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Effect of transversus abdominis plane block on the quality of recovery in laparoscopic nephrectomy

A prospective double-blinded randomized controlled clinical trial

Jun-Mo Park, MD, PhD[a,*], Joonhee Lee, MD[b]

Abstract

Background: Poorly controlled acute postoperative pain after laparoscopic nephrectomy may adversely affect surgical outcomes and increase morbidity rates. In addition, excessive use of opioids during surgery may slow postoperative endocrine and metabolic responses and cause opioid-related side effects and opioid-induced hyperalgesia. The purpose of this study was to evaluate the effect of ultrasound-guided transversus abdominis plane (TAP) block on the postoperative quality of recovery and intraoperative remifentanil requirement in laparoscopic nephrectomy.

Methods: Sixty patients who underwent laparoscopic nephrectomy were randomly divided into 2 groups: TAP and Control groups. After induction of anesthesia and before awakening from anesthesia, the TAP group was administered 40 mL of 0.375% ropivacaine and the Control group was administered 40 mL of normal saline to deliver ultrasound-guided TAP block using 20 mL of each of the above drugs. The main objectives of this study were to evaluate the effect of the TAP block on quality of recovery using the Quality of Recovery 40 (QoR-40) questionnaire and assessments of intraoperative remifentanil requirement. In addition, to evaluate the postoperative analgesic effect of the TAP block, the total usage time for patient-controlled analgesia (PCA) and the number of PCA bolus buttons used in both groups were analyzed.

Results: The QoR-40 score, measured when visiting the ward on the third day after surgery, was significantly higher in the TAP group (171.9 ± 23.1) than in the Control group (151.9 ± 28.1) (P = .006). The intraoperative remifentanil requirement was not significantly different between the groups (P = .439). In the TAP group, the frequency of bolus dose accumulation at 1, 2, 3, 6, 12, 24, 48, and 72 hours after surgery was low enough to show a significant difference, and the total usage time for PCA was long enough to show a significant difference.

Conclusion: In conclusion, we determined that ultrasound-guided TAP block during laparoscopic nephrectomy improves the quality of postoperative recovery and is effective for postoperative pain control but does not affect the amount of remifentanil required for adequate anesthesia during surgery.

Abbreviations: BIS = bispectral index, IV = intravenous, KvQoR-40 = Korean version of the quality of recovery 40, PCA = patient-controlled analgesia, QoR-40 = quality of recovery 40, TAP = transversus abdominis plane.

1. Introduction

Severe acute postoperative pain adversely affects the quality of recovery in surgical patients as well as patients' surgical outcomes.[1] As the average age of patients undergoing surgery continues to increase due to the rapid aging of the global population, the number of patients with underlying medical diseases (including cardiopulmonary, respiratory, and endocrine system diseases) is increasing significantly and at a much higher rate than in the past.[2] Therefore, achieving proper control of acute postoperative pain is necessary. We note that opioids used to maintain proper anesthesia during surgery have a meaningful effect on the patient's immunity, thereby strongly affecting the surgical outcome.[3]

Recently, nephrectomy has been performed laparoscopically to minimize surgical scars and postoperative pain at the surgical site due to performing surgery through the smallest possible incision. Nevertheless, these techniques still require the use of powerful analgesics after surgery. Moreover, in most cases, laparoscopic nephrectomy results in complaints of severe pain requiring the use of patient-controlled analgesia (PCA) after surgery. PCA is widely used on a global scale, as it has proven effective in acute postoperative pain control.[4]However, as the main drugs used for PCA are intravenous opioids and nonsteroidal anti-inflammatory drugs, it is not uncommon for PCA to be removed in the middle of the treatment course due to the common occurrence of adverse side effects, such as dizziness, nausea, vomiting, urticaria, and respiratory depression.[5] Therefore,

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All data generated or analyzed during this study are included in this published article [and its supplementary information files].

[a] Department of Anesthesiology and Pain Medicine, School of Medicine, Kyungpook National University, Kyungpook National University Hospital, Daegu, South Korea, [b] Department of Anesthesiology and Pain Medicine, Kyungpook National University Chilgok Hospital, Daegu, South Korea.

**Correspondence: Jun-Mo Park, Department of Anesthesiology and Pain Medicine, Kyungpook National University Chilgok Hospital, 807 Hoguk-ro, Bukgu, Daegu 41404, South Korea (e-mail: pjm4013@naver.com).*

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in many cases, a pain control method to replace PCA is urgently needed, and a multimodal approach has recently been recommended to this effect.[6,7] As part of a multimodal approach (and given recent developments in ultrasound devices), regional analgesia under ultrasound guidance is currently widely performed in order to minimize the use of opioids during surgery and to reduce postoperative pain, even in surgeries performed under general anesthesia.[8]

Since Rafi et al[9] first introduced the landmark-guided transversus abdominis plane (TAP) block in 2001, it has become one of the most commonly performed truncal blocks (after undergoing several modifications). It is effective for acute postoperative pain control after various types of abdominal surgery using laparotomy or laparoscopy.[10] In particular, with recent developments in ultrasound devices, the increased use of portable devices has made it easier to implement ultrasound devices in a clinical setting, thereby enabling the performance of safer and more accurate procedures (even in an already state-of-the art operating room).[11,12]

The quality of recovery after anesthesia and surgery is critically important in evaluating the success of the operation and is an important measure in judging a patient's initial health status after surgery.[13] With increasing interest in the quality of recovery, several methods for assessing this metric have been under active development within the field of anesthesia. The Quality of Recovery-40 (QoR-40) questionnaire developed by Myles et al[13] is one of the most commonly used tools in this regard. Despite the distinctly different cultural backgrounds of targeted patients, the Korean version of the QoR-40 (KvQoR-40) has been shown to be acceptable and as reliable as the original English-language QoR-40 in terms of assessing the quality of recovery after anesthesia and surgery in Korean patients.[14]

The purpose of this study was to determine the effect of ultrasound-guided TAP block, administered after induction of general anesthesia and before awakening from general anesthesia, on the quality of recovery after surgery using the QoR-40 as well as to assess remifentanil requirements during surgery in patients undergoing laparoscopic nephrectomy. We hypothesized that the use of ultrasound-guided TAP block would enhance patients' quality of recovery and reduce the use of remifentanil.

2. Materials and Methods

2.1. Study design

This study was conducted at the Kyungpook National University Chilgok Hospital (Daegu, South Korea) between January 2016 and February 2017. The study protocol was approved by the Research Ethics Committee of the Kyungpook National University Chilgok Hospital, Daegu, South Korea. This study received institutional approval (KNUCH 2015-12-004) and was conducted in accordance with the principles of the Declaration of Helsinki. All the participants provided their informed consent prior to participation.

2.2. Patient selection

Sixty of the 87 patients who underwent laparoscopic nephrectomy during the study period participated in this study. Only patients, aged between 20 and 80 years, with an American Society of Anesthesiologists physical status class I to III who had undergone laparoscopic nephrectomy under general anesthesia in the Department of Urology at Kyungpook National University Chilgok Hospital were included in the current study.

Patients were excluded from this study if they refused to participate or if they exceeded American Society of Anesthesiologists physical status class III, were younger than 19 years of age or older than 81 years of age, had difficulty communicating due to an intellectual disability, underwent partial nephrectomy or nephroureterectomy, had previously undergone abdominal or pelvic surgery, were undergoing multiple (combined) surgeries on other parts of the body/other organs, were excessively obese (body mass index >35 kg/m^2), had a history of long-term opioid usage, had a hemorrhagic predisposition or a hemorrhagic disorder, or presented with contraindications to regional anesthesia.

2.3. Randomization and blinding

Patients were randomly assigned to either the TAP group (receiving 40 mL of 0.375% ropivacaine; n = 30) or the Control group (receiving only 40 mL of normal saline; n = 30). Randomization was computer-generated (https://www.randomizer.org), and a sealed opaque envelope method was used to hide patient randomization numbers until the start of anesthesia induction. The sealed opaque envelope was opened by the research investigator immediately before performing the TAP block. A registered nurse, who did not enter the operating room and was fully familiar with the methods and procedures of this study, was in charge of consultation with patients and data collection and was blinded to the group assignments, which were not disclosed until the final statistical analysis was completed.

2.4. General anesthesia and monitoring

The patients included in this study were not administered any prior medication. During the operation, the patient was monitored using pulse oximetry, electrocardiography, noninvasive arterial pressure measurements, capnography, bispectral index (BIS) measurements, and a nasopharyngeal temperature probe. However, some elderly patients and/or those with cardiovascular disease were monitored using invasive radial arterial blood pressure measurements. To induce general anesthesia, total intravenous anesthesia was initiated using target-controlled infusion of propofol and remifentanil (Orchestra; Fresenius Vial, Auvergne Rhone Alpes, France). The initial effect-site concentration of propofol was 6.0 μg/mL; this was gradually increased until BIS values reached 40 to 60. Following this, 3.0 ng/mL of remifentanil was started with a targeted injection of remifentanil at the effect site. When the remifentanil concentration reached the target value, 0.8 mg/kg of rocuronium was administered to facilitate endotracheal intubation. The lungs were ventilated with a tidal volume of 7 mL/kg, and the respiratory rate was adjusted to maintain the end-tidal partial pressure of carbon dioxide at 30 to 40 mm Hg. Target-controlled infusion of propofol and remifentanil was continued throughout the surgery. Concentrations of propofol and remifentanil were continuously adjusted to maintain a BIS value of 40 to 60 and a mean arterial pressure of ±20% of the reference value. To maintain the patient's vital signs, the remifentanil concentration was maintained below 2 ng/mL; in addition, phenylephrine was injected when the patient's mean arterial blood pressure was maintained below 80% of the baseline. To maintain vital signs, nicardipine was administered when the remifentanil concentration was maintained at ≥8 ng/mL or when the patient's mean arterial blood pressure was maintained at or above 120% of the baseline value. Atropine and esmolol were administered separately when the patient's heart rate dropped to less than 46 beats per minute or increased to more than 30 seconds or increased to more than 90 beats per minute for more than 30 seconds. Repeated or continuous infusion was performed when deemed necessary. Rocuronium was injected at 1 μg/kg/min to maintain muscle relaxation during surgery and was stopped before closing the abdomen. During surgery, lactated Ringer's solution was continuously injected at 8 mL/kg/h, and the amount of bleeding was supplemented with 3 times the volume of lactated Ringer's solution throughout the surgery. A heated blanket and warm intravenous and surgical irrigation fluids were applied to maintain normal body temperature. In all patients, PCA was

connected to the patient immediately before skin closure was completed, and propofol and remifentanil infusions were discontinued. After sufficient oral aspiration, the inhaled oxygen fraction and fresh gas flow rate were increased to 100% and 8 L, respectively. The neuromuscular blockade was reversed with 0.4 mg glycopyrrolate and pyridostigmine (15 mg) and confirmed by train-of-four monitoring. The endotracheal tube was removed when the patient regained spontaneous breathing and consciousness. The patient was then transferred to the postoperative recovery room. Lactated Ringer's solution was injected in the postoperative recovery room at a rate of 2 mL/kg/h.

2.5. TAP block

In all surgeries, the TAP block was performed twice (after induction of general anesthesia and before awakening from general anesthesia). All surgeries and TAP blocks were performed in the lateral decubitus position with a slight table break at the waist.

All study procedures were performed by one of the study authors (with more than 10 years of experience in ultrasound procedures), including injecting 20 mL of 0.375% ropivacaine or normal saline into the TAP space under ultrasound guidance (ProSound Alpha7 Premier; Hitachi Aloka Medical, Tokyo, Japan) using a broadband (4–13 MHz) linear array ultrasound probe. Both the subcostal and lateral approaches were used to sufficiently cover the entire surgical site of the laparoscopic nephrectomy.[10] The subcostal approach targets the TAP compartment of the anterior abdominal wall (between the xyphoid process and the anterosuperior iliac spine), whereas the lateral approach targets the TAP compartment of the lateral abdominal wall (between the mid-axillary and anterior axillary lines). Drug injection was performed at 3 to 5 sites, and an ultrasound scan was performed to confirm that the drug was evenly distributed throughout the skin incision.

2.6. The QoR-40 questionnaire

One of the study authors fully explained the QoR-40 to the study patients when visiting the ward the day before the surgery. This study was conducted before the research results of KvQoR-40 were introduced; therefore, a translation of QoR-40 from English into Korean was used. After the research results of KvQoR-40 were introduced, it was confirmed that there was no difference between the translated content and the content or meaning of the KvQoR-40 questionnaires. Namely, it consists of 40 questions in Korean; 5 points are awarded for each question for a maximum total of 200 points. The higher the total score, the higher the quality of recovery. On the third day of surgery, a researcher blinded to the patient's group assignment completed the QoR-40 questionnaire.

2.7. PCA data extraction and analysis

Patients were treated using an electronic intravenous (IV) PCA device (Accumate 1100, Woo Young Medical, Seoul, South Korea); the drug consisted only of fentanyl and ramosetron, with a total volume of 60 mL. The basal infusion rate was 0.5 mL/h and the bolus dose was set at 0.5 mL. The lockout interval was set at 15 minutes. An IV PCA was connected to the venous fluid line before the end of the skin sutures. On the day before the surgery, patients were instructed to press the PCA bolus button when they felt pain (visual analog scale score of 3 or higher). After pressing the bolus button, if pain (visual analog scale score of 3 or higher) persisted for more than 15 minutes, the same procedure was repeated. If the pain still persisted, a rescue analgesic was used according to the existing manual set forth by the Department of Urology at our hospital. After the IV PCA was completely used, it was collected and the total usage time of the PCA was checked. In addition, the information stored in the PCA machine was extracted into an Excel datasheet (Excel 2018; Microsoft, Redmond, WA), and the frequency of bolus doses of IV PCA injected into the patient at 1, 2, 3, 6, 12, 24, 48, and 72 hours after surgery was analyzed.

2.8. Study outcomes

The main purpose of this study was to evaluate the effect of TAP block, which was administered twice (after induction of general anesthesia and before awakening from general anesthesia), on the postoperative quality of recovery using the QoR-40 as well as patients' intraoperative remifentanil requirements (μg/kg/h) in comparative evaluations between the TAP and Control groups. In addition, to evaluate the postoperative analgesic effect of the TAP block, the total duration of PCA used after surgery and the frequency of bolus doses of IV PCA injected into the patient at 1, 2, 3, 6, 12, 24, 48, and 72 hours after surgery in both groups were analyzed.

2.9. Sample size

The postoperative quality of recovery using the QoR-40 and intraoperative remifentanil requirements were evaluated to judge the effect of the TAP block. In a preliminary study of 16 patients, the means ± standard deviations of the QoR-40 score, used to confirm the postoperative quality of recovery in the Control and TAP groups, were 160.3 ± 25.1 and 188.3 ± 6.3, respectively. As we aimed to maintain 95% power and a 5% significance level, we calculated a target sample size of 14 patients per group. In a preliminary study of 16 patients, the means ± standard deviations for the intraoperative remifentanil requirement (μg/kg/h) in the Control and TAP groups were 0.153 ± 0.053 and 0.104 ± 0.035, respectively. Again, as we aimed to maintain 95% power and a 5% significance level, we calculated a target sample size of 23 patients per group. We followed the results of the intraoperative remifentanil requirement for study accuracy. We determined that, assuming a 30% dropout rate, a minimum of 30 patients per group would be required to achieve meaningful results in this study.

2.10. Statistical analysis

Data were entered into a study database and analyzed using IBM SPSS Statistics (v. 27.0; IBM Corp, Armonk, NY). Statistical analysis was performed using the x^2 test for comparative evaluations by sex (among the demographic data), and independent *t* tests were used to evaluate the distributions of the other demographic data across groups. In addition, the statistical significance between the TAP and Control groups with regard to QoR-40 scores, intraoperative remifentanil requirements, and IV PCA administrations (Excel data) were verified using independent t-tests. All values were expressed as means ± standard deviations. All reported *P* values were 2-sided, and *P* values <.05 were considered statistically significant.

3. Results

3.1. Patient characteristics

Of the 87 patients who underwent laparoscopic nephrectomy during the study period, 5 refused to participate in this study, 14 underwent laparoscopic partial nephrectomy, 4 underwent laparoscopic nephroureterectomy, 2 underwent combined surgeries, and 2 had a body mass index of >35 kg/m^2. Thus, a total of 60 patients were randomly assigned to 2 groups. Two patients from the Control group and 1 patient from the TAP group were excluded from the study due to side effects arising from IV PCA, including nausea, vomiting, and urticaria. Two patients from the Control group and 1 patient from the

TAP group were excluded from the study because of a switch to open surgery. A total of 54 patients (Control group, n = 26; TAP group, n = 28) were included in the final study population (Fig. 1). Table 1 presents the comparative demographic and perioperative characteristics for the 2 groups. There were no significant differences in these medical and demographic characteristics between the 2 groups.

3.2. The QoR-40 questionnaire

The QoR-40 score, measured when visiting the ward on the third day after surgery, was significantly higher in the TAP group (171.9 ± 23.1) than in the Control group (151.9 ± 28.1) (P = .006) (Fig. 2).

3.3. Intraoperative remifentanil requirement

The intraoperative remifentanil requirement (μg/kg/h) did not show a significant difference between groups (0.100 ± .050 in the TAP group vs 0.111 ± .060 in the Control group) (P = .439) (Fig. 3).

3.4. PCA data

The frequency of use of the bolus dose accumulated at 1, 2, 3, 6, 12, 24, 48, and 72 hours after surgery was 1.15 ± 0.97, 2.85 ± 1.08, 3.81 ± 1.44, 6.38 ± 3.60, 10.12 ± 5.96, 14.96 ± 10.53, 23.30 ± 17.44, 24.40 ± 17.76, respectively, in the Control group and 0.64 ± 0.83, 1.86 ± 1.18, 2.68 ± 1.44, 4.32 ± 3.43, 6.21 ± 5.50, 9.43 ± 9.22, 10.70 ± 9.64, 12.44 ± 11.32, respectively, in the TAP group. All results for each time period showed a significant difference (P = .041, P = .002, P = .006, P = .036, P = .015, P = .047, P = .008, P = .034) (Fig. 4). The total usage time for PCA showed a significant difference, as the usage time in the TAP group (70.26 ± 34.0 hours) was much greater than that in the Control group (50.05 ± 32.6 hours; P = .030) (Fig. 5).

4. Discussion

The results of this study demonstrated that the implementation of a unilateral ultrasound-guided TAP block during laparoscopic nephrectomy significantly affected patients' quality of recovery after surgery. The remarkably improved quality of recovery achieved using the TAP block procedure was also confirmed by the increase in total PCA usage time and significantly fewer injections of the PCA bolus dose in the TAP group than in the Control group. However, the TAP block had no effect on the amount of remifentanil required for adequate anesthesia during surgery.

With the recent development of ultrasound technology and increase in the use of ultrasound devices, new regional anesthetic and analgesic techniques are being actively developed and implemented.[15] This trend has made it possible to safely inject an appropriate amount of local anesthetics around the desired nerve, avoiding major structures such as blood vessels, instead of the conventional method of injecting a large amount of local anesthetic around a large peripheral nerve.[11,12] Recently, fascial plane block has received considerable attention.[15] However, adequate studies that can draw clear conclusions about its effects are still lacking. The TAP block is one of the most commonly

Table 1

Patient characteristics and intraoperative data.

	Control (n = 26)	TAP (n = 28)	*P* value*
Gender (M/F)	18/8	19/9	.914
Age, yr	58.8 ± 11.7	59.4 ± 9.0	.847
Height, cm	164.8 ± 9.5	164.3 ± 9.3	.840
Weight, kg	66.4 ± 10.5	69.5 ± 11.9	.303
BMI	24.4 ± 2.8	25.7 ± 3.5	.125
Operation time, min	186 ± 53.7	197 ± 38.1	.398
Anesthesia time, min	225.8 ± 55.7	247.6 ± 33.1	.091

BMI = body mass index (kg/m^2).

Results are presented as means ± standard deviation, or numbers of patients.

*P < .05 indicates a significant difference between groups.

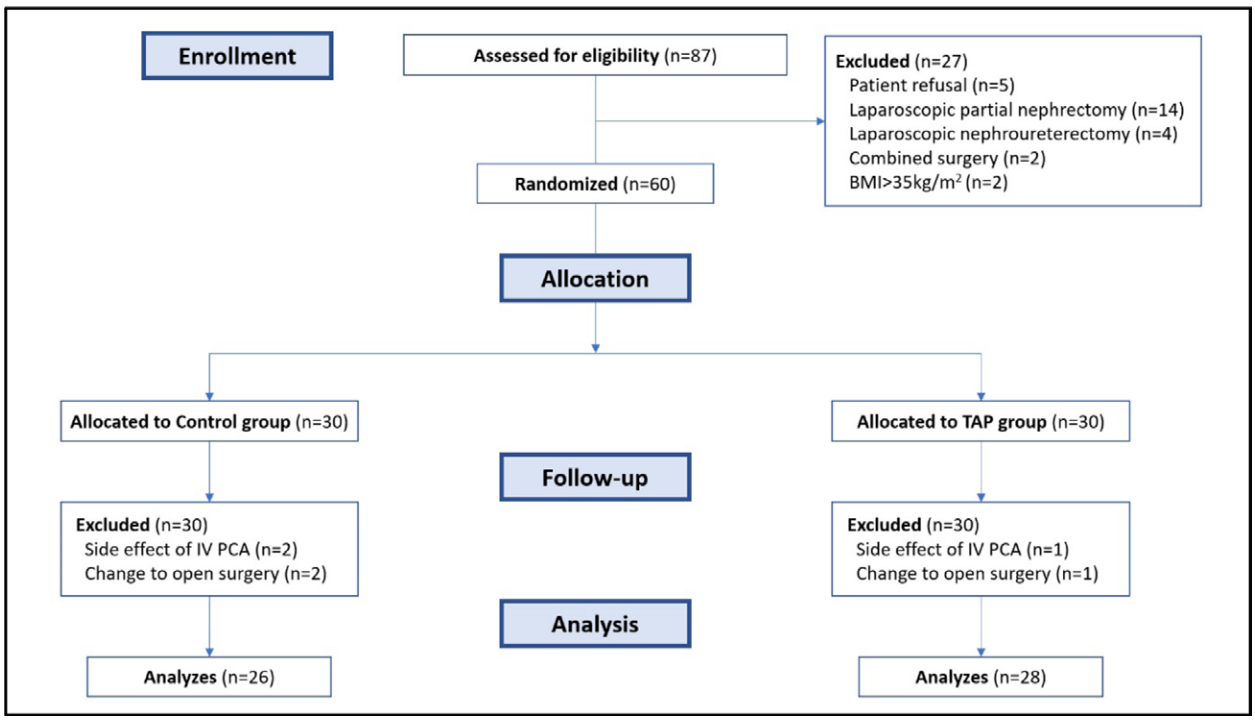

Figure 1 Patient flowchart showing the patients included in the enrollment, group allocation, follow-up, and analysis phases of the study.

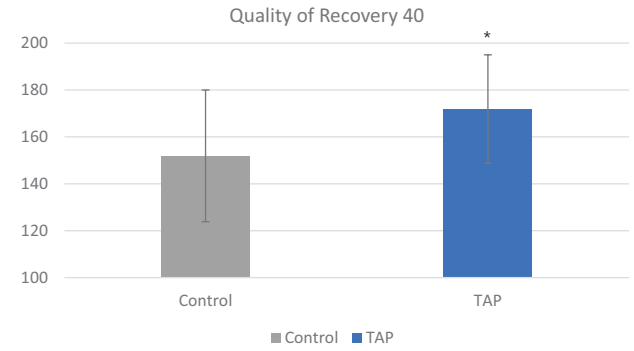

Figure 2 Quality of recovery 40 questionnaire findings. *P < .05 indicates a significant difference between groups.

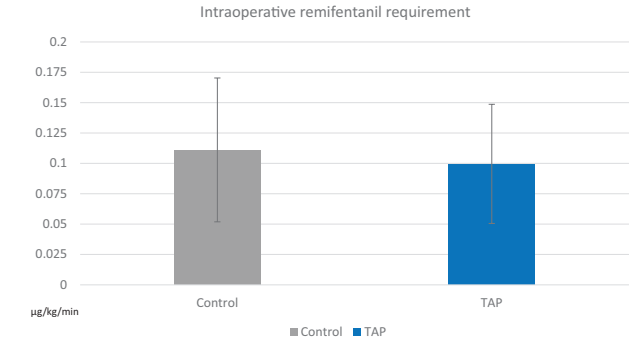

Figure 3 Intraoperative remifentanil requirement.

used methods and is one of the first used methods among fascial plane blocks.

In some studies, ultrasound-guided TAP block in laparoscopic nephrectomy reduced acute postoperative pain scores and early opioid consumption.[16,17] A recent study showed that ultrasound-guided TAP block performed in robotic partial nephrectomy reduced morphine consumption and somatic pain for 24 hours postoperatively and reduced the incidence of chronic pain.[18] However, the results of a recent study contradict those of previous studies.[19] Moreover, a recent meta-analysis of the analgesic effect of ultrasound-guided TAP block in laparoscopic abdominal surgery showed that TAP block had marginal postoperative analgesic effect.[20] According to the most recently published systematic review and meta-analysis of TAP blocks in urological procedures, although TAP block appears to provide improved analgesia in urological surgery, there is great heterogeneity between the findings of the included studies, and due to significant risk of bias, careful review is recommended.[21] Given these limited results, it is still inappropriate to conclude that TAP blocks contribute to early postoperative analgesia after laparoscopic nephrectomy.

Conflicting results have been reported on the effects of TAP block in abdominal surgeries other than urological surgery (e.g., nephrectomy). Studies showed that TAP blocks in robot-assisted distal pancreatectomy and total abdominal hysterectomy reduced postoperative pain and opioid consumption.[22,23] However, a study reported no effect of TAP block in total abdominal hysterectomy.[24] Although it is not possible to explain exactly why the results of TAP blocks in different types of surgery are conflicting, it is clear that TAP blocks show conflicting results across different types of surgery. However, recent studies have shown promising results possibly due to the increase in the skill and experience of the TAP block operator along with the development of ultrasound equipment.

Although the common goal is to block afferent nociceptive propagation, fascial plane blocks such as TAP blocks do not target specific nerves, unlike conventional methods that target specific nerves. Fascial plane block is a method of injecting a local anesthetic into a compartment (plane) between 2 anatomically separated fascia layers.[25] Fascial plane block has recently attracted attention because it is relatively easy, and safe and can provide meaningful analgesia in various clinical settings.[26] However, there is controversy about how clinical effects are achieved because fascial plane blocks exert their effects through several different pathways, as opposed to conventional methods.[25] In fascial plane block, dense nerve block is rarely seen, the results obtained in individual patients may be different, and the degree of skin sensory block may not sufficiently reflect the analgesic effect.

The causes of pain associated with laparoscopic nephrectomy vary, including port pain, lower abdominal incision (to retrieve

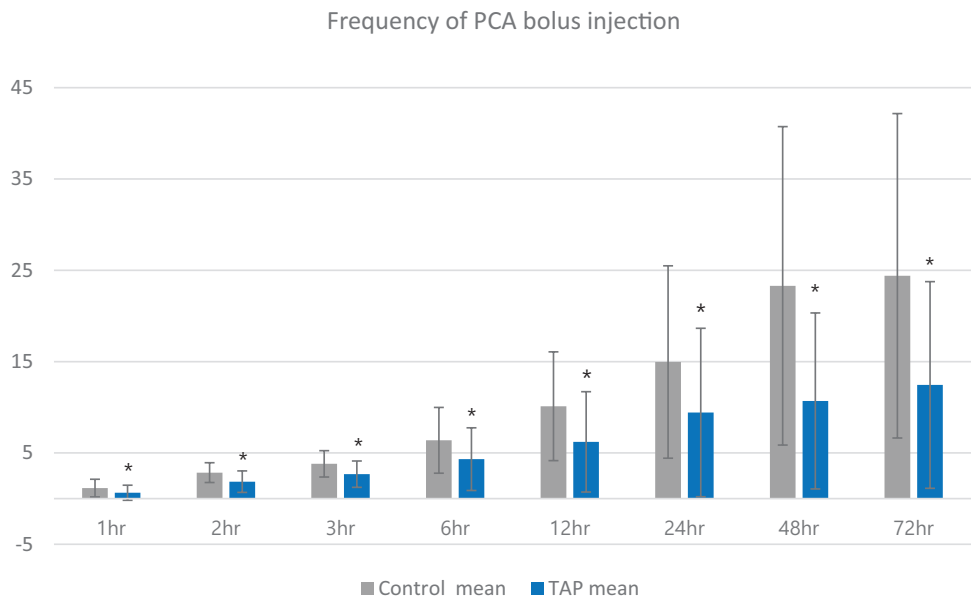

Figure 4 Frequency of PCA bolus injection. PCA = patient-controlled analgesia. *P < .05 indicates a significant difference between groups.

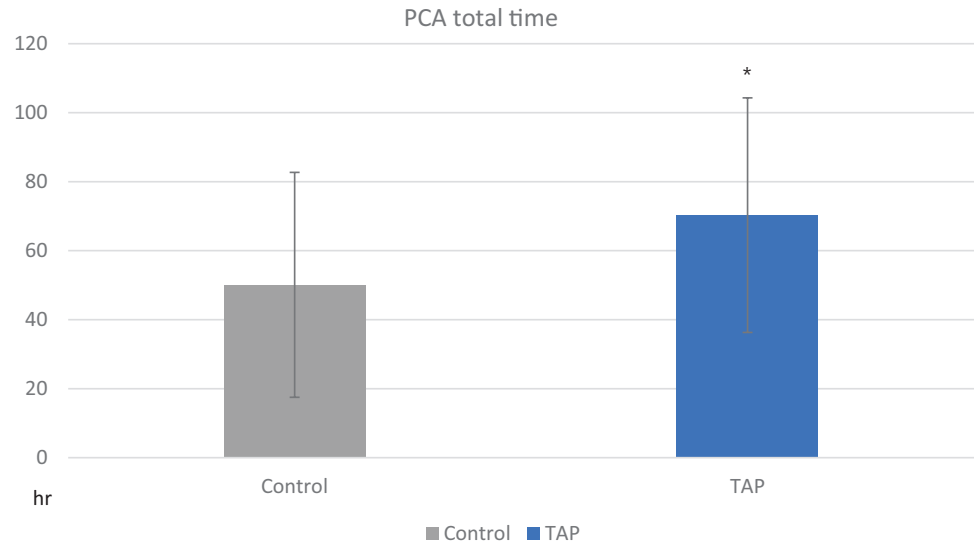

Figure 5 Total time for use of PCA. PCA = patient-controlled analgesia. *P < .05 indicates a significant difference between groups.

the kidney) pain, pelvic organ pain, diaphragm stimulation (discomfort at the tip of the shoulder due to residual pneumothorax), and urethral catheter discomfort.[27] There is no difference in acute postoperative pain scores after laparoscopic and laparotomy, and if acute postoperative pain is not reduced appropriately, the likelihood of chronic postsurgical pain is the same.[28] Chronic postsurgical pain is most affected by postoperative pain severity and psychological vulnerability.[27] The more severe the postoperative dynamic pain (movement-induced pain), the higher the risk of chronic postsurgical pain. Although opioids are potent analgesics, they are mostly unsuitable for treating dynamic pain, whereas regional analgesia using local anesthetics, nonsteroidal anti-inflammatory drugs, α_2-agonists, and N-methyl-D-aspartate receptor antagonists may be effective for controlling dynamic types of pain and preventing central sensitization.[27] Preemptive TAP block in laparoscopic nephrectomy can potentially reduce the intraoperative metabolic response and avoid central sensitization, thereby reducing the incidence of chronic postsurgical pain.

With the current risk of the opioid epidemic being highlighted, the enhanced recovery after surgery pathway has emerged as one of the best strategies to improve the value and quality of surgical treatment.[6] Multimodal analgesia is one of the most essential components of the enhanced recovery after surgery pathway. Multimodal analgesia can have additive, if not synergistic, effects using various regional analgesic techniques or non-opioid analgesics and can reduce opioid usage and opioid-related side effects. Regional analgesic techniques that can be used for laparoscopic nephrectomy are generally divided into neuraxial (e.g., epidural analgesia and intrathecal morphine) and peripheral (e.g., TAP, quadratus lumborum block, retrolaminar block, erector spinae plane block, and wound infiltration) blocks or catheters. Epidural analgesia remains the standard method of application for major abdominal surgeries, but has the disadvantage of higher risks associated with the procedure.[29] Fascial plane blocks such as TAP blocks are very important factors in multimodal analgesia and have the advantage of being safer than epidural analgesia in patients with obesity, but they are not effective in controlling visceral pain and do not match the duration of analgesia.[11] Recently, in addition to TAP block, quadratus lumborum block, retrolaminar block, and erector spinae plane block have been found to be useful in patients undergoing laparoscopic nephrectomy.[30–33]

There might be several possible reasons underlying the results that the intraoperative remifentanil requirement did not differ, but the postoperative pain control and opioid consumption differed between the 2 groups. A commercially available ampule of 0.75% ropivacaine was used for convenience in conducting this study and to avoid local anesthetic systemic toxicity. For both procedures (i.e., after anesthesia induction and before awakening from anesthesia), 20 mL of 0.75% ropivacaine was mixed with 20 mL of normal saline to constitute 40 mL of 0.375% ropivacaine. Only a limited effect was considered to be shown in reducing the intraoperative remifentanil requirement because a proper regional anesthetic was not administered (i.e., because half the concentration typically used when performing regional anesthesia was used in the current study). However, TAP block, which was administered at the same subanesthetic concentration before awakening from anesthesia, had a significant effect on postoperative pain control; therefore, TAP block is thought to be effective for pain control up to 72 hours after surgery. This can be confirmed by the results reported by Cederholm et al,[34] showing that a lower concentration of ropivacaine decreased the number of blood vessels in the skin, whereas a higher concentration of ropivacaine induced an increase in blood flow. It is thought that a lower concentration of ropivacaine reduces the absorption of local anesthetic into the systemic circulation by decreasing the number of blood vessels, allowing the local anesthetic to stay around the target nerve for a longer period of time, and exhibiting analgesic effects for a longer period of time. Based on the results of the present study, we conclude that additional research according to the type and concentration of local anesthetics used in the TAP block is needed and that this gap in the literature should be addressed in future research endeavors. Considering the characteristics of the procedure (which is performed under ultrasound guidance), it is thought that the operator's skill level or experience as well as the quality of the ultrasound device can greatly influence the results of the procedure. However, considering that all study procedures were performed by one study authors, who had more than 10 years of experience using ultrasound, the possibility of adverse effects occurring due to a lack of operating skill level or experience is low. At the same time, it should be considered that the fascial plane in which the TAP block is applied is poorly vascularized and that the TAP block may have a prolonged analgesic effect due to slow drug clearance.[35,36]

Therefore, we conclude that ultrasound-guided TAP block during laparoscopic nephrectomy improves the quality of postoperative recovery and is effective for postoperative pain control, but does not affect the amount of remifentanil required for adequate anesthesia during surgery.

Author contributions

Conceptualization: Jun-Mo Park.
Data curation: Joonhee Lee.
Formal analysis: Joonhee Lee.
Investigation: Jun-Mo Park.
Supervision: Jun-Mo Park.
Validation: Jun-Mo Park.
Visualization: Joonhee Lee.
Writing – original draft: Jun-Mo Park.
Writing – review & editing: Jun-Mo Park.

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