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Ultrasound-Guided Erector Spinae Plane Block Versus Intravenous Patient-Controlled Analgesia In Percutaneous Nephrolithotomy

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ABSTRACT

Intravenous patient-controlled analgesia is frequently used to optimize postoperative analgesia in many surgeries. In recently, ultrasound-guided erector spinae plane block has begun to be widely used. Does ease of application, fewer complications and providing effective analgesia with a single injection make it more advantageous in postoperative pain management? The aim of this study is to compare the postoperative analgesic efficacy of the ultrasound-guided erector spinae plane block with that of the intravenous patient-controlled analgesia in percutaneous nephrolithotomy surgery.

Sixty participants selected for elective percutaneous nephrolithotomy were included in this study. The patients were randomized into two groups using a closed-envelope method. An ultrasound-guided erector spinae plane block was applied with 20 mL of the local anesthetic mixture at the T-7 level in group erector spinae plane block. In the PCA group a loading dose of 50 mg tramadol was administered 10 minutes before extubation. Following the extubation, patient-controlled analgesia was initiated with a 20 mg bolus, a 30minute lockout period, with a 4hour tramadol limit of 200 mg, and a basal infusion rate of 5 mg/hour.

Demographic data and ASA scores of the groups were similar. In the erector spinae plane block group, VAS scores, and analgesic requirement were significantly lower, and patient satisfaction were higher in the first 6hours postoperatively. However, in the PCA group, VAS score and analgesic requirement were lower than group ESP at the 12th hour postoperatively.

Erector spinae plane block block and iv PCA are effective in PNL surgery. We believe that the erector spinae plane block performed under USG guidance is more effective and advantageous in the first 6 hours.

Keywords: Analgesia, patient controlled, bupivacaine, erector spinae plane block, lidocaine, nephrolithotomy percutaneous, tramadol

Introduction

Percutaneous nephrolithotomy (PNL) is an effective and commonly performed surgical technique used to treat patients with renal calculi. However, severe pain can occur due to the stimulation of visceral and somatic nerves associated with surgical incisions areas and renal pelvis injury, particularly within the first 24 hours following PNL surgery (1-3). It is well known that effective analgesia positively impacts the recovery process (4). Various regional analgesia methods, such as local anesthetic infiltration at the incision site, intravenous (IV) opioid administration, IV patient-controlled analgesia (PCA), intercostal blocks, paravertebral blocks, and erector spinae plane (ESP) blocks, are used for postoperative analgesia (5). Patient-controlled analgesia (PCA) delivered via a PCA pump is frequently used to optimize postoperative analgesia. With PCA, patients can control their pain by self-administering small doses of analgesics based on their pain status (6).

Sensory nerve roots innervating the abdominal wall exit the medulla spinalis at the thoracic 6 to lumbar 1 (T6–L1) vertebrae levels to form the intercostal nerves. In PNL surgery, procedures are performed within the area innervated by both visceral (T6–L1) and somatic nerves. Therefore, effectively blocking the nerves innervating the surgical area provides adequate postoperative analgesia (7). In recently, ultrasound-guided erector spinae plane block (ESPB) has begun to be widely used especially in thoracic surgery, nephrolithotomy and nephrectomy, breast surgery and spine surgeries [8-10]. It has begun to be used in postoperative pain managment due to its ease of application, fewer complications and providing effective analgesia with a single injection (11,12). Ultrasound-guided ESP block may be more advantageous in postoperative pain management. The primary aim of this study is to determine the

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effectiveness of the IV PCA and ultrasound-guided ESP block by comparing the postoperative pain scores. The secondary aim of the study were to compare the effects by measuring analgesic requirement in 12 hours, first walking time and patient satisfaction.

Materials and Methods

This prospective, single-blind, randomized, controlled study was conducted following the approval, dated 02/03/2022, of the Van Yuzuncu Yil University Faculty of Medicine Clinical Research Ethics Committee (approval number 2022/03-04). Written informed consent was obtained from all participants. The trial was registered prospectively in ClinicalTrials.gov with registration number NCT05845281.

Sixty participants selected for elective PNL surgery were included in the study. All were American Society of Anesthesiologists (ASA) physical status (PS) class I–III, were aged between 18 and 65 years, and had a body mass index (BMI) of 18–30 kg/m^2. Exclusion criteria included ASA PS class ≥ IV patients; obese (BMI ≥ 35) patients; those with cardiovascular, hepatorenal, coagulopathy, or metabolic diseases; those with drug allergies; pregnant females; and patients unwilling to participate in the study. The included participants were evaluated preoperatively, and their written informed consent was obtained after providing them with all necessary information about the study. The patients were randomized into two groups using a closed-envelope method, with 30 patients in each group.

Before induction of anesthesia, two 22G cannulas were inserted for venous access, and 0.9% NaCl isotonic IV fluid was administered to all patients in the operating theatre. Standard ASA monitoring, including non-invasive blood pressure (NIBP), heart rate (HR), peripheral oxygen saturation (SpO_2), and electrocardiogram monitoring, was performed continuously. After preoxygenation, anesthesia induction was carried out with IV 1 mg of midazolam (Demizolam®; Dem Medikal, Istanbul, Turkey), 2 μg/kg fentanyl (Fentanyl Citrate®; Hospira Inc., Lake Forest, IL, USA), 2 mg/kg propofol (Propofol-®Lipuro 1% [10 mg/ml]), and 0.6 mg/kg of rocuronium (Esmeron®; Organon, Kloosterstraat, Netherlands).

Endotracheal intubation with a spiral-cuffed endotracheal tube was performed once adequate muscle relaxation was achieved. Anesthesia was maintained with 40% O_2, 60% medical air, and 6% desflurane along with 0.15 mg/kg rocuronium for maintenance dosing, as required. The patient was placed in the lateral position, and the surgical procedure was initiated. Hemodynamic parameters and oxygen saturation were continuously recorded at 15-minute intervals. Demographic data and the duration of surgery were recorded.

Hypoxia ($SpO_2 \leq 92$), hypercapnia ($etCO_2 \geq 45$), hypocapnia ($etCO_2 \leq 35$), hypertension, and hypotension were avoided during anesthesia. Systolic blood pressure (SBP) of more than 20% from the baseline for 1 minute was considered hypertension, while a 20% drop was defined as hypotension. In hypertensive cases, anesthesia was initially deepened with additional opioids, and if it persisted, nitroglycerin (Perlinganit®; Adeka, Wilmington, DE, USA) was administered at 50–100 mcg (IV push). In hypotensive cases, the percentage of inhalation anesthetics was reduced, and the rates of intravenous fluid replacement increased. If hypotension persisted, 5 mg of ephedrine (IV push) was administered. A HR below 50 beats/minute was considered bradycardia, while an HR above 100 beats/minute was considered tachycardia. In cases of bradycardia, 0.5 mg of atropine (IV) was administered, while in cases of tachycardia, anesthesia was deepened with additional opioids, fluid replacement was adjusted according to volume deficit, and esmolol (Brevibloc®; Polifarma, Istanbul, Turkey) was administered at 5–10 mg (IV) if necessary. Repeat doses of opioid (IV 0.5 mcg/kg fentanyl) and muscle relaxant (IV 0.15 mg/kg rocuronium) were administered. Thirty minutes before the completion of the surgical procedure, all patients received IV paracetamol (Polaminofen®, Polifarma, Istanbul, Turkey) 15 mg/kg as an analgesic.

After the surgery was completed, an ESP block was applied in the lateral position on the surgical side in the patients in Group ESPB. While the patient was in the lateral position, we positioned a linear 10–18 MHz ultrasound probe (Esaote MyLab 30, Genova, Italy) in a sterile sheath to the T-7 spinous process in the paramedian plane after proper asepsis with povidone iodine. The transverse processes and pleura at the T7 level were visualized, and a 22G, 100-mm block needle (Pajunk, Geisingen, Germany) was advanced in-plane until it contacted the transverse process.

After it was visualized, the needle tip was seen between the erector spinae muscles and the transverse process, and the erector spinae plane was confirmed by hydrodissection with a 1-mL local anesthetic (LA) injection. Patients were administered 1 mg/kg 0.5% bupivacaine (Buvasin®; Vem, Istanbul, Turkey) + 1 mg/kg 2% lidocaine (Lidon®; Onfarma, Samsun, Turkey) in a 20 ml volume. Normal saline was used to increase the total volume to 20 ml. The same anesthesiologist performed all ESP blocks. The volatile aesthetic agent was discontinued after the

ESP block was performed, and the patient was turned into the supine position. After spontaneous breathing started, standard decurarization was performed with atropine (0.02 mg/kg) and neostigmine (0.05 mg/kg). Extubation was performed after proper oral suction, and the patient was sent to the recovery room.

In the PCA group, tramadol was prepared at a concentration of 2 mg/cc and set into the PCA device (CADD-Legacy® PCA; Smith Medical ASO, Inc., St. Paul, MN, USA). Ten minutes before the extubation, a 50-mg loading dose of tramadol (Tramosel®; Haver Farma İlaç A.Ş, Istanbul, Turkey) was administered. Following the extubation, PCA was initiated with a 20 mg bolus, a 30-minute lockout period, and a basal infusion rate of 5 mg/hour. The 4-hour limit was set at 200 mg. Patients were sent to the recovery room with the PCA device in operation. Patients with an Aldrete score 9 or higher were sent to the service.

The visual analog scale (VAS) score, analgesic requirement, time to first walking, and vital signs were assessed and recorded at 30 minutes as well as at 1, 3, 6, and 12 hours during the postoperative period. Whenever the VAS score (0 represented no pain and 10 represented the most severe pain) in either group was above ≥ 4, 15 mg/kg of intravenous paracetamol was administered as a rescue analgesic. Patient satisfaction was evaluated at the 12-hour point using a 5-point Likert verbal rating scale: 5 = very satisfied, 4 = satisfied, 3 = unsure, 2 = dissatisfied, and 1 = very dissatisfied.

Statistical Analysis: In the study, the postoperative 6th hour VAS scores were accepted as the primary characteristic, and the difference in VAS scores between the groups was predicted to be 35-40%. With a margin of error of 5% and a power of 80%, the standard effect size was determined to be 0.73, and 27 patients were planned to be admitted to each group (13, 14). Considering the possibility of measurement errors, a study was planned with 30 + 30 cases. In the descriptive statistics of the data, mean, standard deviation, median lowest, highest, frequency, and ratio values were used. The Kolmogorov–Smirnov test measured the distribution of the variables. In the analysis of independent quantitative data, independent sample t tests and Mann–Whitney U tests were used. In the analysis of independent qualitative data, the chi-square test was used, and when chi-square test conditions were not met, the Fischer test was used. P-values < 0.05 were considered statistically significant, and p-values < 0.001 were considered statistically very significant. The SPSS 28.0 program was used in the analysis.

Results

Of the 65 patients assessed for eligibility, 60 completed the study. Hence, 5 patients were excluded for the study because they did not meet the inclusion criteria (Figure 1). The mean age of the 60 patients included in the study was 44.05 ± 13.3 years, and 66.7% were male. The patients' demographic data and ASA PS scores were similar in both groups (p =0.719) (see Table 1).

The measured mean blood pressure, heart rate, and peripheral oxygen saturation (SpO_2) values of the groups during the intraoperative and postoperative periods were similar, as shown in Figure 2-4.

In the first 6 postoperative hours, VAS scores were lower in the ESP group than in the PCA group and were lower and statistically very significant (p = 0.001) after 30 minutes, 1 hour, and 3 hours, and lower and statistically significant after 6 hours (p=0.002). The VAS score after 12 postoperative hours (p=0.001) was found to be higher and statistically very significant in the ESP group (Table 2).

Regarding the need for rescue analgesia, there was no significant difference between the two groups after 1 postoperative hour (p =0.492). In the ESP group, the need for rescue analgesia was lower and statistically significant after 3 (p=0.001) and 6 postoperative hours (p = 0.002). However, after 12 postoperative hours, the need for rescue analgesia was lower and statistically very significant in the PCA group (p=0.001) (Table 3).

In terms of the time to first walking, no statistically significant difference was observed between the groups (p=0.216) (Table 2). Patient satisfaction was found to be higher and statistically significant (p=0.004) in patients who received the ESP block (Table 4).

Discussion

In this prospective clinical study conducted with 60 patients who underwent PNL surgery, we found that the ESP block provided more effective pain control in the first 6 hours compared to PCA. On the other hand, we noted that PCA provided more effective analgesia after 12 postoperative hours compared to the ESP block.

Çiftçi et al., in a study conducted with patients undergoing video-assisted thoracic surgery, reported that ESP block provided effective analgesia in the first 24 hours, thus reducing the VAS score (15). Turan et al. stated that ESP block reduced pain scores in radical prostatectomy surgery (6). Meanwhile, Krishna et al., in a study evaluating ESP block in terms of

Table 1: The patients demographic profiles and ASA scores

		ESPB				PCA				P-value	
		Mean.	±	SD	n-%	Median	Mean.	±	SD	n-%	Median		
Age (Year)		44.6	±	14.0		43.5	43.5	±	12.6		43.0	0.750	t
Gender	Female	9.0			30.0%		11.0			36.7%		0.584	X^2
	Male	21.0			70.0%		19.0			63.3%			
BMI		24.8	±	3.6		24.5	26.1	±	3.8		26.5	0.158	t
ASA Score	I	8.0			26.7%		6.0			20.0%			
	II	18.0			60.0%		21.0			70.0%		0.719	X^2
	III	4.0			13.3%		3.0			10.0%			

SD: Standart Deviation, BMI: body mass index, X^2: Chi-square test (Fischer test), ESPB: Erector spinae plane block, PCA: Patient control analgesia, ASA: American Socieyt Anesthesiologists, [t]Bağımsız örneklem t test

Table 2: Comparison of VAS score between the groups and first walking times of groups

	ESPB				PCA				P-value	
	Mean.	±	SD	Median	Mean.	±	SD	Median		
VAS Score										
Post op 30. min	1.6	±	0.6	2.0	2.7	±	0.5	3.0	0.001	m
Post op 1. hour	2.1	±	0.7	2.0	3.3	±	0.7	3.0	0.001	m
Post op 3. hour	2.6	±	0.6	3.0	3.6	±	0.9	3.0	0.001	m
Post op 6. hour	3.4	±	1.1	3.0	4.2	±	0.9	4.0	0.002	m
Post op 12. hour	5.8	±	0.9	6.0	4.2	±	1.1	4.0	0.001	m
First Walking Time (hour)	10.4	±	2.1	10.0	9.6	±	1.5	10.0	0.216	m

SD: Standart Deviation, X^2: Chi-square test (Fischer test), ESPB: Erector spinae plane block, PCA: Patient control analgesia, Post op: Postoperative, min: Minute, [m] Mann-whitney u test

Table 3: Comparison of groups in terms of rescue analgesia need

		ESPB		PCA		P value	
		n	%	n	%		
The need for rescue analgesics							
Postoperative frst hour	+	0.0	0.0%	2.0	6.7%	0.492	X^2
	-	30.0	100.0%	28.0	93.3%		
Postoperative 3. hour	+	0.0	0.0%	10.0	33.3%	0.001	X^2
	-	30.0	100.0%	20.0	66.7%		
Postoperative 6. hour	+	9.0	30.0%	21.0	70.0%	0.002	X^2
	-	21.0	70.0%	9.0	30.0%		
Postoperative 12. hour	+	30.0	100.0%	19.0	63.3%	0.001	X^2
	-	0.0	0.0%	11.0	36.7%		

ESPB: Erector spinae plane block, PCA: Patient control analgesia, X^2 Chi-square test (Fischer test), n: Number of patients, (+): need for rescue analgesics, (-): No need for rescue analgesics

postoperative analgesia in cardiac surgery, reported that the numerical rating scale (NRS) measured constantly in the ESP group was significantly lower than the control group and provided better analgesia (16). In this study, we found that the ESP block provided more effective analgesia during the first 6 postoperative hours, significantly reducing the VAS score, while IV PCA provided more effective analgesia and a lower VAS score after 12 postoperative hours. We attributed the effectiveness of the ESP block during the first 6 hours to its rapid onset. However, since the analgesic effect of the ESP block gradually decreases after the first 6 hours, we believe that IV PCA is relatively more effective after 12 postoperative hours.

Table 4: Patients satisfaction scale scores of the groups at the postoperative 12th hour

		ESPB		PCA		P value
		n	%	n	%	
Likert satisfaction scale	Dissatisfied	4.0	13.3%	5.0	16.7%	0.004 X^2
	Not sure	5.0	16.7%	13.0	43.3%	
	Satisfied	7.0	23.3%	10.0	33.3%	
	Very Satisfied	14.0	46.7%	2.0	6.7%	

ESPB: Erector spinae plane block, PCA: Patient control analgesia, n: Number of patients, X^2: Chi-square test (Fischer test)

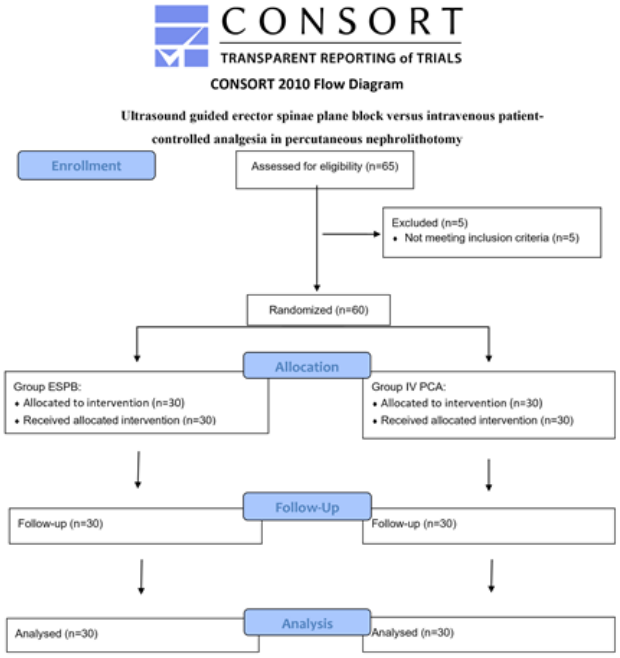

Fig.1. Consort-2010-flow-Diagram-Ultrasound Guided Erector Spinae Plane Block Versus Intravenous Patient-Controlled Analgesia In Percutaneous Nephrolithotomy

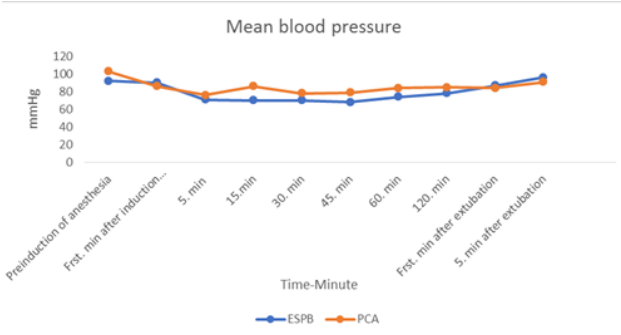

Fig. 2. The mean blood pressure of the groups

Turan et al. reported that the ESP block reduced the need for analgesia in both intraoperative and postoperative periods in radical prostatectomy surgery (6). Yayık et al. mentioned that patients undergoing lumbar spinal decompression surgery receiving the ESP block had a lower postoperative need for additional analgesia compared to the control group

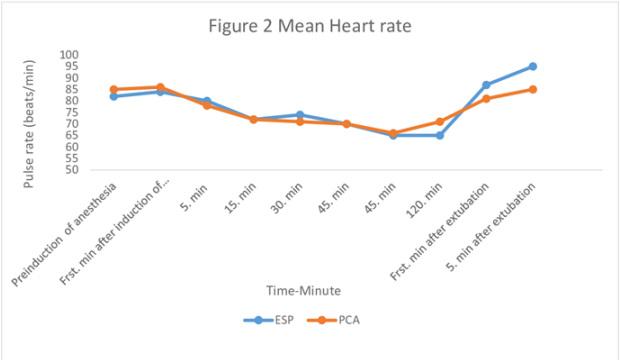

Fig.3. The mean heart rates of the groups

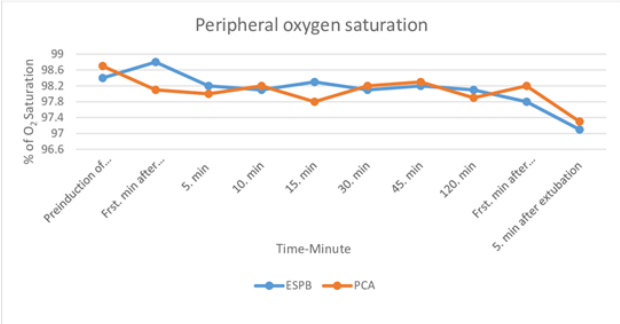

Fig.4. The peripheral oxygen saturation values of the groups

(17). In our study, patients with a postoperative VAS score ≥ 4 received 15 mg/kg of paracetamol for their rescue analgesia. The highest VAS score at 30 minutes was 3 in patients who received ESPB, while in the group receiving IV PCA, the highest VAS score was 4. The need for additional analgesia was similar in both groups during the first postoperative hour. The need for additional postoperative analgesia at the third and sixth hours was lower in patients who received the ESP block. Moreover, the need for additional postoperative analgesia after 12 hours was found to be statistically significantly higher in patients who received the ESP block, which we attributed to the continued effectiveness of the ESP block up to 6 hours, followed by a gradual decrease in effectiveness and inadequate analgesia received at 12 hours. Therefore, we believe that IV PCA may be better than

the ESP block in terms of long-term postoperative analgesia.

Various methods and techniques have been used for postoperative analgesia. The importance of patient satisfaction in the development of these techniques and methods has been emphasized in many scientific studies (18). Pandey et al. reported that patients who received ESP block for postoperative analgesia in PNL had significantly higher patient satisfaction scores after 12 postoperative hours compared to the control group (9). In a study comparing ESP block with oblique subcostal transverse abdominal plane (SCTAP) block for postoperative analgesia after laparoscopic colorectal surgery, patient satisfaction was found to be higher in patients who received the ESP block (19). Similarly, we found that patient satisfaction was higher in the ESP group than in the IV PCA group.

The ESP block has several advantages, including ease of application, not requiring multiple injections (20), providing effective and rapid analgesia, being performed with a single injection under ultrasound guided (USG) guidance, not requiring repetition (21), and not requiring patient compliance. We believe that adding lidocaine (with its fast onset of action) as the local anesthetic, especially for the first 6 hours, increased patient satisfaction. Patient compliance and education levels play a crucial role in the effectiveness of IV PCA. We believe that observed patient non-compliance in the application may be a factor reducing patient satisfaction in the IV PCA group.

Effective postoperative analgesia positively influences recovery and early mobilization (9). Patients who receive effective analgesia in the postoperative period can mobilize early, significantly reducing the length of hospital stay (18). Krishna et al. mentioned that ESP block in cardiac surgery allows for earlier mobilization (16). In our study, there was no difference in terms of the time to first walking within the timeframe up to 12 hours. We considered the extubation time as postoperative hour zero and determined the time when patients started their first walk after surgery accordingly. However, we believe there may have been no difference between the two groups, since we limited the follow-up to 12 postoperative hours.

Our study has some limitations. Patient compliance plays an important role in the effectiveness of patient-controlled analgesia (PCA) and this is related to the patient's educational attainment level. However, education levels were not surveyed. Postoperative patient follow-up was limited to 12 hours. We were unable to evaluate the long-term impacts of ESP block. In addition, while the volume of local anesthetic used in the ESP block remained constant, the concentration of the drug varied depending on the patient's weight. We believe that studies could be conducted to determine the ideal dose and volume of local anesthetic for the ESP block.

In conclusion; ESP block performed under USG guidance in PNL surgery, it provided effective analgesia until 6 postoperative hours. Moreover, it reduced postoperative pain scores and the need for rescue analgesia and increased patient satisfaction. Since the effect of the ESP block decreased over time, intravenous PCA was found to be more effective in pain control after 12 postoperative hours. We believe that both ESP block and IV PCA can be safely used for postoperative analgesia in PNL surgery.

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Authorship: All the authors met the requirements for authorship. Concept (HYG, CK, MEK), Design (HYG, CK, MEK), Data Collection and/or Processing (HYG, CK, MEK), Analysis and/or Interpretation (HYG, CK, MEK)

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