Original Article

The analgesic efficacy of ultrasound-guided transversus abdominis plane block with mid-axillary approach after gynecologic laparoscopic surgery: A randomized controlled trial

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Abstract

Background and Aims: The transversus abdominis plane (TAP) block is widely used in clinical practice as a part of the multimodal analgesic regimen after abdominal surgery. The analgesic efficacy of ultrasound (US)-guided TAP block with the mid-axillary approach was investigated in patients undergoing laparoscopic gynecologic surgery in a randomized controlled clinical trial.
Materials and Methods: Adult patients (n = 119) undergoing laparoscopic gynecologic surgery were randomized to undergo either TAP block with ropivacaine (Group A, n = 60) or that with saline (Group B, n = 59), in a blinded manner. Following general anesthesia, TAP block was performed bilaterally by infusion of either 20-mL 0.375% ropivacaine/one side in Group A or 20-mL saline/one side in Group B, under US guidance with a mid-axillary approach. Patient-controlled analgesia (PCA) was performed postoperatively with tramadol. The analgesic effect was postoperatively evaluated using a four-grade pain score and the prince Henry pain scale (PHS) at 0, 6, 12, and 24 h. Postoperative tramadol PCA consumption and vomiting/nausea were recorded. Statistical analyses were performed using the Mann-Whitney U-test or Fisher's exact probability test. A $P < 0.05$ was considered significant.
Results: There was no statistically significant difference in background characteristics. The dose of remifentanil was significantly higher in Group B ($P = 0.01$). The pain score ($P = 0.02$) and PHS ($P = 0.01$) were significantly lower in Group A at 0 h. Tramadol PCA consumption in the period of 0-6 h ($P = 0.01$) and postoperative nausea ($P = 0.04$) were significantly less in Group A.
Conclusion: Postoperative pain/nausea and PCA consumption were significantly lower in patients with TAP block in the early postoperative stage. TAP block with a mid-axillary approach holds considerable promise as a part of a balanced postoperative analgesic regimen following laparoscopic gynecologic surgery.

Key words: Anesthetic technique, laparoscopic surgery, transversus abdominis plane block, ultrasound

Introduction

The transversus abdominis plane (TAP) block is widely used in clinical practice as a part of the multimodal analgesic regimen after abdominal surgery.[1-3] There are currently a number of ultrasound (US)-guided approaches, including a subcostal approach, a mid-axillary approach and a posterior approach. The analgesic effect of the TAP block is likely to depend on the extent of spread of local anesthetic within the TAP, and the spread depends on the site of injection of anesthetic.[4,5] Although laparoscopic gynecologic surgery is a minimally invasive surgical procedure with lower perioperative pain compared with open procedures, it is still associated with substantial postoperative pain.[6,7] It was hypothesized that the US-guided TAP block with the mid-axillary approach could reduce pain after laparoscopic gynecologic surgery. In this prospective, double-blinded, randomized, placebo-controlled study, we aimed to assess, for laparoscopic gynecologic surgery, the early postoperative analgesic efficacy of the US-guided TAP block with the mid-axillary approach under general anesthesia with remifentanil, an ultra-short-acting analgesic that provides early recovery from anesthesia.[8,9]

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Materials and Methods

With an institutional review board approval and the informed consent signed from each patient, 119 adult patients with American Society of Anesthesiologist-physical status 1 or 2, who were scheduled to undergo laparoscopic gynecologic surgery from September 2009 to August 2010 in our institute, were randomized to undergo the TAP block with either ropivacaine (Group A, $n = 60$) or TAP block with saline (Group B, $n = 59$) with the envelope method. The sample size calculation was based on data from a pilot study with the assumption that TAP block will reduce tramadol patient-controlled analgesia (PCA) consumption in patients undergoing laparoscopic gynecologic surgery. Assuming a power of 80%, a level of significance of 5%, a difference of means = 27 mg, and a common standard deviation = 50.4, it was estimated that 56 patients would be required in each group. To minimize any effect of data loss, we recruited 60 patients in Group A and 59 patients in Group B in the study period.

Without premedication, 500 mL of acetate Ringer's solution was given through a peripheral venous access. Standard monitoring was performed, including noninvasive blood pressure, three-lead electrocardiogram; pulse oximetry (SpO_2), (S/5 Anesthesia Monitor, GE Healthcare, Helsinki, Finland) was applied. All patients in both groups ware monitored with Bispectral Index (BIS™). Patients in both groups received propofol, 0.1 μg/kg/min of remifentanil for analgesia, and 1 mg/kg of rocuronium for muscle relaxation before tracheal intubation. Propofol was given through target controlled infusion pumps (Terfusin™ TCI pump TE371,Terumo, Tokyo, Japan) with a target effect-site concentration of 3.0 μg/mL. After intubation, the lungs were ventilated to an end-tidal carbon dioxide concentration of 35 (30-40) mmHg.

After induction of general anesthesia, the TAP block performed under US guidance with a SoneSite™ portable US device and a linear 6-13 MHz US transducer (Sonosite, Bothell, WA, USA). Once the external oblique abdominal muscle (EOAM), internal oblique abdominal muscle (IOAM), and transverse abdominal muscle (TAM) were visualized at the level of the mid-axillary line between the 12th rib and the iliac crest (a mid-axillary approach), the puncture area and US probe were prepared in a sterile manner. The block was performed with a 22-G 80-mm Touhy nerve blockade needle (Unisis™, Tokyo, JAPAN). Once the tip of the needle was placed in the space between the IOAM and TAM and a negative aspiration of blood was confirmed, the TAP block was performed bilaterally by infusion of 20-mL of 0.375% ropivacaine/one side in Group A and 20-mL saline/one side in Group B. Anesthesiologists who performed the bilateral block were unaware of the contents of syringe (i.e., ropivacaine or saline).

All patients received volume-controlled ventilation with a tidal volume of 7-10 mL/kg and a frequency of 10-12/min, with a 1:2 mix of oxygen and air. Anesthesia was maintained by propofol and remifentanil titrated to keep the mean arterial blood pressure within the range between 80% and 120% of that before the introduction of anesthesia. The target effect-site concentration of propofol was adjusted to maintain BIS level between 40 and 60 during surgery. When abdominal skin closure commenced, 2 mg/kg of tramadol and 5 mg of prochlorperazine were administered intravenously. When skin closure was completed, 400 mg of acetaminophen was administered suppository and anesthesia was discontinued before tracheal extubation. Postoperatively, patients received a PCA setting of a bolus of 12 mg tramadol with 10 min lockout time without basal infusion. The solution was prepared as 300 mg (6 mL) of tramadol diluted with 44 mL of isotonic saline.

The total amounts of remifentanil and propofol administered were recorded. The presence or absence of nausea and vomiting after extubation and in the period during 24 h after surgery were recorded in each patient. The postoperative pain was evaluated at 0, 6, 12, and 24 h after surgery using a four-grade pain score (0 - no pain; 1 - slight pain; 2 - moderate pain; 3 - intolerable pain)[10] and prince henry pain scale (PHS) (0 = no pain on coughing; 1 = pain on coughing, but not on deep breathing; 2 = pain on deep breathing but not at rest; 3 = slight pain at rest; 4 = severe pain at rest).[11] The postoperative pain at the postoperative time point of 0 h was evaluated on emergence before PCA was started. The four-grade pain score, PHS, and the dose of tramadol PCA administration were recorded. The sites of injection of the TAP block were visually checked for the presence of hematoceles or infection.

After testing for normal distribution, data are expressed as medians with ranges, and group data, including baseline demographics, clinical characteristics except laparoscopic procedures, four-grade pain score, PHS, and the dose of tramadol PCA administration, were compared using Mann-Whitney U-test. Laparoscopic procedures and the number of patients with nausea and/or vomiting were analyzed statistically using Fisher's exact probability test. A $P < 0.05$ was considered significant.

Results

Ultrasonographic visualization of EOAM, IOAM, and TAM, and observation of the tip of the needle and the

spread of local anesthetic were possible in all TAP blocks. No technical adverse events related to the TAP block were encountered (e.g., blood aspiration, visceral injuries, and intramuscular bleeding causing hematoma). No patient demonstrated symptoms of local anesthetic toxicity.

The laparoscopic procedures included hysterectomy ($n = 34$), myomectomy ($n = 30$), and cystectomy ($n = 55$). Baseline demographics and clinical characteristics of participants in Groups A and B are shown in Table 1. There was no significant difference between the two groups in age, height, weight, and duration of anesthesia, surgery, and pneumoperitoneum, or the dose of propofol given during general anesthesia. The dose of remifentanil was significantly higher in Group B ($P = 0.01$) [Table 1].

Four-grade pain score ($P = 0.02$) and PHS ($P = 0.01$) were significantly lower in Group A compared with those in Group B on emergence (i.e., at the postoperative time point of 0 h) [Table 2]. The dose of tramadol PCA administration was significantly lower in Group A in the period between 0 and 6 h ($P = 0.01$) [Table 2, Figure 1].

There was no significant difference in the number of patients with nausea (3/60 vs. 1/59, $P = 0.62$) and vomiting (0/60 vs. 1/59, $P = 0.50$) after extubation. During the first 24 h, the number of patients with nausea was significantly lower in Group A compared that in Group B (11/60 vs. 21/59, $P = 0.04$). The number of patients taking medication for nausea was not significantly different between the two groups (6/60 vs. 9/59, $P = 0.42$).

Table 1: Baseline demographics and clinical characteristics in Groups A and B

Number	Group A	Group B	*P* value
	60	59	
Age (yr)	41 (24-70)	38 (24-53)	0.13
Height (cm)	158 (148-172)	160 (145-169)	0.47
Weight (kg)	52 (40-79)	52 (40-76)	0.94
Anesthesia time (min)	169 (95-250)	185 (94-423)	0.24
Operation time (min)	121 (50-204)	134 (40-370)	0.10
Pneumoperitoneum time (min)	100 (35-187)	111 (30-355)	0.15
Propfol (mg)	831 (430-1800)	856 (334-2480)	0.29
Remifentanil (mg)	1.7 (0.7-4.0)	2.1 (0.8-8.5)	0.01
Surgery (Hys/Myo/Cys)*	19/15/26	15/15/29	0.73

**Hys = Hysterectomy, Myo = Myomectomy, Cys = Cystectomy*

Discussion

This study showed that the TAP block successfully reduced postoperative pain at rest and on movement with the use of perioperative multimodal analgesia in patients undergoing laparoscopic gynecologic surgery. The TAP block resulted in significantly lower intra- and post-operative opioid use and decreased need for tramadol PCA. Postoperative nausea was significantly fewer in patients with a TAP block compared with those without the block.

The TAP block originally reported by Rafi was conducted using a superficial landmark between the latissimus dorsi, EOAM, and the iliac crest (i.e., the triangle of Petit).[1] The introduction of US guidance enabled direct visualization of all anatomical structures, needles, and the spread of local anesthetics.[12] In this trial, a safe and effective TAP block was conducted with a portable US device, with clear views of the three muscle layers. There have been a number of recent studies using similar US-guided approaches, including an anterior oblique-subcostal approach, a mid-axillary approach, and a posterior approach.[4,5] The spread pattern of local anesthetics differs depending on the site of injection into the transverses abdominis plane. The anterior oblique-subcostal approach is suitable for upper abdominal incision due to the anterior spread.[13,14] The posterior approach is suitable for lower abdominal incision and its effect lasts longer than other two approaches. The mid-axillary approach is suitable for infraumbilical incision due to the mainly anterior spread and faint spread into the paravertebral space at T12-L2. The area and duration of action of the mid-axillary approach are intermediates of an anterior oblique-subcostal approach and a posterior approach. The spread of local anesthetics into paravertebral space might have a favorable influence on the prolonged analgesia. As laparoscopic gynecologic procedures usually utilize ports placed below the level of the umbilicus, a mid-axillary approach was chosen in this study. Local anesthetics, such as 0.375% levobupivacaine, 0.375-0.75% ropivacaine, or 0.5% bupivacaine, have been used in the amounts of 15-20 mL bilaterally.[15-20] Pain relief is usually achieved without local anesthetic toxicity; however,

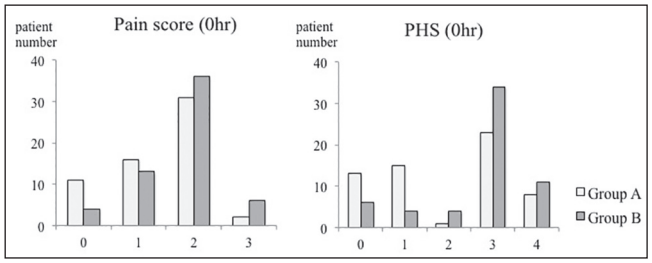

Figure 1: The four-grade pain score and the prince henry pain scale on emergence (at the postoperative time point of 0 h)

Table 2: Pain score, PHS, and the dose of Tramadol required after surgery

	Pain score				PHS				Tramadol (mg) (PCIA)		
	0 h	6 h	12 h	24 h	0 h	6 h	12 h	24 h	0 h-6 h	6 h-12 h	12 h-24 h
Group A (n = 60)	2 (0-3)	1 (0-3)	1 (0-2)	1 (0-2)	3 (0-4)	1 (0-4)	1 (0-3)	1 (0-3)	18 (0-144)	3 (0-96)	0 (0-108)
Group B (n = 59)	2 (0-3)	1 (0-3)	1 (0-2)	1 (0-2)	3 (0-4)	1 (0-4)	1 (0-3)	1 (0-3)	24 (0-84)	0 (0-72)	6 (0-72)
P value	.02	.85	.55	.23	.01	.80	.70	.79	.01	.30	.22

the possibility of toxicity needs to be considered while used in the TAP block. The measurements of ropivacaine blood levels may be helpful to know the distribution of the analgesia and prevent its toxic reaction.

Previous randomized controlled trails have demonstrated the efficacy of the TAP block as a component of a multimodal regimen, in providing postoperative analgesia after abdominal surgeries, including large bowel resection, cesarean delivery, abdominal hysterectomy, open appendectomy, and laparoscopic cholecystectomy.[13,15-17] The TAP block may confer particular advantages in procedures with small to moderate surgical trauma and pain, as in gynecologic laparoscopic surgery.[6,7,21-23] Remifentanil is an ultra-short-acting opioid and is favorable for such surgeries because of early and clear emergence. Previous studies evaluating the efficacy of the TAP block primarily used fentanyl, which remains in effect several hours after surgery. In surgery with mild or moderate operative invasion, we frequently use remifentanil for early emergence. Postoperative analgesics are important even in laparoscopic surgery under general anesthesia with remifentanil, because the effect of remifentanil ceases quickly once administration is stopped. This study revealed that the TAP block reduced the amount of remifentanil required during surgery, as well as lowering the postoperative pain scores and tramadol consumption. Laparoscopic surgery to minimize the operative scar, an ultra-short-acting anesthetic enabling early emergence, and the use of the TAP block to reduce postoperative pain, all of which were used in this study, may enhance early recovery from surgery and shorten hospital stay.

To evaluate the efficacy of the TAP block, especially for postoperative pain with movement, we used a four-grade pain score and PHS. The four-grade pain score reflects pain at rest, and PHS reflects pain while coughing and breathing. A recent study showed that the TAP block after laparoscopic cholecystectomy reduced pain while coughing, but not pain at rest.[24] In our study, postoperative pain at rest and on movement was significantly lower in patients undergoing the TAP block on emergence. Tramadol PCA was utilized for postoperative pain relief in this study; therefore, the significant reduction of tramadol consumption in the postoperative time period of 0-6 h indicated that the TAP block was possibly effective for early postoperative pain. The precise duration of effects of the TAP block was not clarified, because tramadol possibly affected the next period after 6 h due to its longer effect compared with fentanyl. The reduction in tramadol consumption may be related to the fact that postoperative nausea was fewer in patients with a TAP block, which is one of adverse effects of tramadol PCA.[25]

Conclusion

The US-guided TAP block with a mid-axillary approach holds a considerable promise as a part of a balanced postoperative analgesic regimen following laparoscopic gynecologic surgery. Further studies are needed to investigate the optimal local anesthetic concentration and volume required to maintain postoperative pain relief for an adequate length of time.

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