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The efficacy of erector spinae plane block (ESPB) applied under ultrasonography guidance in percutaneous nephrolithotomy operations

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ABSTRACT

Aims: This study aimed to evaluate the effect of erector spinae block (ESPB) applied preoperatively under ultrasonography guidance in percutaneous nephrolithotomy (PNL) operations in terms of the intraoperative need for opioids, postoperative analgesia, and patient satisfaction.

Methods: Of 60 patients who were 18 to 65-year-old and evaluated as American Society of Anesthesiologists (ASA) risk I-II-III were planned to undergo elective PNL. The patients were randomly separated into two groups as the Block group-administered ESPB under sedation in the preoperative period and the Control group-administered no ESPB. All the operations were performed under general anesthesia. The study data were analyzed using Mann-Whitney U-test and the Independent Samples t-test.

Results: Demographic data of the patients were not different between the groups ($p>0.05$). Neither intraoperative opioids nor analgesics were required for any of the patients in the ESPB group whereas intraoperative opioids and analgesic drugs had to be administered to all of the patients in the control group ($p<0.001$). The postoperative patient satisfaction scores in the ESPB group were found statistically higher than that of the control group ($p<0.001$).

Conclusion: The results demonstrated that ESPB applied preoperatively under USG guidance reduced the need for intraoperative opioids and postoperative analgesia in PNL operations. This, in turn, increased patient satisfaction by maintaining patient comfort after surgery.

Keywords: Erector spinae plane block, percutaneous nephrolithotomy, preemptive analgesia, ultrasonography

INTRODUCTION

In 2016, Forero et al.[1] described erector spinae block (ESPB) to provide a strong postoperative pain elimination following thoracic and abdominal surgery. ESPB is applied by injecting local anesthetic solution between the erector spinal muscles (iliocostalis, longissimus, spinalis) and the transverse process under ultrasonography (USG) guidance.[2] The analgesic effect is formed by local anesthetic spreading to the paravertebral area affecting the dorsal and ventral branches of the thoracic spinal nerves and with the effect on the sympathetic ganglia of the thoracic spinal nerves, and this provides multi-dermatomal sensory block.[1]

In the percutaneous nephrolithotomy (PNL) that has been commonly used in open surgery in the treatment of kidney stones, the postoperative pain is severe, and to be able to control this pain in the postoperative period, intravenous opioids and local anesthetic infiltration are often used.[3-5] Although regional analgesia methods such as paravertebral block and intercostal block have also been used, the efficacy of these on postoperative pain has still not been fully determined in PNL surgery.[3,6,7]

This study aimed to evaluate the effect on the need for intraoperative opioids, the efficacy of postoperative analgesia, and patient satisfaction of ESPB applied preoperatively under USG guidance in PNL operations.

METHODS

The study was carried out with the permission of Kırıkkale University Clinical Researches Ethics Committee (Date 28.05.2019, Decision No: 11/03). All procedures were carried

out in accordance with the ethical rules and the principles of the Declaration of Helsinki. The study was conducted in the Anesthesiology and Reanimation Clinic between June 2019 and December 2019.

Patients

A total of 60 patients were included in the study, aged 18-65 years, who were planned to undergo elective PNL in the Urology Clinic and were classified preoperatively as American Society of Anesthesiologists (ASA) risk I, II, III. All the patients provided informed consent.

Patients were excluded from the study if they had coagulopathy, any psychiatric disease, a history of allergy to local anesthetics, the presence of local infection in the area where the injection was to be applied, any spinal/paravertebral deformity, a history of pneumothorax, severe aortic stenosis, morbid obesity (BMI >40 kg/m²), or if they did not wish to participate in the study.

The patients were randomly separated into 2 groups using the sealed envelope method;

- Control Group (consisted of the patients who were applied general anesthesia only, n=30)
- BLOCK Group (consisted of the patients who were applied general anesthesia and preoperative ESPB, n=30).

General Anesthesia Protocol

All the operations were performed under general anesthesia. For the patients in the block group, ESPB was applied in the block room under standard ASA monitoring (ECG, non-invasive blood pressure, SpO_2) and sedation before entering the operation room. Patients admitted to the operating room were administered intravenous (iv) sedation of 0.03-0.05 mg/kg midazolam (Sedozolam®, Monemfarma, Ankara, Turkey) through a venous cannulation opened under standard ASA monitorisation. All patients in both groups were administered 1g iv paracetamol (Partemol®, Vem, İstanbul, Turkey) before anesthesia induction. Induction was applied with 2-3 mg/kg iv propofol (Propofol®, Fresenius, Kabi, Melsungen, Germany), 1 mcg/kg iv fentanyl (Fentanyl Citrate®, Hospira, USA) and 0.6 mg/kg iv rocuronium (Esmeron®, Organon, Kloosterstraat, Holland). Anesthesia maintenance was provided with 2% sevoflurane (Sevorane®, Abbott, Chicago, USA), with 50% O_2 and 50% air.

ESPB under Ultrasonography Guidance

Standard ASA motorization was applied to the patients in the block room before the operation. Sedation was provided with 0.03-0.05 mg/kg iv midazolam. The ESPB procedure was applied under USG guidance to the side to be operated on. The patients were then transferred to the operating room. In the application of ESPB, the patient was positioned sitting, and after providing sterility, a linear 10-18 MHz USG probe (Esaote MyLab 30, Geneva, Italy) was placed between the two transverse processes in the paramedian plane. The transverse processes and pleura were visualized at the T7 level. Anesthesia of the skin and subcutaneous tissue was provided with 2% lidocaine (Aritmal®, Osel, İstanbul, Turkey). An 18 Gauge 50 mm needle (Pajunk, Geisingen, Almanya) was advanced in-plane until it touched the transverse process. When the tip of the needle was between the erector spinae muscles and the transverse process, aspiration was applied then 20 ml 0.5% bupivacaine was injected (Buvasinn ®, Vem, İstanbul, Turkey). Dissemination of the local anesthetic cephalad and caudally was observed with USG (**Figures 1** and **2**). ESPB Block applications were performed by the same person in all patients.

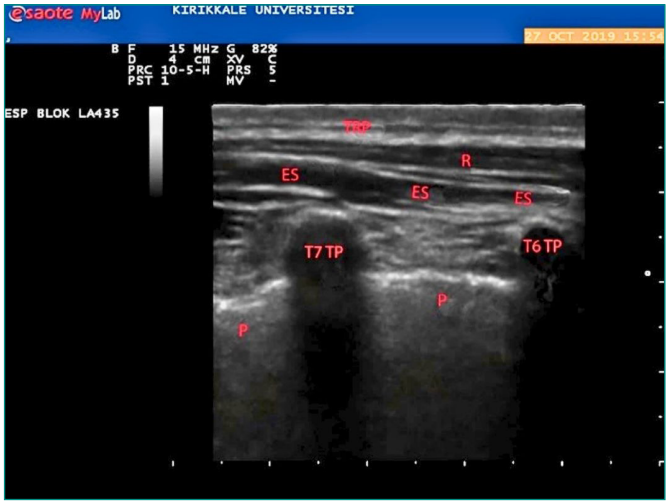


Figure 1. ESPB USG image (TRP: Trapezius muscle, R: Rhomboid Major muscle, ES: Erector Spinae muscle, TP: Transverse Process, P: Pleura)

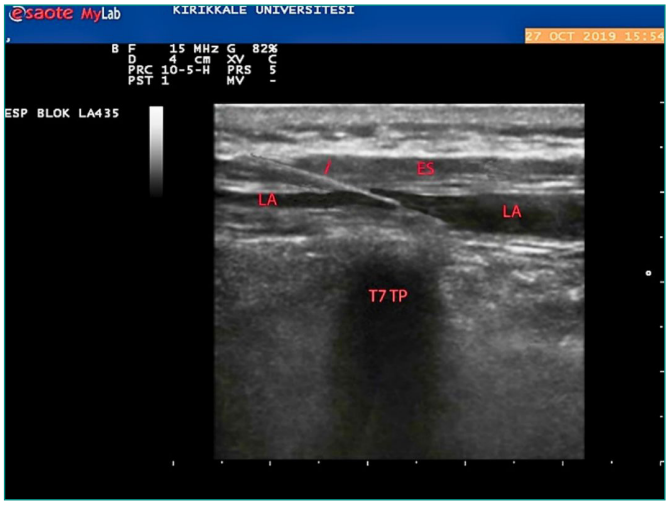


Figure 2. The spread of ESPB local anesthetic (ES: Erector Spinae muscle, TP: Transverse Process, I: Block Needle, LA: Local anesthetic)

Surgical Procedure

Before the operation was started all patients were placed in the lithotomy position and a 5 Fr ureter catheter was advanced to the ureter with a 19Fr cystoscope, then a Foley catheter was placed. The patients administered with general anesthesia were then positioned prone. After administration of the opaque substance from the access ureter catheter to the targeted calyx, a guidewire was advanced to the renal collecting system or ureter with an 18-gauge percutaneous entry needle under C-arm fluoroscopy guidance. After the access cutaneous road was dilated with the aid of Amplatz dilators (Cook Medical, Bloomington, IN, USA) up to 12Fr over the guidewire. Then, the nephrostomy balloon dilation catheter (Plasti-med, İstanbul, Turkey) was inflated up to 14-atmosphere pressure, and an access sheath (30 Fr) was placed over it.

Entering the renal collecting system with a 26 Fr nephroscope (Storz, Tuttlingen, Germany), stones were fragmented with a pneumatic or laser lithotriptor and extracted using a grasper and aspirator. After completion of the operation, a 14Fr nephrostomy tube was placed within the access sheath, and after checking with fluoroscopy, the operation was terminated.

Intraoperative Pain Management

In the intraoperative period, when there was an increase of 20% in pulse rate or blood pressure compared to baseline, a remifentanil (Rentanil ®, Vem, İstanbul, Turkey) infusion of 0.5-20 mcg/kg/min was started. A record was made for each patient of the intraoperative requirement for opioids. Towards the end of the operation, all the patients were administered 8mg iv ondansetron (Zofran®, Glaxo Smith Kline S.p.A, Italy). For neuromuscular reversal at the end of the surgery, 0.04 mg/kg neostigmine (Neostigmine®, Adeka, Samsun, Turkey) and 0.015 mg/kg atropine (Atropine sulfate®, Biofarma, İstanbul, Turkey) were administered iv. When sufficient muscle strength was achieved, patients were extubated. Cases taken to the postoperative recovery room were then transferred to the Urology ward.

Postoperative Pain Management

The severity of postoperative pain was evaluated with a Visual Analog Scale (VAS) at 0, 1, 2, 6, 12, and 24 hours postoperatively. Any complications in the first 24 hours were recorded. Patients with a VAS score of >4 were administered iv 50 mg dexketoprofen trometamol (Arveles®, Ufsa, İstanbul, Turkey) and for those with VAS >6, iv 1mg/kg tramadol (Tramosel®, Haver, İstanbul, Turkey) was administered. The requirement for postoperative additional analgesia was recorded.

Visual Analog Scale (VAS)

This 10cm scale is used to evaluate the severity of pain, with the lowest point of 0 indicating no pain and the highest points of 10, intolerable pain.

Patient Satisfaction Scale

Postoperatively, a patient satisfaction scale was applied to evaluate the satisfaction of patients in respect of pain management. The scale was evaluated as 5 points (5: very satisfied, 4: satisfied, 3: not sure, 2: not satisfied, 1: not satisfied at all) and the level of patient satisfaction was considered high when the score was high.

VAS score inquiries and satisfaction inquiries were done by a blinded observer independent of the study.

Sample Size, Power Analysis and Statistical Analysis

The sample size was calculated using G*Power© software version 3.1.9.4 (Institute of Experimental Psychology, Heinrich Heine University, Dusseldorf, Germany). Depending on the results of previous research with two tails, Type-I error 0.05 and power of 80%, effect size (d) factor 0.875, N2/N1= 1 should involve at least 44 patients.

The post hoc power was calculated using G*Power© software version 3.1.9.4 (Institute of Experimental Psychology, Heinrich Heine University, Dusseldorf, Germany). Depending on the results of the research two tails, Type-I error 0.05 and effect size (d) factor 2.758, post hoc power calculated as 99.99%.

Data obtained in the study were analyzed statistically using SPSS vn. 21.0 software. Demographic and laboratory test data were calculated as median ± standard deviation, minimum and maximum values, number (N), and percentage (%). In the evaluation of the differences in non-parametric data, the Mann-Whitney U test was used ($p<0.05$). Parametric data were analyzed with the Independent Samples t-test. A value of $p<0.05$ was accepted as statistically significant.

RESULTS

The data of a total of 60 patients who underwent PNL between June 2019 and December 2019,

were analyzed. We used CONSORT flow diagram for our study (**Figure 3**).

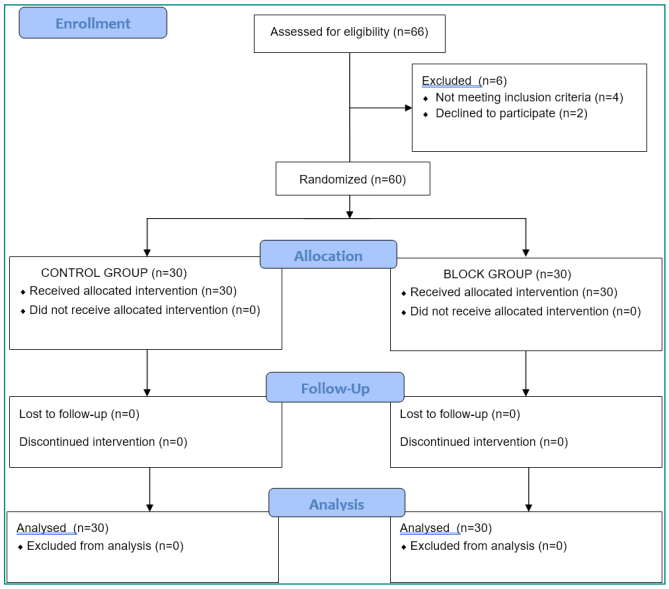
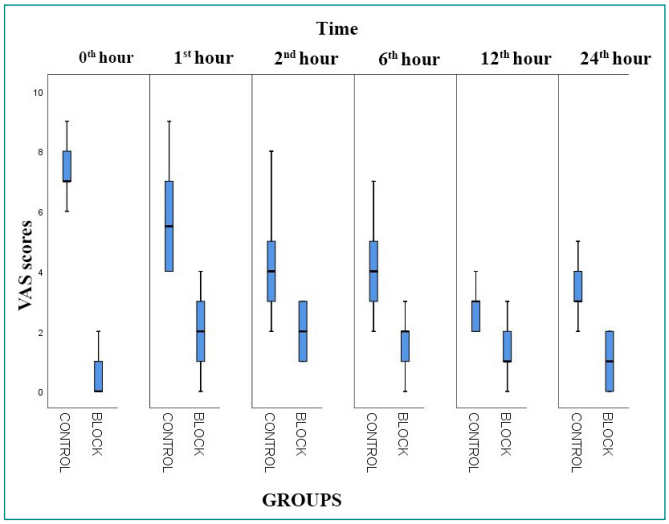


Figure 3. Flowchart of the patients

The demographic data consisted of the age, sex, body height, body weight, body mass index (BMI), and ASA scores were not different between the groups ($p>0.05$). However, the intraoperative need for opioids, postoperative VAS scores at 0, 1, 2, 6, 12, and 24 hours, the need for postoperative analgesia, and patient satisfaction scores were statistically significant between groups. Neither intraoperative opioids nor analgesics were required for any of the patients in the ESPB group whereas intraoperative opioids and analgesic drugs had to be administered to all of the patients in the control group ($p<0.001$). The postoperative patient satisfaction scores in the ESPB group were found statistically higher than that of the control group ($p<0.001$). No statistically significant difference was found between the groups in respect of the operation time and length of stay in the hospital ($p>0.05$) (**Table 1**). The distribution of the postoperative VAS scores of the groups is shown in **Graph 1** and **Table 2**.



Graph 1. Postop VAS scores of the groups at 0, 1, 2, 6, 12, and 24 hours

Table 1. Comparisons of the demographic and clinical data of the groups

Variable	CONTROL Mean ± SD/ Median (min-max)/ N (%)	BLOCK Mean ± SD/ Median (min-max)/ N (%)	p
Age (years)	49.50 (18-65)	43.50 (22-65)	0.953†
Gender			
Female	9 (30.00%)	14 (46.70%)	0.188‡
Male	21 (70.00%)	16 (53.30%)	
Height (m)	1.70 ± 0.10	1.68 ± 0.10	0.236*
Weight (kg)	80.07 ± 14.59	81.23 ± 16.60	0.444*
Body mass index	27.74 ± 5.12	28.61 ± 5.44	0.777*
ASA	2 (1-3)	2 (1-3)	0.132†
Opioid requirement			<0.001‡
Yes	30 (100%)	-	
No	-	30 (100%)	
VAS time (hour)			
0	7 (4-9)	0 (0-3)	<0.001†
1	5.50 (4-9)	2 (0-4)	<0.001†
2	4 (2-8)	2 (1-3)	<0.001†
6	4 (2-7)	2 (0-3)	<0.001†
12	5 (2-8)	1 (0-3)	<0.001†
24	3 (1-5)	1 (0-2)	<0.001†
Additional analgesia			<0.001‡
Yes	30 (100%)	-	
No	-	30 (100%)	
Operation time (minutes)	116.90 ± 33.24	127.73 ± 29.42	0.545*
Length of stay in hospital (days)	3 (2-5)	3 (2-9)	0.444†
Patient satisfaction score	3 (2-5)	5 (4-5)	<0.001†

(*) independent samples t-test; (†) Mann-Whitney U test; (‡) Pearson's chi-square test, p<0.05 (SD: standard deviation, min: minimum, max: maximum, N: number of patients, VAS: visual analog scale, ASA: American Society of Anesthesiologists)

Table 2. Distribution of the VAS scores of the groups

Group	Score	Measurement time of the VAS (hour) VAS 0 N (%)	VAS 1 N (%)	VAS 2 N (%)	VAS 6 N (%)	VAS 12 N (%)	VAS 24 N (%)
CONTROL	0	-	-	-	-	-	-
	1	-	-	-	-	-	1 (3.3%)
	2	-	-	3 (10%)	5 (16.7%)	1 (3.3%)	2 (6.7%)
	3	-	-	9 (30%)	5 (16.7%)	-	14 (46.7%)
	4	2 (6.7%)	8 (26.7%)	7 (23.3%)	12 (40%)	11 (36.7%)	10 (33.3%)
	5	1 (3.3%)	7 (23.3%)	4 (13.3%)	3 (10%)	12 (40%)	3 (10%)
	6	4 (13.3%)	6 (20%)	3 (10%)	2 (6.7%)	2 (6.7%)	-
	7	12 (40%)	5 (16.7%)	3 (10%)	3 (10%)	2 (6.7%)	-
	8	10 (33.3)	2 (6.7%)	1 (3.3%)	-	2 (6.7%)	-
	9	1 (3.3%)	2 (6.7%)	-	-	-	-
BLOCK	0	18 (60%)	3 (10%)	-	1 (3.3%)	4 (13.3%)	9 (30%)
	1	6 (20%)	10 (33.3%)	9 (30%)	9 (30%)	12 (40%)	11 (36.7%)
	2	4 (13.3%)	8 (26.7%)	11 (36.7%)	13 (43.3%)	11 (36.7%)	10 (33.3%)
	3	2 (6.7%)	8 (26.7%)	10 (33.3%)	7 (23.3%)	3 (10%)	-
	4	-	1 (3.3%)	-	-	-	-
	5	-	-	-	-	-	-
	6	-	-	-	-	-	-
	7	-	-	-	-	-	-
	8	-	-	-	-	-	-
	9	-	-	-	-	-	-

(N: number of the patients, VAS: Visual Analog Scale)

DISCUSSION

The present study results showed that the preoperative application of ESPB could reduce the intraoperative requirement of opioids. Indeed, In the control group, the postoperative VAS score at 0 hours was at least 4 (4-9), whereas, in 60% of the patients in the ESPB group, this value was 0. The postoperative VAS scores at 0 hours were ranged from 4 to 9 in the control group. However, the maximum score was 3 in the BLOCK group. These results showed that ESPB could provide a high level of analgesic efficacy postoperatively, and therefore the patients were extremely comfortable and patient satisfaction was at high levels.

Pre-emptive analgesia provides analgesia before noxious stimulation, and therefore sensitivity to painful stimuli is decreased without the development of central sensitization. It has been reported that pre-emptive analgesia is the most effective method in reducing postoperative analgesic consumption and postoperative pain.[8,9] Postoperative pain is an acute pain activated by the stress response to trauma. It also increases pulmonary, cardiac, and gastrointestinal complications and lays the ground for hypercoagulability. The generally accepted view on postoperative pain is that the pathogenesis is multifactorial. Therefore, it must be eliminated with multimodal analgesia approaches.[10] Opioids administered in the treatment of postoperative pain have nowadays been replaced by pre-emptive analgesia included in multimodal analgesia techniques. Aydin et al.[11] reported that pre-emptive analgesia significantly reduced intraoperative opioid use in patients who were to undergo laparoscopic cholecystectomy. This benefit of pre-emptive analgesia was seen with ESPB applied before general anesthesia in the present study as there was no requirement for intraoperative opioids by any of the patients in the BLOCK group. It was also thought that this brought about a significant decrease in VAS values postoperatively.

To obtain sufficient analgesia for PNL, there must be blockage of both the somatic and visceral nerves that innervate the skin, muscles, kidneys, and ureter. Pain in the kidneys is carried by the T10-L1 nerves and pain in the ureter by T10-L2 nerves. Based on this anatomic knowledge, it is thought that nerve blockage between T10 and L2 provides sufficient analgesia during PNL.[7,12] The accepted view of the effect mechanism of ESPB is that local anesthesia spreads to the epidural and paravertebral areas and blocks the dorsal and ventral branches of the spinal nerves in those regions. Thus, somatic and visceral analgesia is obtained with ESPB.[13] In the current study, both somatic and visceral analgesia was obtained with ESPB between T5 and L1.

The use of USG has become routine for regional anesthesia and nerve block. The most important advantage of the use of USG in regional blocks is that the local anesthetic dose and complications are reduced. That the correct needle position can be determined and the dissemination of local anesthetic can be observed in real-time are also extremely important advantages of regional anesthesia under USG guidance.[11] In literature, ESPB has been attempted in-plane and out-of-plane in parasagittal and transverse planes. In several published studies, in-plane in the parasagittal plane has been

applied. When a block is applied in the parasagittal plane, the spread of the local anesthesia caudally and cephalad can be more clearly seen. The risk of pleural punction and excessively deep injection with the risk of entering the neural foramen is lower in the in-plane approach than in the out-of-plane technique.[13] In the current study, ESPB was applied in-plane in the parasagittal plane. This application of ESPB under USG guidance allowed the simultaneous observation of local anesthesia dissemination between T5 and L1. At the same time, with correct needle positioning and an anatomic view, complications can be prevented.

In the results of the current study, there was no significant difference between the groups in respect of age, gender, BMI, ASA, and operating time. This showed the homogeneity of the two groups. It is also important that several factors which could affect pre-emptive analgesia were standardized, and this increased the reliability of the study.

In the literature, in a randomized, controlled study by Gultekin et al.[6] conducted between January 2017 and March 2019, 60 patients who were to undergo PNL operation were randomly assigned to one of two groups; one group was applied with ESPB at T8 level using 20 cc 0.5% bupivacaine, and the other group was not applied with a block. It was planned to administer iv tramadol and paracetamol as rescue analgesia in the postoperative period. The results of the study showed that the VAS scores at 0, 1, 6, and 24 hours and the amount of rescue analgesia used were significantly lower in the block group than in the group without block. In another randomized controlled study in literature, Ibrahim et al.[7] evaluated 58 patients between September 2017 and September 2018. The patients were separated into two groups; one group was applied with ESPB at T11 level in the prone position using 30 cc 0.25% bupivacaine, and the other group was administered 30 cc saline at the same level. When there was an increase of 20% in the basal pulse rate or blood pressure, an intravenous bolus of 0.5 mcg/kg fentanyl was administered. Patient-controlled analgesia (PCA) containing morphine was prepared for patients in the postoperative period. The study results showed that the VAS values at 2 and 6 hours postoperatively, the amount of intraoperative fentanyl used, and the amount of morphine use in the first 24 hours were statistically significantly lower in the block group than in the control group, and the time to the first use of the PCA was statistically significantly longer in the block group.

Several studies have shown that the effect of ESPB has a rapid onset and effective analgesia is provided for up to 24 hours postoperatively.[14-17] In the current study, none of the patients in the BLOCK group required intraoperative opioids, which showed the rapid onset of the effect of the block. When the VAS scores were examined at postoperative 0 hours, the highest value in the block group was 3 while the lowest value in the control group was 4. This demonstrates that ESPB applied pre-emptively provided pain-free awakening at the end of surgery. In the follow-up data, all the VAS values in the first 24 hours postoperatively were significantly lower in the BLOCK group than in the control group, which can be considered evidence that the ESPB provided effective analgesia for 24 hours.

Several studies have stated the importance of patient satisfaction in the process of eliminating postoperative pain.[18] In the current study, patient satisfaction was also considered to be of great importance in this process. A statistically significantly higher level of patient satisfaction was recorded for the BLOCK group than for the control group. The main reason for this can be considered to be that in addition to the pre-emptive application of ESPB providing good analgesia, by reducing the need for opioids in the intraoperative and postoperative periods there could also be a reduction in side-effects associated with opioids.

Study Limitations

This study had some limitations. First, as patient-controlled analgesia (PCA) devices could not be available in the clinic, the analgesia had to be provided using the single-injection method. Second, because of the study methodology, the VAS values were only examined in the first 24 hours and therefore long-term pain follow-up results of the patients could not be evaluated in this study.

CONCLUSION

As a result, this study demonstrated that ESPB applied pre-emptively under USG guidance to patients who were to undergo PNL could reduce the intraoperative need for analgesia. Due to the postoperative analgesic efficacy of the ESPB, the VAS scores were seen to be significantly reduced. This was observed to have positively affected both patient comfort and patient satisfaction. With these results, it was thought that the preoperative application of ESPB can be an effective method to provide postoperative analgesia and increase patient satisfaction in PNL operations.

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of Kırıkkale University Clinical Researches Ethics Committee (Date 28.05.2019, Decision No: 11/03).

Informed Consent: All patients signed the free and informed consent form.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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