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Original Contribution

Anesthesia management with ultrasound-guided thoracic paravertebral block for donor nephrectomy: A prospective randomized study☆

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ABSTRACT

Study objective: To determine the efficacy of ultrasound-guided thoracic paravertebral block intraoperatively and 24 hours postoperatively in patients undergoing donor nephrectomy.
Design: Prospective randomized controlled study.
Setting: Private foundation university hospital; November 2014 to June 2015.
Patients: Thirty-two patients undergoing donor nephrectomy (exclusion criteria: coagulation disorders, allergy to local anesthetics, and unwillingness to participate). The final study population comprised 30 patients (15 male, 15 female) randomly assigned to either Group P (paravertebral block, n = 14) or Group M (morphine, n = 16).
Interventions: In Group P, a unilateral paravertebral catheter was inserted 1 day preoperatively; on the day of surgery, a single-level unilateral paravertebral block was administered through the catheter before general anesthesia. Infusion of bupivacaine continued intraoperatively and postoperatively. Patients in Group M received only general anesthesia, and morphine patient-controlled analgesia was begun postoperatively.
Measurements: Intraoperative analgesic and anesthetic requirement, postoperative numerical rating scale pain scores, additional analgesic consumption during the postoperative period, and incidence of complications related to thoracic paravertebral block (TPVB) like pleural puncture, pneumothorax, epidural spread, injection into the subarachnoid space, intravascular injection, and Horner's syndrome and rate of opioid related adverse reactions like nausea and vomiting, itching, constipation, and respiratory depression.
Results: Intraoperative remifentanil consumption was significantly higher in Group M, and postoperative morphine consumption was significantly lower in Group P ($P < .001$). During the first 24 hours postoperatively, the mean numerical rating scale pain scores were similar and there were no significant differences between the 2 groups. There were no statistically significant differences in the additional analgesic consumption and rate of adverse reactions between the 2 groups. We didn't detect any complication related to TPVB in group P.
Conclusions: Continuous thoracic paravertebral block provides good intraoperative stability with a low anesthetic requirement and reduces postoperative morphine consumption for up to 24 hours. Ultrasound guided technique enhanced the safety of TPVB and provides analgesia without major complications.

1. Introduction

A flank approach may allow better dissection of the renal pelvis and pedicles and be advantageous in open nephrectomy; however, this approach induces more persistent pain [1]. Intravenous patient-controlled analgesia (IV-PCA) with opioids is one of the most widely used methods of pain control, but IV-PCA alone is insufficient for managing some patients with severe postoperative pain [2]. Thoracic paravertebral block (TPVB) is a simple and a safe method with significant advantages over neuraxial or intercostal blocks and results in ipsilateral somatic motor and sensory nerve block of multiple contiguous thoracic dermatomes above and below the injection site [3]. TPVB may also reduce anesthetic and analgesic requirements and provide hemodynamic stability in surgical patients. Many studies have shown that TPVB is an effective form of analgesia after thoracotomy, multiple fractured ribs, major breast surgery, and inguinal hernia repair [4]. However, data on the use of TPVB in patients undergoing renal surgery [2,5-7], especially donor nephrectomy [2,8,9] are limited.

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Three randomized studies have assessed the efficacy of PVB for percutaneous nephrolithotomy [5-7]. In one study, lumbar (L_1–L_2) PVB was performed and a catheter inserted to provide intraoperative surgical anesthesia [5], and in another, multiple-level TPVB (T_{10}–T_{12}) was performed at the end of surgery to provide postoperative analgesia [6]. In a recent prospective, observer-blinded randomized controlled study, single-level ipsilateral TPVB with a catheter was administered at T_9–T_{10} for percutaneous nephrolithotomy [7]. The authors concluded that PVB provides intraoperative and postoperative pain relief and improves the quality of recovery in patients undergoing percutaneous nephrolithotomy.

PVB has also been described as a technique for postoperative analgesia for open renal surgery in adults [2,8,9] and children [10,11]. Recently, an observer-blinded, randomized controlled study using TPVB for nephrectomy added preoperative single TPVB to IV-PCA, which resulted in better analgesia than with IV-PCA alone [2].

Several reports [2,5-11] have shown that TPVB provides safe and effective perioperative analgesia for renal procedures. However, differences between the level of catheter placement and technique make study comparison difficult. Also, to our knowledge, there are no randomized controlled studies of ultrasound-guided continuous TPVB in donor nephrectomy. Therefore, our aim in this prospective randomized controlled study was to determine the efficacy of ultrasound-guided TPVB intraoperatively and during the first 24 hours postoperatively in patients undergoing donor nephrectomy.

2. Methods

Ethical approval for this study (project no: KA14/102) was provided by the Baskent University Institutional Review Board and Ethics Committee, Ankara, Turkey (chairperson H. Ozkardes, MD, PhD) on 17 November 2014. After obtaining written informed consent from the study participants we enrolled 32 patients undergoing donor nephrectomy in this prospective randomized controlled study from November 2014 to June 2015.

We excluded patients with coagulation disorders, those with a history of allergy to local anesthetics, and those who elected not to participate. Patients were randomly assigned to one of 2 groups: Group P (PVB) and Group M (morphine) using the closed-envelope technique. The number of patients required for each group was determined using a power analysis. Anticipating a 2.5 point difference in the numerical rating scale (NRS) score for pain (where 0 = no pain, 10 = worst pain) as the desired difference with a standard deviation of 2 points (observed in a previous study of PVB), the estimated sample size was 14 per group with $\alpha = 0.05$ and power = 90%. The study was conducted with 16 patients in each group to ensure adequate final numbers. A unilateral paravertebral catheter was inserted 1 day before surgery in patients in Group P, and on the day of surgery, a single-level unilateral paravertebral block was administered through the paravertebral catheter, followed by general anesthesia. Patients in Group M received only general anesthesia. During and after the surgery, bupivacaine infusion continued through the catheter in Group P. In Group M, morphine PCA was begun in the postanesthesia care unit.

A thoracic paravertebral catheter was inserted at T_{11}–T_{12} in 16 donor nephrectomy cases by the same anesthetist with the help of a radiologist under ultrasound guidance (Siemens Antares ultrasound unit; Siemens Healthcare, Mountain View, CA) with a 5- to 13-MHz frequency range VF13–5 linear probe. We previously used the study reported by Baik and coll. [2] to determine the ideal level of the PVB in a pilot study of four cases. Two catheters inserted at T_9 provided inadequate analgesia, and both patients suffered pain at the distal incision. A catheter inserted at T_{11}–T_{12} in the other 2 cases did provide adequate analgesia.

One day before surgery on the proposed side of operation, a thoracic paravertebral catheter was inserted under ultrasound guidance with the patient in a sitting posture and under strict aseptic precaution. The transducer was placed at a point approximately 2 cm lateral to the tip of the spinous process in a vertical and/or longitudinal orientation alongside the probe in an "in-plane" technique (Fig. 1). After obtaining a sonographic view of the pleura and transverse process, local anesthetic was infiltrated into the skin. Next, a Tuohy needle was advanced into the paravertebral space until the pleural border was reached. Saline was then injected into the paravertebral space under real-time ultrasound guidance. Thereafter, a compatible catheter (18-G multi-orifice epidural catheter; B. Braun Medical Inc., Bethlehem, PA) was advanced 4 cm into the paravertebral space and fixed to the skin. Patients then received a bolus test dose of 3 ml of 2% lidocaine with epinephrine 1:2 000 000.

After premedication with 0.03 mg/kg of intravenous midazolam, all patients were admitted to the operating room, and noninvasive blood pressure, pulse oximetry, and electrocardiography were monitored continuously. In Group P after administration of the test dose of local

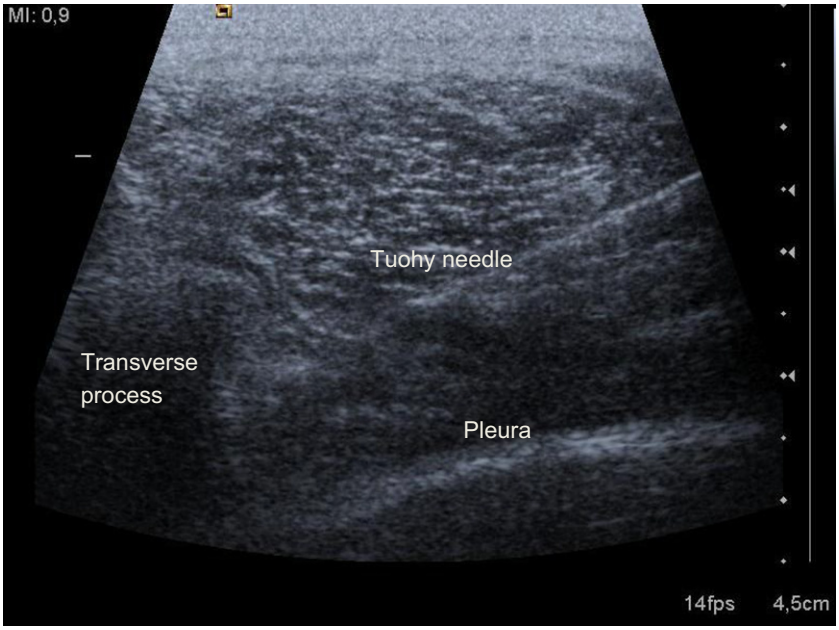

Fig. 1. Ultrasound view of Tuohy needle while inserting the paravertebral catheter.

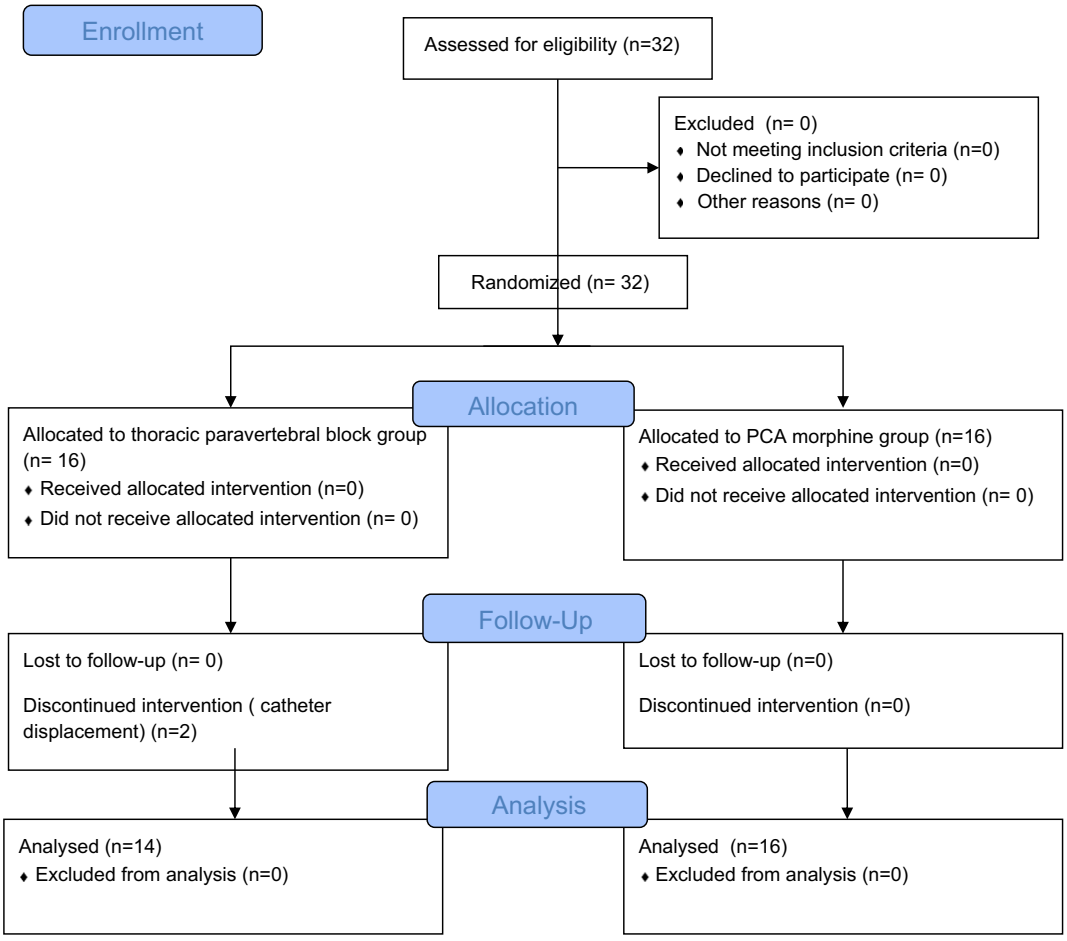

Fig. 2. Consolidated Standards of Reporting Trials (CONSORT) diagram showing the assessment of thoracic paravertebral block for donor nephrectomy.

anesthetic, 0.1 mL/kg of 0.5% bupivacaine was injected through the catheter. Twenty minutes after the bolus dose of bupivacaine, the level of block was confirmed with a pin-prick test and induction of general anesthesia was initiated. One hour after the bolus dose, 0.25% bupivacaine infusion was begun at 6 mL/h and continued during the operation.

General anesthesia was initiated with a bolus of 50 μg/mL remifentanil at a dose of 0.05 to 2 μg/kg. Two minutes later, 3 to 5 mg/kg of thiopental sodium and 0.6 mg/kg of rocuronium were given for anesthesia induction. In addition to standard monitoring, anesthesia depth was monitored with bispectral index (BIS) [12]. In all patients, following standard endotracheal intubation, anesthesia was maintained with isoflurane in a 50% oxygen/air mix and continuous infusion of remifentanil (0.05–2 μg/kg per minute) until the end of surgery with the aim of maintaining the BIS between 40 and 60 and heart rate and blood pressure changes within 20%. All patients were extubated at the end of surgery after reversing the neuromuscular block with neostigmine and atropine.

Systolic and diastolic arterial blood pressure (SBP and DBP), heart rate, arterial oxygen saturation, and BIS values were recorded before the block, 10 and 20 minutes after the block (Group P), pre-induction, after induction (at 5, 10, and 15 minutes), after skin incision, during surgery, and after extubation. At the end of surgery, the duration of surgery and remifentanil consumption were recorded. Postoperative pain was measured by the NRS pain score [13] and sedation was measured by the Ramsay score [14], and both scores were monitored for 24 hours postoperatively. The scores were recorded at 1, 2, 4, 8, and 12 hours postoperatively. SBP and DBP and heart rates were recorded at the same time intervals. If the NRS score was >4, 2 mg of morphine was administered intravenously to Group P patients as a rescue analgesic in the postanesthesia care unit. Bupivacaine PCA (0.25% bupivacaine; 6 ml/h infusion; 4-ml bolus; lockout time, 20 min) through the PVB catheter was administered in Group P, and intravenous morphine PCA (0.2 mg/mL morphine; 1-mg bolus only; lockout time, 20 min) was administered in Group M in the postanesthesia care unit and continued for 24 hours postoperatively. During follow-up in the ward, if the NRS score was >4, paracetamol + codeine phosphate + caffeine (Geralgine-K; Munir Sahin, Istanbul, Turkey) was administered orally to all patients as a rescue analgesic. The NRS pain score, Ramsay score, blood pressure, additional analgesic consumption and the rate of opioid related adverse reactions like nausea and vomiting, itching, constipation, respiratory depression were recorded during the first 24 hours after surgery. Also

Table 1
Demographic data and patient characteristics

		Group M Mean ± SD	Group P Mean ± SD	P^1
Age (years)		51.0 ± 8.5	55.5 ± 10.7	.222
Weight (kg)		75.5 ± 10.5	76.5 ± 8.4	.779
Surgery time (min)		193.5 ± 50.4	190.4 ± 46.8	.863
		n (%)	n (%)	P^2
Sex	Female	9 (56.3)	6 (42.9)	1.000
	Male	7 (43.7)	8 (57.1)	

SD, standard deviation.
[1] Student's t-test;
[2] Yates continuity correction test.

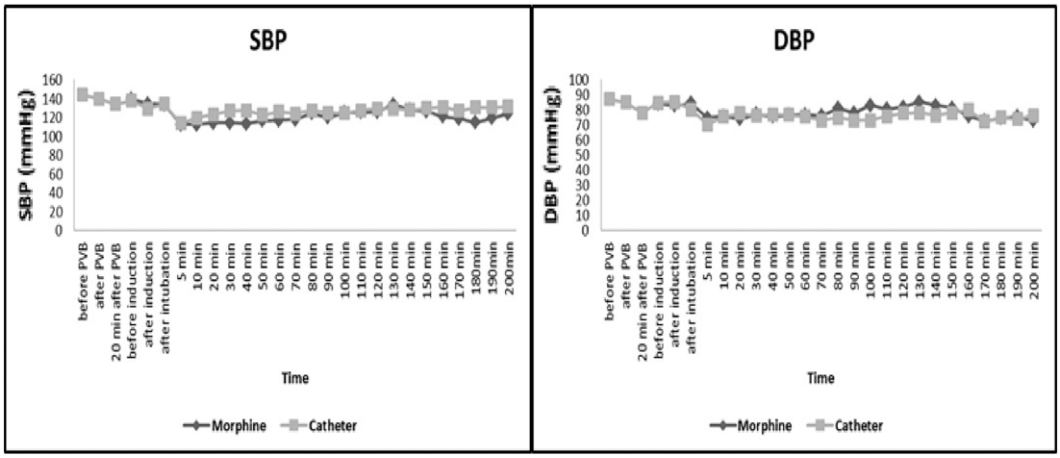

Fig. 3. Average intraoperative blood pressures.

the incidence of complications related to thoracic paravertebral block (TPVB) like pleural puncture, pneumothorax, epidural spread, injection into the subarachnoid space, intravascular injection and Horner's syndrome were recorded.

2.1. Statistical analysis

Statistical analyses were conducted using SPSS software (Version 22; IBM SPSS, Chicago, IL, USA). The Kolmogorov-Smirnov test was used to test the distribution of the data. Normally distributed data were analyzed using Student *t* test and the paired-samples *t* test. The Mann–Whitney *U* test and Wilcoxon signed-rank test were used as appropriate for analysis of categorical and skewed data. Data are presented as mean ± standard deviation. Yates continuity correction was used for analysis of nominal data. $P < .05$ was considered statistically significant.

3. Results

Two patients in Group P had failure of the paravertebral block: one patient's catheter displaced in the operating room, and another's displaced during transportation to the postanesthesia care unit. These 2 patients were excluded from the study. A total of 30 patients completed the study (Group P = 14, Group M = 16). The Consolidated Standards of Reporting Trials (CONSORT) diagram is shown in Fig. 2. Patients' demographic details are shown in Table 1; there were no significant differences in the demographic data between the 2 groups.

There were no significant differences in the mean SBP between the groups except that 40 minutes after intubation when the mean SBP was significantly higher in Group P ($P < .05$). There were no significant differences in the mean DBP between the groups except at 100 minutes after intubation, when it was significantly higher in Group M ($P < .05$) (Fig. 3). There were no significant differences in intraoperative heart rates between the 2 groups (Fig. 4).

During the first 24 hours postoperatively, there were no significant differences in SBP between the groups except at 6 and 12 hours, when the mean SBP was significantly higher in Group P. There were no statistically significant differences in postoperative DBP values between the groups (Fig. 5).

There were no significant differences in the BIS values between the 2 groups, and both groups had statistically significant decreases in the BIS following induction and later, mean BIS values were 91 ± 9.28 in group M, 95 ± 1.78 in group P and decreased to 63 ± 14.45, 65 ± 14.12 after induction, respectively. There were no significant differences between the 2 groups.

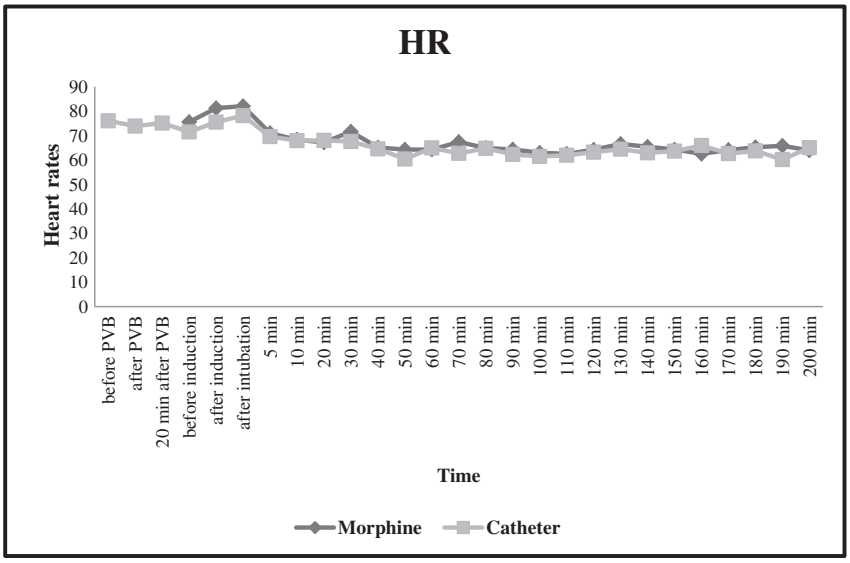

Fig. 4. Average intraoperative heart rates.

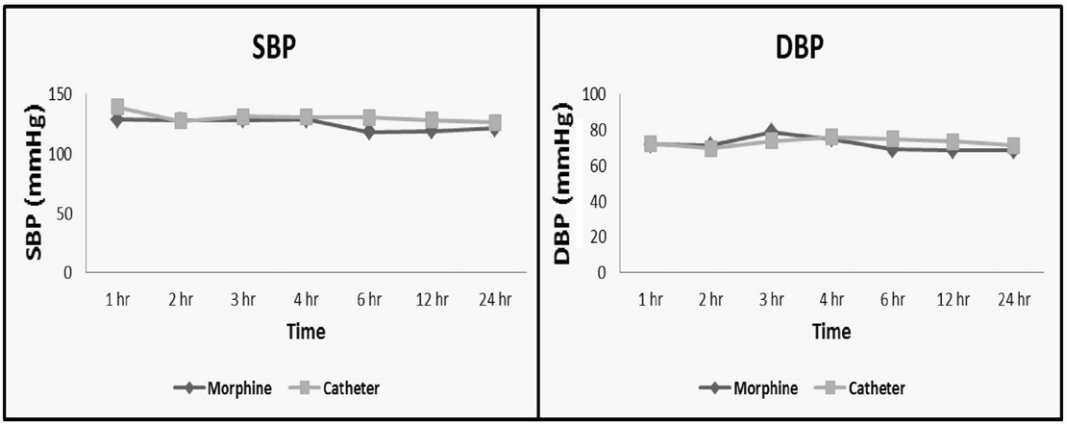

Fig. 5. Average blood pressures during the first 24 hours postoperatively.

In Group M 1 hour postoperatively and in Group P 2 hours postoperatively, the mean NRS score was ˜3. The mean NRS score when patients entered the postanesthesia care unit was 4.9 in Group P and 6 in Group M. During the first 24 hours postoperatively, the mean NRS scores were similar and there were no significant differences between the 2 groups (Fig. 6).

The mean Ramsay score in Group P (2.2) was lower than that in Group M (2.3), but the difference was not statistically significant ($P > .05$) (Fig. 7). Intraoperative remifentanil consumption was significantly higher in Group M, and postoperative morphine consumption was significantly lower in Group P ($P < .001$) (Table 2).

A rescue analgesic was administered to nine patients in Group M and eight patients in Group P during the postoperative period. In Group M, six patients required paracetamol + codeine phosphate + caffeine and three patients required morphine. In Group P, three patients required paracetamol + codeine phosphate + caffeine and five patients required morphine as a rescue analgesic (Table 3).

There was no significant difference in nausea and vomiting between the 2 groups. Vomiting was observed in 2 patients in Group M and one patient in Group P, and nausea was observed in four patients in Group M and one patient in Group P (Table 3).

4. Discussion

In the present study, continuous TPVB reduced intraoperative and postoperative opioid consumption with pain relief comparable to intravenous morphine PCA during the first 24 hours postoperatively in patients undergoing donor nephrectomy.

TPVB is an accurate, simple, and safe method with significant advantages over neuroaxial or intercostal blocks [15]. In addition, it results in somatic motor and sensory nerve block of multiple contiguous thoracic dermatomes above and below the injection site [16]. TPVB resulted in fewer pulmonary complications, less urinary retention, reduced nausea and vomiting, decreased hypotension, and reduced rates of a failed block with comparable analgesic effectiveness in a meta-analysis comparing TPVB with epidural block for thoracotomy [4]. The efficacy of TPVB for surgical analgesia or anesthesia has been reported for several surgical procedures, but rarely for open nephrectomy [2,8,9].

Baik and colleagues [2] recently reported the results of a randomized controlled study of the efficacy of TPVB in open nephrectomy cases. They randomized patients to receive TPVB plus IV-PCA or IV-PCA alone. A single 18-ml injection of 0.75% ropivacaine was administered into the T_{10} or T_{11} paravertebral space preoperatively under ultrasound guidance, and fentanyl was used for IV-PCA. The authors concluded that a preoperative single TPVB improved postoperative analgesia by reducing the postoperative pain score and fentanyl consumption. We questioned whether the single block technique provides adequate analgesia and assessed TPVB under ultrasound guidance. We prefer the "in plane" technique, and the mean time for our procedure was 17 ± 5 minutes. Locating the paravertebral space can be technically difficult, in part because it requires locating the transverse process by blind needle placement, and has an overall failure rate of >10% [17]. A risk associated with the use of PVB is the potential for unintentional pleural puncture. Ultrasound guidance facilitates placing a catheter in the paravertebral space without complications like pneumothorax [18]. We encountered no complications related to the procedure in our study.

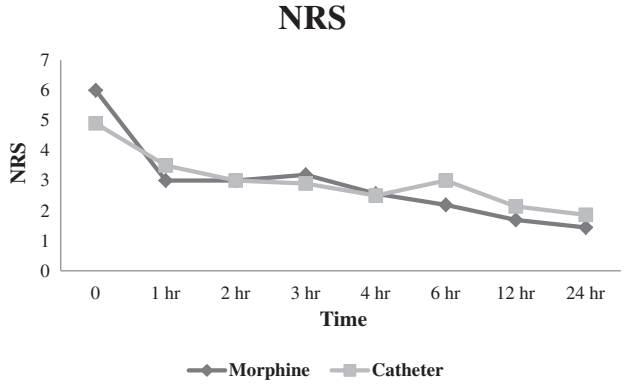

Fig. 6. Postoperative pain scores (NRS).

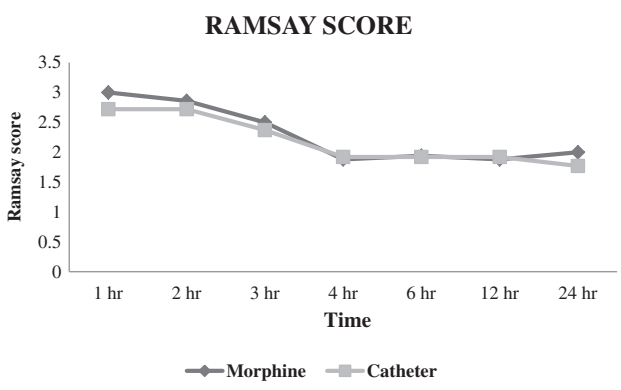

Fig. 7. Postoperative Ramsay scores.

Table 2
Remifentanil and morphine consumption.

	Group M Mean ± SD	Group P Mean ± SD	P[1]
Remifentanil (mg)	1.8 ± 0.7	0.8 ± 0.5	0.001**
Morphine (mg)	25.9 ± 9.4	6.0 ± 3.1	0.001**

SD, standard deviation.
[1] Student *t* test;
** $P < .01$.

Table 3
Patients requiring rescue analgesia and patients experiencing adverse events

	Group M n (%)	Group P n (%)	Total n (%)
Analgesic	9 (52.9)	8 (61.5)	17 (56.7)
Nausea	4 (23.5)	1 (7.7)	5 (16.7)
Vomiting	2 (11.8)	1 (7.7)	3 (10.0)

Elbealy and colleagues [5] provided surgical anesthesia for percutaneous nephrolithotomy by inserting a lumbar PVB (L_1–L_2) catheter and administering bupivacaine, removing the catheter after the procedure and once morphine PCA was begun. We performed our block at T_{11}–T_{12} and used 6-mL/h continuous infusion of 0.25% bupivacaine after a bolus of 0.1 ml/kg of 0.5% bupivacaine. We limited the PVB infusion to the first 24 hours after surgery, because patients were discharged after 48 hours. In the study by Elbealy and colleagues [5], patients in the PVB group had lower VAS scores and morphine requirements than did the epidural block group and the general anesthesia group. Likewise, Baik and colleagues [2] performed a randomized controlled study and found lower pain scores in the PVB group than in controls. Zhang and colleagues [9] recently reported the results of a randomized controlled trial of the effects of postoperative continuous PVB in nephrectomy cases and, unlike the previous studies, they found a difference in VAS scores between groups (continuous PVB group and continuous epidural anesthesia group) only when patients were moving and not at rest. Several studies have reported that continuous thoracic paravertebral infusion of bupivacaine offered better pain control than a bolus regimen [19]. In our study, we could not achieve an NRS score of ˂3 during the first 2 postoperative hours without administering morphine as a rescue analgesic. We cannot explain these higher NRS scores, but they may be related to high Ramsay scores and psychological factors related to organ donation.

There were no statistically differences in NRS pain scores between 2 groups in our study. Those results may be related to higher morphine consumption in group M. And also other possible explanations may include inadequate dermatomal distribution of local anesthetic, inadequate rate of Bupivacaine infusion and experience in catheter placement.

As in the study by Elbealy and colleagues [5], we also observed that TPVB significantly reduced intraoperative and postoperative opioid consumption. All patients in our study were hemodynamically stable during the surgery, but intraoperative remifentanil consumption in Group P was 55% lower than that in Group M. In addition, the Group P ısoflurane requirement was never higher than 0.6% intraoperatively. With the addition of TPVB to general anesthesia, we provided adequate intraoperative anesthesia to allow for lower amounts of opioids; morphine consumption in Group M (25.8 ± 9.4) was significantly higher than that in Group P (6.0 ± 3.06). Similar results were observed in a study by Ak and colleagues [6], in which patients who received one-time, multiple-level PVB at T_{10}–T_{12} at the end of the surgery had significantly lower morphine consumption (22.3 ± 6.1 mg) than the control group (43.2 ± 9.5 mg). Unlike these studies [5-7], we performed continuous paravertebral block and were able to reduce the opioid consumption significantly, particularly in those patients with a single kidney.

There was no statistically significant difference in the Ramsay sedation scores or the incidence of nausea and vomiting between the 2 groups. However, the number of patients suffering from nausea and vomiting was higher in Group M. If we could have avoided morphine consumption in Group P during the first postoperative hour, we believe that the incidence of nausea and vomiting would have been statistically higher in Group M. Continuous PVB provides high quality analgesia, lowers opioid consumption, and therefore reduces adverse events.

A small sample size and short observation period were limitations in our study. We only observed patients for 24 hours postoperatively, so we could not demonstrate any long-term beneficial effects with TPVB.

In conclusion, continuous TPVB performed at T_{11}–T_{12} by ultrasound guidance reduces the postoperative opioid consumption up to 24 hours without major complications. TPVB also provides better intraoperative stability with a lower anesthetic requirement.

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