae plane block versus ScTAP-RS block for relieving visceral pain.

Conclusion

We conclude that the combined use of the unilateral ScTAP and bilateral RS blocks decrease the opioid consumption and pain scores compared to the local infiltration block after laparoscopic cholecystectomy. Therefore, we believe that these methods are effective in the management of postoperative pain.

Abbreviations

ASA: American Society of Anesthesiologist; LC: Laparoscopic cholecystectomy; PCA: Patient-controlled analgesia; ScTAP-RS: Transversus abdominis plane block and rectus sheath block

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Authors' contributions

IHT and ECC have done the nerve blocks in patients while MEA and ECC have done the sample size calculation and statistical analysis. All authors have a major contribution in writing the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The data sets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

Institutional ethical committee approval number BEAH KA EK 2018/20-210 was obtained from local ethics committee of Erzurum Regional Training and Research Hospital, on December 17, 2018. A written informed consent was

obtained from each participating patient, and written informed consent was obtained from patients' legal guardian(s) after the description of the procedure and its potential complications.

Consent for publication

A consent to publish has been obtained from the participant to report individual patient data.

Competing interests

The authors declare that they have no competing interests.

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