Effectiveness of ultrasound-guided transversus abdominis plane block and rectus sheath block in pain control and recovery after gynecological transumbilical single-incision laparoscopic surgery

M. Mugita[1], R. Kawahara[2], Y. Tamai[2], K. Yamasaki[2], S. Okuno[2], R. Hanada[2], M. Inaoka[3], T. Funato[4]

[1] Department of Rehabilitation, [2] Department of Anesthesiology and Palliative Care, [3] Department of Orthopedics, [4] Department of Obstetrics and Gynecology, Nissay Hospital, Osaka (Japan)

Summary

Purpose: To evaluate the effectiveness of ultrasound-guided transversus abdominis plane (TAP) and rectus sheath (RS) blocks in pain management and recovery after gynecological single-incision laparoscopic surgery (SILS). *Materials and Methods:* A bilateral TAP block (Group A, n=9), bilateral TAP and RS blocks (Group B, n=10), and a bilateral RS block (Group C, n=9) with 40 ml ropivacaine per patient were conducted in 28 patients undergoing SILS for ovarian tumors. A pain score and walking distance in a 6-minute walk test (6MWT) were examined. *Results:* Pain scores were significantly lower on postoperative day (POD) 3 than on POD 1 in Groups B (p = 0.03) and C (p = 0.02). The walking distance on POD 3 was comparable with that before surgery in Group C (p = 0.75), but shorter in Groups A (p = 0.004) and B (p = 0.02). *Conclusions:* The RS block alone was the most effective in relieving pain and accelerating general recovery after gynecological SILS.

Key words: Single-incision laparoscopic surgery; Transversus abdominis plane block; Rectus sheath block; 6-minute walk test.

Introduction

Single-incision laparoscopic surgery (SILS) has recently become a popular technique and has improved the outcomes of gynecological surgery. The SILS procedure requires only one incision at the umbilicus, yielding the potential benefits of better cosmetic results, less postoperative pain, quicker recovery, and fewer operative complications; therefore, it has attracted much attention from gynecological surgeons. Nevertheless, a large port scar created specifically for the SILS procedure causes uncomfortable umbilical pain in a certain proportion of patients [1, 2]. Therefore, adequate postoperative pain management is required for quicker recovery.

Previous randomized controlled trials demonstrated the efficacy of the transversus abdominis plane (TAP) block as a component of a multimodal regimen in providing analgesia after abdominal surgery [3-8]. After gynecological laparoscopic surgery with four port scars, postoperative pain was decreased by administering the TAP block [9, 10]. The effectiveness of this block in pain management after SILS procedures was also reported [11]. The rectus sheath (RS) block was utilized for providing postoperative analgesia in patients who underwent umbilical hernia repair [12]. The RS block provides analgesia after procedures requiring a midline incision by acting on the terminal branches of the 7th to 11th intercostal nerves within the rectus sheath [13]. Although the effectiveness of the RS block in pain management after SILS procedures has not been evaluated, this technique may work by decreasing umbilical pain. In this study, the authors investigated the effectiveness of ultrasound (US)-guided TAP and RS blocks in pain control and recovery of physical condition after gynecological SILS procedures.

Materials and Methods

Subjects

After obtaining the approval of the institutional review board of Nissay Hospital and written informed consent from each patient, 28 women (mean age, 34 ± 9 years) were recruited for this study at the present institute between October 2010 and January 2012. All patients were scheduled to undergo an SILS procedure for ovarian tumors and were classified as American Society of Anesthesiologists physical status 1 or 2. Patients who could not undergo functional measurements because of other diseases and those who could not complete the questionnaires because of cognitive reasons were excluded.

Anesthesia

Without premedication, 500 ml of acetate Ringer's solution was administered via peripheral venous access. Standard monitoring, including non-invasive blood pressure monitoring, three-lead electrocardiography, and pulse oximetry, were performed. All patients were assessed using the bispectral index (BIS). Patients in both groups received propofol, 0.1 μg/kg/min of remifentanil, and one mg/kg of rocuronium before tracheal intubation. Propofol was administered via target-controlled infusion pumps, with a target effect-site concentration of 3.0 μg/ml. After intubation, the lungs were ventilated to an end-tidal carbon dioxide concentration within the range of 30–40 mmHg.

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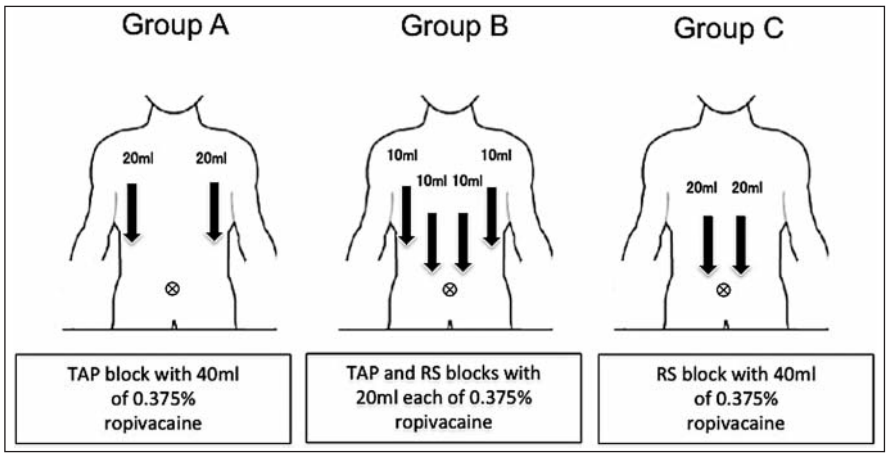

Figure 1. — Puncture sites for the transversus abdominis plane (TAP) block, combined TAP, and rectus sheath (RS) block, and RS block. The combination block was administered bilaterally using 50% doses under ultrasound-guided control.

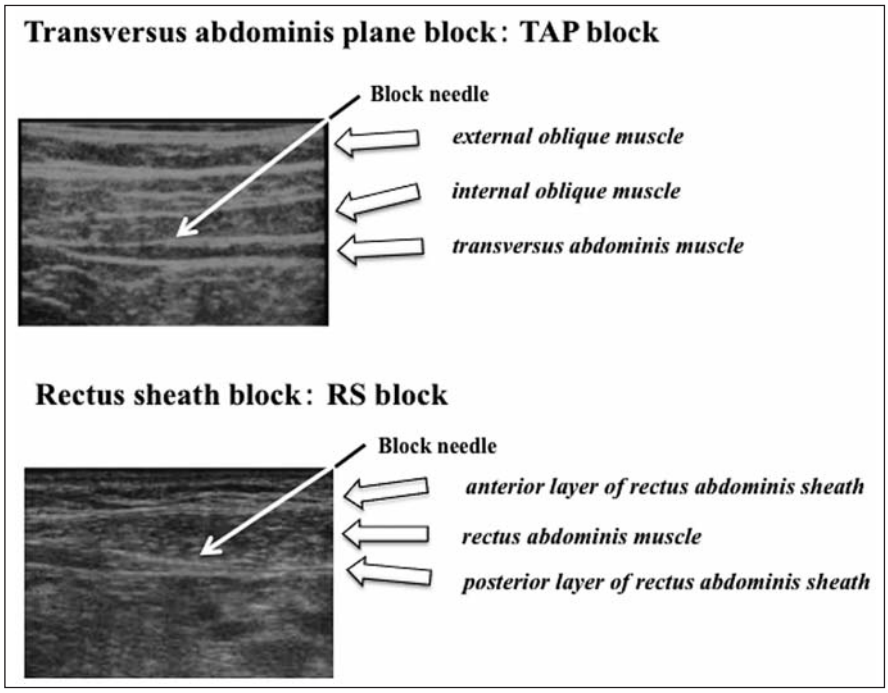

Figure 2. — Ultrasound images of the transversus abdominis plane (TAP) block and rectus sheath (RS) block.

Following the induction of general anesthesia, a TAP block with 40 ml of 0.375% ropivacaine (Group A), a TAP block with 20 ml of 0.375% ropivacaine and an RS block with 20 ml of 0.375% ropivacaine (Group B), and an RS block with 40 ml of 0.375% ropivacaine (Group C) were administered to 9, 10, and 9 patients, respectively (Figure 1). The authors used a real-time, in-plane needle insertion technique under US guidance. The TAP and RS blocks were administered under US guidance with a portable US device and a linear 6–13-MHz US transducer. The blocks were administered with a 22-G, 80-mm Tuohy nerve block needle. The TAP block was administered using a mid-axillary approach. After visualization of the external oblique abdominal muscle (EOAM), internal oblique abdominal muscle (IOAM), and transverse abdominal muscle (TAM) at the level of the mid-axillary line between the 12th rib and the iliac crest, the puncture area and a US probe were prepared in a sterile manner. After placing the tip of the needle in the space between the IOAM and TAM and confirming negative aspiration of blood, the TAP block was bilaterally administered by infusion of 20 ml of 0.375% ropivacaine per side in Group A and ten ml of 0.375% ropivacaine per side in Group B (Figure 1). For patients randomized to receive the RS block, the area of the abdomen between the lateral border of the rectus muscle and one cm cephalad to the umbilicus and a US probe were prepared in a sterile manner. The needle tip was placed close to the lateral border of the rectus sheath between the posterior sheath and rectus muscle. Spread of the local anesthetic was visualized between the rectus sheath and rectus abdominis muscle under US guidance (Figure 2). The RS block was bilaterally administered by infusion of 10 ml of 0.375% ropivacaine per side in Group B and 20 ml of 0.375% ropivacaine per side in Group C.

Anesthesia was maintained by propofol and remifentanil titrated to maintain the mean arterial blood pressure at 80%–120% of that before the induction of anesthesia. The propofol dose was adjusted to maintain the BIS between 40 and 60 during surgery. Following skin closure, 400 mg of acetaminophen was administered by suppository and anesthesia was discontinued before tracheal extubation. To manage postoperative pain, the authors used

two types of analgesics on demand, namely intravenous flurbiprofen (50 mg) on the operation day (OPD), and oral loxoprofen sodium hydrate (60 mg) on postoperative days (PODs) 1–3.

Assessment

The sites of administration of the TAP and RS blocks were visually checked for the presence of hematoceles or infection. The total amount of remifentanil and propofol administered was recorded. The presence or absence of nausea and vomiting after extubation and during the first 24 hours after surgery were recorded for each patient.

Analgesic effects were evaluated using a numerical rating scale (NRS) and the 6-minute walk test (6MWT). NRS was used to assess pain intensity in patients who were able to self-report. All patients were assessed on a 11-point scale numbered from 0 to 10 (high scores indicating intolerable pain) on PODs 1 and 3.

The 6MWT is used as a performance-based measure of functional exercise capacity and exercise tolerance [14]. In this study, it was performed indoors on a hard, level surface in a straight corridor, free of distractions and in accordance with a standardized protocol recommended by the American Thoracic Society. Standard phrases of encouragement at one-minute intervals were provided during the 6MWT to control the influence of encouragement on test performance [15]. Participants were required to walk as far as possible' in six minutes, but they were allowed to stop and rest as required. To ensure patient safety, blood pressure was measured immediately before and after the 6MWT, while heart rate and peripheral oxygen saturation (SpO_2) were monitored continuously by finger pulse oximetry. A resting blood pressure of >150/100 mmHg and/or a heart rate of >100 beats per minute (bpm) precluded the 6MWT. The postoperative 6MWT was interrupted if SpO_2 dropped to below 90% or if the heart rate exceeded 125 bpm. The 6MWT was conducted once before surgery to establish a baseline and again on PODs 1 and 3.

Statistical analysis

Differences in baseline demographics among the three groups were expressed as average values ± standard deviations, and one-way analysis of variance (ANOVA) was used to evaluate these differences.

The frequency of administration of flurbiprofen and loxoprofen sodium hydrate was expressed as medians (range), and differences in values for OPD and PODs 1–3 among the three groups were compared using the Kruskal–Wallis test. The NRS scores for postoperative pain were expressed as medians (range). Differences in scores between PODs 1 and 3 in each group were compared using the Wilcoxon signed rank test, and differences among the three groups on PODs 1 and 3 were compared using the Kruskal–Wallis test.

Table 1. — *Baseline demographics.*

	Group A	Group B	Group C	*p* value
Patient number	9	10	9	
Age (yrs)	32±6	38±11	33±10	0.34
Height (cm)	159±5	159±4	155±6	0.19
Weight (kg)	54±7	52±4	56±16	0.74
BMI (kg/m^2)	21.1±2.4	20.7±1.6	23.0±6.3	0.40
Anesthesia time (min)	129±23	123±30	124±28	0.85
Operation time (min)	79±24	67±31	77±28	0.59
Propofol (mg)	611±137	667±151	770±256	0.41
Remifentanil (mg)	1.4±0.5	1.3±0.4	14±0.4	0.95

Walking distances in 6MWT were expressed as average values ± standard deviations. Differences among the distance walked before surgery and on PODs 1 and 3 in each group were compared using one-way ANOVA repeated measurement, while those among the three groups before surgery and on PODs 1 and 3 were compared using one-way ANOVA. Blood pressure and SpO_2 values were expressed as average values ± standard deviation, and differences in values before and after the 6MWT were compared using the Wilcoxon signed rank test.

All data analyses were performed using Ekuseru-Toukei 2012 and *p*-values of <0.05 were considered statistically significant.

Results

All patients successfully underwent a transumbilical SILS procedure without open conversion. No complications associated with the block procedures were encountered. All patients satisfied the authors' well-defined discharge criteria and were discharged to their homes on POD 5. There were no statistically significant differences with regard to age, body height and weight, body mass index, duration of anesthesia and surgery, and dose of remifentanil and propofol among the three groups (Table 1).

The frequency of intravenous administration of flurbiprofen was 1 (0–2), 1 (0–2), and 1 (0–2) on OPD (p = 0.92) in Groups A, B, and C, respectively. The frequency of

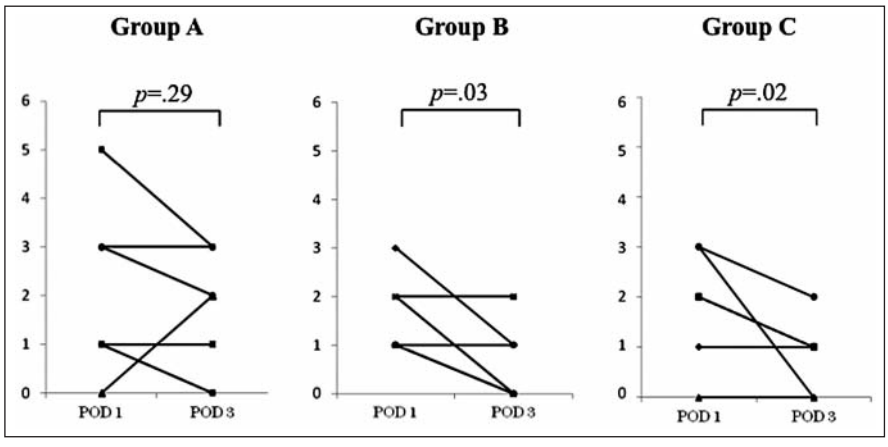

Figure 3. — Numerical rating scale (NRS) scores on postoperative days (PODs) 1 and 3 in Groups A, B, and C.

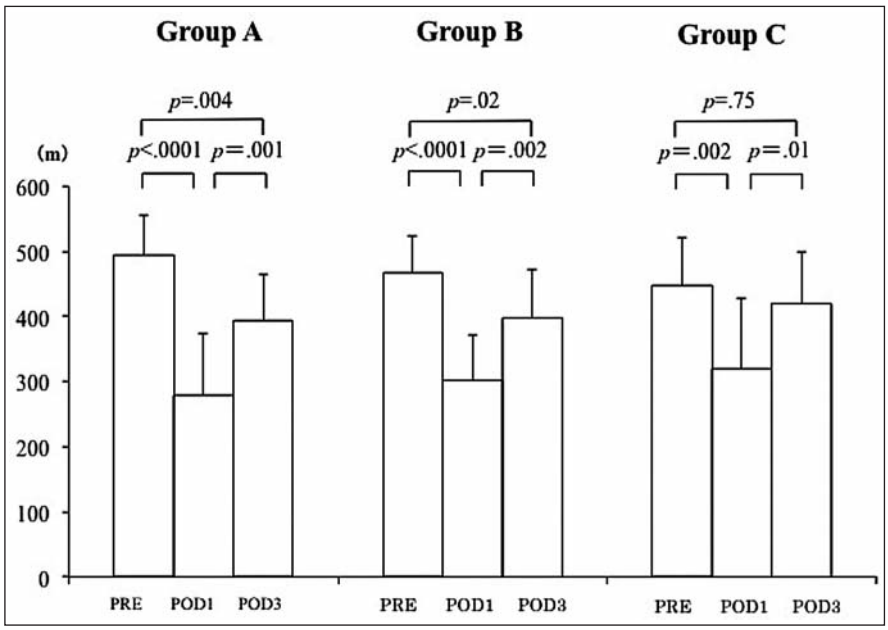

Figure 4. — The distance walked (m) in the 6-minute walk test (6MWT) before surgery and on postoperative days (PODs) 1 and 3 in Groups A, B, and C.

Table 2. — *Distances walked in the 6-minute walk test (6MWT) (m).*

	Group A	Group B	Group C	*p* value
PRE	494±63	468±57	448±74	0.33
POD 1	279±95	303±71	321±108	0.63
POD 3	394±72	399±76	421±80	0.73

oral administration of loxoprofen sodium hydrate was 1 (0–3), 1 (0–1), and 0 (0–2) on POD 1 ($p = 0.27$), 0 (0–1), 0 (0–1), and 0 (0–1) on POD 2 ($p = 0.76$), and 0 (0–2), 0 (0–1), and 0 (0–0) on POD 3 ($p = 0.12$) in Groups A, B, and C, respectively.

The NRS scores were 1 (0–5), 2 (1–3), and 2 (0–3) on POD 1 and 1 (0–3), 1 (0–2), and 1 (0–2) on POD 3 in Groups A, B, and C, respectively. There were no significant differences in NRS scores among the three groups on POD 1 ($p = 0.72$) and POD 3 ($p = 0.60$). The scores on POD 3 were significantly lower than those on POD 1 in Groups B ($p = 0.03$) and C ($p = 0.02$), but not in Group A ($p = 0.29$; Figure 3).

There were no significant differences in the distance walked in the 6MWT among the three groups before surgery ($p = 0.33$) and on POD 1 ($p = 0.63$) POD 3 ($p = 0.73$, Table 2). Compared with this at baseline, the distance walked decreased significantly on POD 1, while compared with that on POD 1, the distance increased on POD 3 in all three groups. The distance walked on POD 3 was significantly lower than that before surgery in Groups A ($p = 0.004$) and B ($p = 0.02$), whereas in Group C, the distance on POD 3 was comparable with that before surgery ($p = 0.75$, Figure 4). There were no significant changes in blood pressure and oxygen saturation after the 6MWT at all time points (Table 3).

Discussion

The SILS procedure has recently come to be preferred as a more minimally invasive procedure compared with conventional laparoscopic surgery. However, this procedure is associated with substantial postoperative pain, probably because of extensive manipulation of the fascial wall beneath

Table 3. — *Mean blood pressure and oxygen saturation before and after the 6MWT.*

	Group A			Group B			Group C		
	PRE	POD 1	POD 3	PRE	POD 1	POD 3	PRE	POD 1	POD 3
Blood pressure (mmHg)									
before	115/75	114/76	115/76	118/75	116/75	111/72	118/77	122/79	118/76
after	121/79	113/74	117/78	122/76	128/81	112/78	125/80	119/77	122/75
p value	0.10	0.45	0.36	0.25	0.06	0.38	0.21	0.38	0.34
Oxygen saturation (%)									
before	98±1	96±1	97±1	98±1	98±1	98±1	98±1	97±1	98±1
after	98±1	97±1	98±1	98±1	98±1	98±1	98±1	98±1	99±1
p value	0.50	0.10	0.07	0.26	0.32	0.25	0.21	0.19	0.27

the umbilical skin incision. Ultrasound-guided TAP and RS blocks are now widely used as part of a multimodal analgesic regimen after abdominal surgery and are speculated to be effective in relieving umbilical pain after SILS procedures. To the present authors' knowledge, no literature has reported the efficacy of regional anesthesia combined with general anesthesia, except for a case report by Matthes *et al.* [11] who reported that a 30-year-old woman who was breastfeeding her infant received TAP block with bupivacaine and successfully underwent SILS cholecystectomy without the need for intraoperative and postoperative opioids. The present randomized controlled trial systematically investigated the effects of preoperative TAP and/or RS blocks on the course of pain and mobility over three days after an SILS procedure.

No statistically significant difference was found in NRS scores among the three groups on PODs 1 and 3, whereas these had significantly decreased on POD 3 compared with those on POD 1 in the two groups who received the RS block (Groups B and C). This finding suggests that the RS block is more appropriate than the TAP block for gynecological SILS procedures, providing analgesia to the periumbilical tissues supplied by the branches of nerves T9–11.

The 6MWT was chosen for the evaluation of overall physical function in the acute postoperative period. This test is now the most extensively used among the many walking tests available, and it is currently recommended for use in both research and clinical settings [16]. When conducted safely following abdominal surgery, as in this study, the 6MWT is a useful objective tool to evaluate postoperative pain and measure clinical progress. The distance walked before surgery was comparable among the three groups, while on POD 1, the patients showed a marked decrease in all three groups. The distance walked recovered on POD 3 in the patients who had received the RS block alone (Group C), and it was not significantly different from that before surgery. In contrast, it remained significantly low on POD 3 in the patients who had received the TAP block alone or in combination with the RS block. Patients who received the RS block did not require postoperative analgesia on POD 3. These results suggest that the RS block alone is the most beneficial among the three block procedures in facilitating early mobilization after gynecological SILS procedures. Because this block relieves pain in the rectus abdominis muscle, which is used chiefly for standing and walking movements, it may have decreased movement-associated pain, minimizing the decrease in postoperative walking speed.

Enhanced Recovery after Surgery protocols aim at decreasing the surgical stress response and optimizing recovery, thus decreasing the length of hospital stay [17]. Bed rest after surgery is undesirable because it impairs pulmonary function and tissue oxygenation and predisposes the patient to pulmonary complications. To avoid this, it is important to mobilize patients as soon as possible after surgery. Therefore, recovery of the distance walked in patients who receive the RS block may lead to a decrease in postoperative complications, although the length of the postoperative course was similar among the three groups in this study.

This study had some limitations. First, sensory block observation was not included in the study protocol. Second, the sample size of each group was small. It cannot be readily explained why the RS block using ropivacaine was effective in decreasing pain until POD 3. Little is known about the pharmacodynamics and pre-emptive analgesic effects of ropivacaine used in TAP and RS blocks.

Conclusion

The RS block using the same total dose of ropivacaine proved to be more effective for postoperative pain control and general recovery compared with the TAP block alone and in combination with the RS block in the early period after gynecological SILS procedures. Early pain relief may enhance postoperative recovery and contribute to early rehabilitation. Further investigation is necessary to establish the method of regional analgesia that is most appropriate for SILS procedures, which are now enjoying more widespread use in laparoscopic surgery.

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Address reprint requests to:
R. KAWAHARA, M.D.
Department of Anesthesiology and Palliative Care,
Nissay Hospital
6-3-8 Itachibori, Nishi-ku, Osaka-city,
Osaka 550-0012, (Japan)
e-mail: kawahara.ryoko@nissay-hp.or.jp