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Pain related to robotic cholecystectomy with lower abdominal ports: effect of the bilateral ultrasound-guided split injection technique of rectus sheath block in female patients

A prospective randomised trial

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Abstract

Background: Robotic cholecystectomy (RC) using port sites in the lower abdominal area (T12-L1) rather than the upper abdomen has recently been introduced as an alternative procedure for laparoscopic cholecystectomy. Therefore, we investigated the time course of different components of pain and the analgesic effect of the bilateral ultrasound-guided split injection technique for rectus sheath block (sRSB) after RC in female patients.

Methods: We randomly assigned 40 patients to undergo ultrasound-guided sRSB (RSB group, n = 20) or to not undergo any block (control group, n = 20). Pain was subdivided into 3 components: superficial wound pain, deep abdominal pain, and referred shoulder pain, which were evaluated with a numeric rating scale (from 0 to 10) at baseline (time of awakening) and at 1, 6, 9, and 24 hours postoperatively. Consumption of fentanyl and general satisfaction were also evaluated 1 hour (before discharge from the postanesthesia care unit) and 24 hours postoperatively (end of study).

Results: Superficial wound pain was predominant only at awakening, and after postoperative 1 hour in the control group. Bilateral ultrasound-guided sRSB significantly decreased superficial pain after RC ($P < 0.01$) and resulted in a better satisfaction score ($P < 0.05$) 1 hour after RC in the RSB group compared with the control group. The cumulative postoperative consumption of fentanyl at 6, 9, and 24 hours was not significantly different between groups.

Conclusions: After RC with lower abdominal ports, superficial wound pain predominates over deep intra-abdominal pain and shoulder pain only at the time of awakening. Afterwards, superficial and deep pain decreased to insignificant levels in 6 hours. Bilateral ultrasound-guided sRSB was effective only during the first hour. This limited benefit should be balanced against the time and risks entailed in performing RSB.

Abbreviations: BMI = body mass index, CLC = classic laparoscopic cholecystectomy, IEVs = inferior epigastric vessels, PACU = postanesthesia care unit, PCA = patient-controlled analgesia, RC = robotic cholecystectomy, RCNP = robotic cholecystectomy using new port sites, RSB = rectus sheath block, sRSB = split injection technique for RSB, TAP = transversus abdominis plane, TF = transversalis fascia, USG = ultrasound-guided, VRS = verbal rating scale.

Keywords: nerve block, port sites, rectus sheath block, robotic cholecystectomy

1. Introduction

Classic laparoscopic cholecystectomy (CLC) causes moderate to severe postoperative pain during the first 24 hours after surgery,[1] and pain after CLC typically involves several components with different pathophysiologic mechanisms, intensities, and time courses.[2,3] Recently, Kim et al[4] established a version of robotic cholecystectomy using new port sites (RCNP) in the lower abdominal area; all 3 ports were placed below the bikini line. In this technique, the largest port site, which accommodates a 12-mm camera, is located in the midline of the lower abdomen (T12 or L1). In CLC, usually the largest port is located at the inferior aspect of the umbilicus, and the other 2 or 3 smaller ports are placed in the upper abdomen. RCNP with one 12-mm and two 8-mm-diameter trocar sites in the lower abdomen is presumed to produce less severe postoperative wound pain[5,6] and to produce pain with different characteristics compared with CLC. Nonetheless, in the postanesthesia care unit

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JSK and JBC have contributed equally to the study.

The authors report no conflicts of interest.

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(PACU), we noticed that the degree of pain from the camera port was severe enough to require analgesia in most patients who underwent RCNP, whereas the postoperative wound pains associated with the other 2 ports were negligible. Although Kim at al[4] reported that all patients were satisfied with the degree of postoperative pain after RCNP, no report has yet evaluated the characteristics of postoperative pain and its management in this novel version of robotic cholecystectomy (RC).

Several approaches using transversus abdominis plane (TAP) block for the management of peripheral postoperative pain after CLC[7–9] have been evaluated; however, the results have been somewhat contradictory.[10,11] Considering that the main source of pain after CLC is the umbilical trocar site,[12] bilateral rectus sheath block (RSB) may be applicable.[13,14] Bilateral RSB can provide postoperative analgesia for procedures involving a midline incision[15–17] with a slower absorption kinetics profile for local anesthetic than other compartment blocks.[18] Therefore, in the present study, we focused on RSB. It is also a technically simple procedure that has been reported to be effective.[14] To our knowledge, RSB performed in the lower abdomen below the arcuate line has not previously been described.

In the present study, we aimed to evaluate the characteristics of postoperative pain during the first 24 hours after RCNP and the analgesic effect of the split injection technique for RSB (sRSB) performed at the T12 or L1 dermatome of the main trocar site on superficial postoperative pain, and ultimately to investigate the effectiveness of bilateral ultrasound-guided (USG) sRSB as a postoperative analgesic modality for RCNP.

2. Methods

This prospective, randomized, observer-blinded, controlled trial was performed at Ajou University Hospital, Suwon, Republic of Korea, and was approved by our institutional ethics committee (AJIRB-MED-SUR-14–351). After obtaining written informed consent, we enrolled 40 female patients who were scheduled for RC under general anesthesia (American Society of Anesthesiologists physical status I or II and aged 20–60 years). The exclusion criteria were a previous history of abdominal surgery, coagulation disorders, known allergies to local anesthetics, body mass index (BMI) $>27\,kg/m^2$, and evidence of infection around the proposed area of the RSB. The trial is registered in a public trial register (Clinical Research information Service [CRIS]) under the identification number KCT0001401.

Patients were randomly assigned using an opaque envelope system to the control group (n = 20) or the RSB group (n = 20). Anesthesia was induced with intravenous propofol (1–2 mg/kg) and rocuronium (0.6 mg/kg), and was maintained with desflurane 6 to 7 vol% in 50% oxygen.

The RCNP was performed with the 4-arm da Vinci robot system (Intuitive Surgical, CA) using a 3-port technique as described by Kim et al[4] with some modifications. Three trocars were utilized and a Verese needle was inserted through a 2 mm incision at the infraumbilical area and CO_2 gas was introduced through the incision to obtain an intraperitoneal pressure of 12 mm Hg. A 12-mm trocar was inserted through a vertical incision below the umbilicus (camera port). Two 8-mm ports were placed 7 cm distant from the camera port under cameral visualization.

At the end of surgery, patients were provided with the standard postoperative management used in our institute. The regimen for the patient-controlled analgesia (PCA) pump (AutoMed 3200 s, Ace Medical Co., Seoul, Korea) consisted of fentanyl 5 μg/kg (total volume including normal saline of 50 mL) that was programmed to deliver 4 mL per demand with a 30 min lockout during a 24-hour period. Before starting the PCA pump, ramosetrone 0.3 mg (Nasea, Astellas Pharma US, Inc., IL) was given intravenously.

Demographic data on the patients and operation time, defined as the time from skin incision to wound closure, were recorded for all patients, and procedural time of bilateral USG sRSB in the block group was also recorded.

2.1. USG sRSB

Ultrasound-guided sRSB was performed after the completion of surgery with maintenance of general anesthesia and surgical drape. A sterile probe cover was placed over an ultrasound probe (Vivid S5, GE Medical Systems Israel Ltd. Tirat Carmel, Israel). A designated anesthesiologist placed a 22-gauge spinal needle using an in-plane technique under ultrasound guidance. All blocks were performed by 1 expert investigator (JSK). First, the needle was inserted 2 to 3 cm lateral to the 12-mm trocar incision site in the mediolateral direction into the space between the medial side of the inferior epigastric vessels (IEVs) and the transversalis fascia (TF). Five milliliters of 0.375% ropivacaine was injected, and if separation of IEVs from the TF by the injectate was depicted by ultrasound, the needle was considered to be in the correct position (Fig. 1A). Afterwards, the needle was repositioned into the space between the lateral side of the IEVs and the TF in the same manner and 5 mL of 0.375% ropivacaine was injected (Fig. 1B). The same procedure was repeated on the opposite side. The RSB needle insertion site was covered with a bandage, as was the surgical wound.

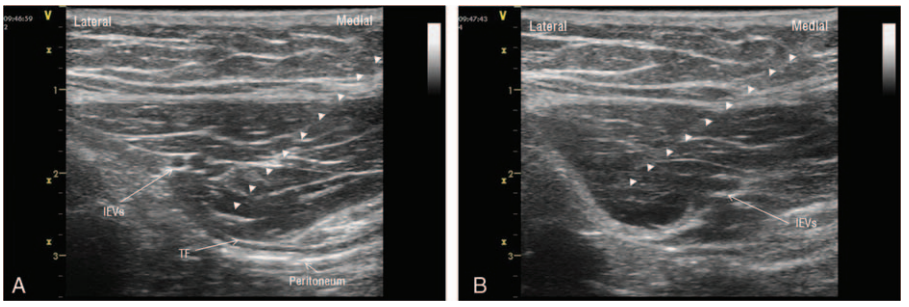

Figure 1. Ultrasound images of the rectus sheath block. A, The needle was inserted into the space between the medial side of the IEVs and the TF. B, The needle was repositioned into the space between the lateral side of the IEVs and the TF. Arrow heads represent needle. IEVs = inferior epigastric vessels, TF = transversalis fascia.

2.2. Postoperative period

In the PACU, standard monitoring consisting of pulse oximeter, noninvasive arterial pressure, temperature, and ventilatory frequency were performed. Postoperative pain treatment was provided using the same protocol. Pain intensity was measured using the verbal rating scale (VRS; from 0 = no pain to 10 = worst pain imaginable) at baseline (time of awakening) and postoperatively at 1 hour (before PACU discharge), 6, 9, and 24 hours. The evaluation was performed by an observer blinded to the patient groups. Pain was subdivided into superficial wound pain, deep intra-abdominal pain, and referred shoulder pain as previously described by Bisgaard et al.[19] For the superficial wound pain component, a VRS was obtained for the camera port. For the deep intra-abdominal pain component, a VRS was obtained in the right upper quadrant and epigastric area. For the referred shoulder pain component, 1 VRS was obtained for the left and right shoulder region together.

At 1 hour (before PACU discharge) and 24 hours (end of study) postoperatively, cumulative consumption of fentanyl and satisfaction scores regarding postoperative analgesia using a numerical scale ranging from 0 (complete satisfaction) to 10 (complete dissatisfaction) were recorded.

2.3. Statistical analysis

According to a previous study evaluating the differences between components of pain after surgery,[20] a sample size of 20 patients per group was used. The primary goal of this study was to evaluate the characteristics of postoperative pain during the first 24 hours after RCNP in the control group. The secondary goal was to compare the superficial incisional pain score between the 2 groups at each time point.

Differences in parametric data (age, weight, height, BMI, operation time), pain score at each time point, and postoperative data (fentanyl consumption, satisfaction scores) between the groups were analyzed by the Wilcoxon rank-sum test. Repeated-measures analysis of variances (ANOVAs) were used to analyze the characteristics of postoperative pain during the first 24 hours after RCNP in the control group.

All values are expressed as means ± SD or medians (interquartile range). A P value <0.05 was considered statistically significant. All statistical analyses were performed using Predictive Analytics Software (PASW) version 22.0 (SPSS Inc., Chicago, IL) and R software version 3.2.1 (R Foundation for Statistical Computing, Vienna, Austria).

3. Results

In total, 50 patients presented for RC. Of these, 5 patients declined to enroll in the study; 4 patients with BMI $>27\,kg/m^2$ and 1 patient with history of previous abdominal surgery history were excluded. Of the remaining 40 patients, 20 patients underwent sRSB with ropivacaine (RSB group) and 20 patients did not undergo any block (control group); the group assignments were made at random. In the RSB group, 1 patient was excluded after enrollment due to postoperative analgesic violation. Thus, 39 patients completed the study (Fig. 2). There were no significant differences between groups as measured by the Wilcoxon rank-sum test. The time taken to perform sRSB was 5.2 ± 1.5 minutes (Table 1).

3.1. Characteristics of postoperative pain

The characteristics of postoperative pain during first 24 hours after RCNP in the control group are shown in Fig. 3. The time course and intensity of the different components of pain after RCNP seemed to differ significantly ($P<0.001$). Superficial incisional pain scores were highest immediately after the operation and decreased significantly throughout the first 6 postoperative hours. Immediately after the operation, superficial incisional pain scores were significantly higher than were scores for the other pain components ($P<0.001$ vs deep pain, $P<0.001$ vs shoulder pain). Deep pain scores were significantly higher than shoulder pain scores as well at immediately after the operation ($P<0.001$). One hour postoperatively, superficial incisional pain scores and deep pain scores were significantly higher than shoulder pain scores ($P<0.001$ and $P<0.001$, respectively). Superficial incisional and deep pain intensity fell throughout the first 6 postoperative hours, at which point there were no significant differences in pain scores among the 3 pain components.

3.2. The effect of sRSB

The pain scores 24 hours after surgery in the 2 groups are shown in Fig. 4. Superficial incisional pain scores were significantly lower in the RSB group compared with the control group immediately and 1 hour postoperatively. Immediately after the operation, the median pain score in the RSB group was 3 (interquartile range 1–5) compared with 7 (interquartile range 6–7.6) in the control group ($P<0.01$). One hour postoperatively, the median pain score in the RSB group was 2 (interquartile range 1–3) compared with 4.7 (interquartile range 4–6) in the control group ($P<0.01$). No significant differences were noted in pain scores at 6, 9, and 24 hours postoperatively between the groups (Fig. 4A). Deep abdomen and shoulder pain scores did not differ between the 2 groups at any postoperative time points (Fig. 4B and C).

3.3. Postoperative outcome

Postoperative fentanyl consumption was similar in the 2 groups during the stay in the PACU (1 and 24 hours postoperatively). The median satisfaction score was more favorable in the RSB group (median 2, interquartile range 1.0–4.5) than in the control group (median 4, interquartile range 2.5–5) in the PACU (1 hour postoperatively). However, there was no significant difference in satisfaction scores at 24 hours postoperatively (Table 2). No complications, including local hematomas or bowel injuries, were observed in the RSB group.

4. Discussion

This prospective, randomized, observer-blinded controlled study demonstrates that the superficial pain from the main trocar site of the T12 or L1 dermatome after RCNP predominated only in the immediate postoperative period; afterward, both superficial and deep abdominal pain decreased to an insignificant level in the next 6 hours. Shoulder pain was not significant during the first 24 hours after RCNP. USG sRSB resulted in lower incisional pain scores and higher patient satisfaction only during the first postoperative hour, and the difference in pain score was not associated with a decrease in total fentanyl consumption.

It is well-known that CLC causes considerable pain despite being minimally invasive,[1] and pain control after CLC is challenging. In fact, the causes of postlaparoscopy pain are multifactorial and complex; they include visceral origins, rapid development of pneumoperitoneum, incisional pain related to

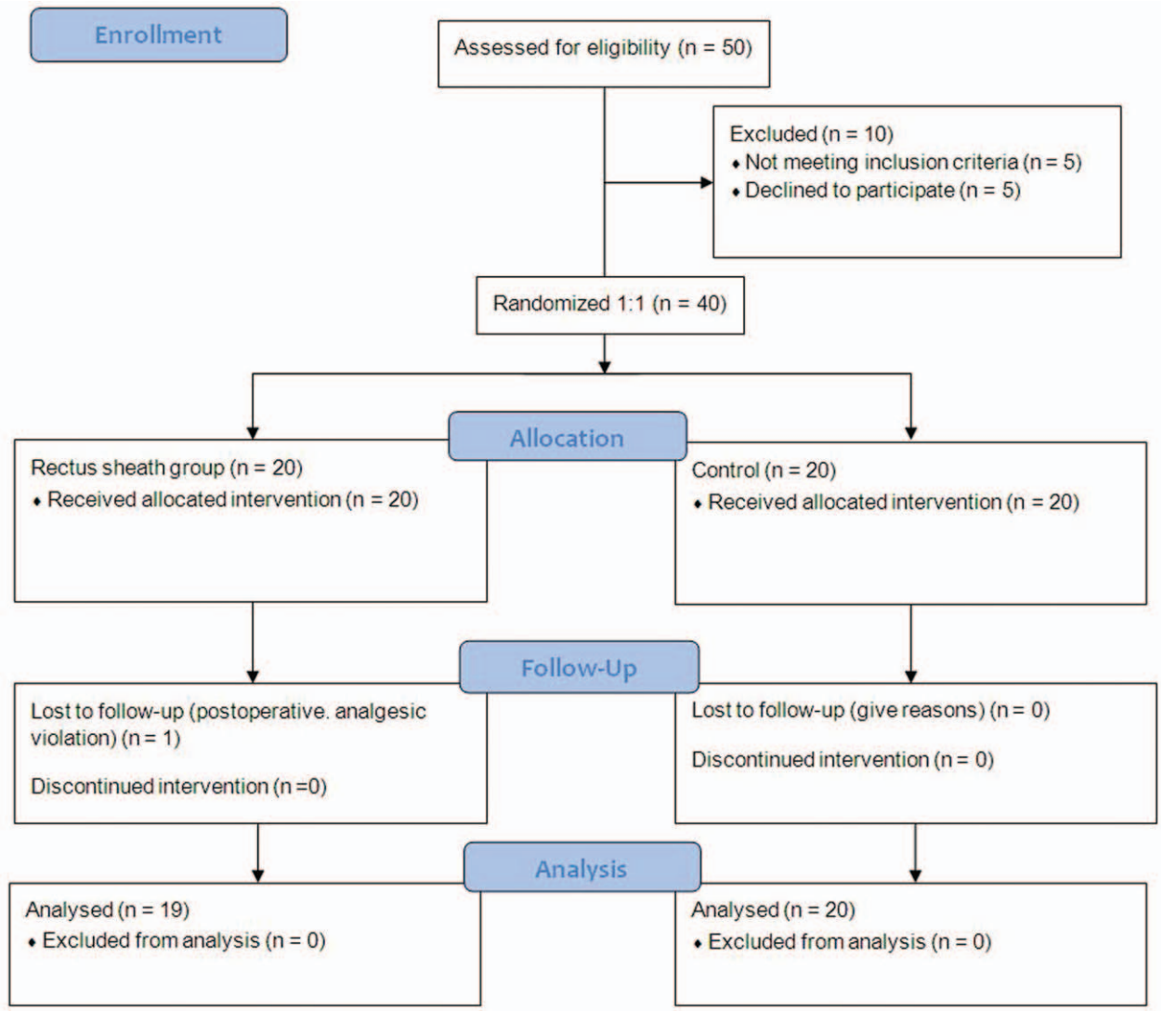

Figure 2. Consolidated standards of reporting trials study flow diagram.

variable numbers and sizes of trocar sites, different analgesic regimens, and individual factors.[21] Pneumoperitoneum can also produce deep parietal pain by sudden distention of the peritoneum associated with tearing of blood vessels, traumatic traction of the nerves, and release of inflammatory mediators,[22] and this type of parietal abdominal pain is difficult for patients to differentiate from true visceral pain. In this respect, an accurate assessment of postoperative pain components after laparoscopic surgery may not be easy. In 1 previous study[23] which investigated the characteristics of pain after CLC by dividing postoperative pain into parietal and visceral pain, visceral pain was shown to predominate over parietal pain during the first 24 hours. On the contrary, several studies have reported that incisional pain predominates on the first postoperative day.[19,20]

Table 1

Patient characteristics.

	Control group (n = 20)	Block group (n = 19)
Age, y	43.0 ± 8.3	39.3 ± 10.8
Weight, kg	55.3 ± 7.1	58.7 ± 9.9
Height, cm	158.0 ± 3.8	159.5 ± 7.1
Body mass index, kg/m^2	22.1 ± 2.6	23.0 ± 3.1
Operation time, min	32.3 ± 9.8	36.7 ± 7.6
Block time for RSB, min		5.2 ± 1.5
Diagnosis		
Cholecystitis	12	12
Gall bladder stone	2	2
Gall bladder polyp	6	5

Values are presented as mean ± SD or number.
There were no significant differences between groups by the Wilcoxon rank-sum test.
RSB = rectus sheath block.

Robotic cholecystectomy was first introduced in 1988 and has now evolved to single-incision RC, which may provide additional benefits in further reducing the already minimal pain of classic 4-port cholecystectomy. However, single-incision RC and CLC produced similar levels of postoperative pain.[24] In the meantime, Kim et al[4] introduced a new version of RC involving 3 ports in the lower abdomen, a technique which was originally designed for better aesthetic outcomes. Generally, lower abdominal incisions produce less postoperative pain[6]; therefore, we presumed that RCNP with 3 ports in the lower abdomen would show different pain characteristics compared with CLC.

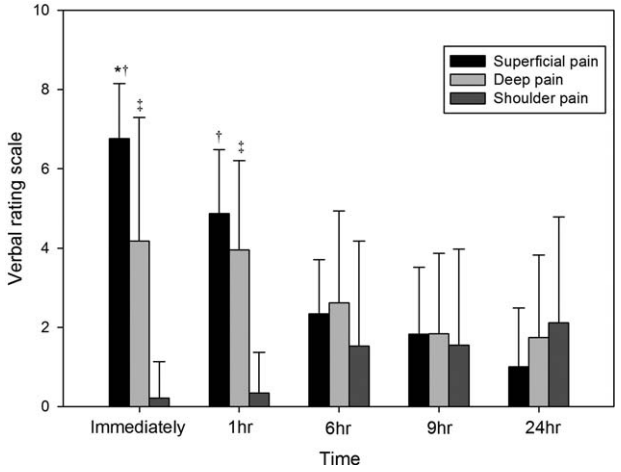

Figure 3. The characteristics of postoperative pain. Superficial incisional pain was significantly more severe than deep pain immediately after the operation. Superficial incisional and deep pains were both significantly greater than shoulder pain during the first 1 hour postoperatively. (*) $P < 0.05$ compared with deep pain; (†, ‡) $P < 0.05$ compared with shoulder pain.

Table 2

Comparison of postoperative outcomes.

	Control group (n = 20)	Block group (n = 19)	*P*
Fentanyl consumption, μg			
1 h postoperatively	29.8 (20–42.8)	24.8 (19.2–32.0)	0.24
24 h postoperatively	80 (50–129)	100 (48–192)	0.37
Satisfaction score, n			
1 h postoperatively	4 (2.5–5)	2 (1.0–4.5)	0.03
24 h postoperatively	1 (1–2)	2 (1–3)	0.73

Values are presented as median (interquartile range).
Comparisons between two groups were analyzed by the Wilcoxon rank-sum test.

Accordingly, we investigated the characteristics of postoperative pain after RCNP for the first time, and, as a result, we noticed that the superficial wound pain from the main trocar site in the T12-L1 dermatome predominated over deep intra-abdominal and referred shoulder pain during the immediate postoperative period, but the difference decreased rapidly to an insignificant level in 6 hours. Also, deep pain did not predominate at any time during the first 24 hours in the control group. Nonetheless, initial superficial wound pain after RCNP was severe enough to require pain therapy.

We performed bilateral USG sRSB for superficial wound pain only when using the 12-mm camera port in the T12 or L1 dermatome because most RCNP patients do not complain of wound pain from the smaller ports. Theoretically, subcostal TAP block may be an appropriate technique covering all trocar sites. However, after TAP block, a satisfactory block for midline incisions may not be completely achieved,[25] and the onset of the sensory block is relatively slow.[26] As in the present study, to increase the success rate and block quality of RSB, we conducted RSB with some modifications. The rectus abdominis muscle is innervated by segment T6-L1, with a constant branch from L1, and in the branching pattern and course of thoracic intercostal nerves that innervate the anterior abdominal wall, communications seem to occur at the multiple locations in the rectus sheath.[27] After approaching the posterior surface of the rectus muscle near the arcuate line, these nerves communicate with a longitudinal band of nerves that run cranio-caudally and form a plexus with branches of the inferior epigastric artery. Therefore, in the case of single shot RSB in this area, laterally deposited local anesthetic in the posterior surface of the rectus muscle may not reach the longitudinal band of nerves that descend cranio-caudally and form the plexus. Accordingly, for complete blockade of the skin and deep area of the abdomen, we injected local anesthetics separately into the medial and lateral areas from the IEVs on both sides. As mentioned previously, IEVs form a plexus with the thoracic intercostal nerves in the ventral part of the posterior surface of the rectus muscle, and they can easily be visualized on an ultrasound. Puncture of these vessels must be avoided; therefore, we used the IEVs as landmarks for the RSB. To our knowledge, this is the first report of bilateral USG RSB targeting the mid-abdominal area of the T12 or L1 dermatomes using the split injection technique in bilateral IEVs for laparoscopic surgery.

Despite the finding of lower superficial incisional pain scores and greater satisfaction in the RSB group soon after surgery, no statistically significant difference was found in consumption of fentanyl between the 2 groups. This may imply that postoperative pain after RCNP is not severe and does not last long enough to be managed by aggressive analgesic modalities such as nerve blocks. In this respect, this new version of RC has definite advantages of not only better aesthetic outcomes but also less need for aggressive postoperative analgesic modalities compared with CLC or single incision RC. Single-incision laparoscopic cholecystectomy may be associated with higher pain scores than CLC

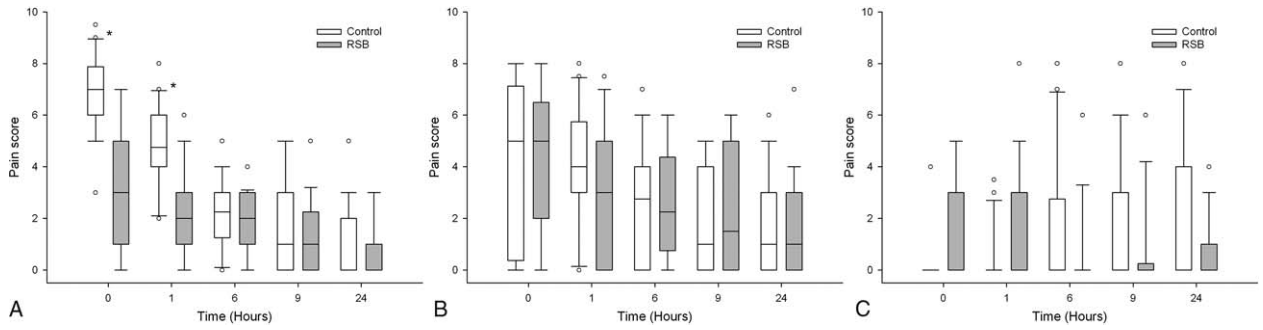

Figure 4. A box plot of pain scores in the 2 groups. The middle line in each box represents the median value and the outer margins of the box represent the interquartile range. A, Superficial incisional pain; B, deep pain; C, referred shoulder pain. (*) $P < 0.05$, Wilcoxon rank-sum test. RSB = rectus sheath block.

because of longer incision or local ischemia induced by the placement of a single larger port.[28] Interestingly, referred shoulder pain was not significant after RC in the present study.

In the present study, we did not measure pain scores at time points between 1 and 6 hours after the completion of RC; therefore, the effective duration of sRSB may have been underestimated.

In conclusion, after RCNP, superficial wound pain is more severe than deep abdominal pain only in the early postoperative period, and the level of both types of pain are insignificant after 6 hours, whereas shoulder pain was not significant at any time during the first 24 hours after RCNP. Although sRSB showed an analgesic effect and increased patient satisfaction during the early postoperative period after RCNP, considering the short-lived superficial incisional pain after RCNP, RSB may not be a useful analgesic option to treat postoperative pain after RCNP in view of risk/benefit analysis; therefore, pharmacological treatment is recommended.

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