SHOULD THE ERECTOR SPINAE PLANE BLOCK BE APPLIED IN THE PAIN MANAGEMENT OF PERCUTANEOUS NEPHROLITHOTOMY?

Şeyma Ünal[1], Semih Başkan[2], Betül GÜVEN AYTAÇ[3], and İsmail Aytaç[4]

[1]Emet State Hospital
[2]Ministry of Health Ankara City Hospital
[3]Ankara Numune Training and Research Hospital
[4]Ankara City Hospital

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Abstract

The Aim: This prospective, randomised controlled study aimed to investigate the efficacy and respiratory effects of postoperative pain management with erector spinae plane block (ESPB) in patients undergoing percutaneous nephrolithotomy surgery. Methods: A total of 60 ASA I-II patients aged 18–65 years, scheduled to undergo percutaneous nephrolithotomy (PCNL) were included. Patients were randomized either to the ESPB or control group. Ultrasound-guided ESPB with 15mL 0.5% bupivacaine at the T11 level was performed preoperatively using the in-plane technique in the ESP group. In both groups, 1gr of intravenous paracetamol was administered intraoperatively. Postoperative pain and agitation was evaluated using VAS, Dynamic VAS at 0, 6 and 24 hours and the Riker sedation-agitation scale at 0th Hours after surgery. Peak expiratory flow rate(PEFR) and SPO2 were measured in preoperative examination and at the 0th, 6th, 24th hours postoperatively. In the postoperative period, intravenous tramadol (100mg) was administered as a rescue analgesic when VAS [?] 4. Time and number of the rescue analgesias, mobilization time and length of hospital stay were also recorded and analyzed. Results: A significantly lower VAS and DVAS were observed at 0th, 6th, 24th hours in the ESPB group ($p < 0.05$ for each timepoint). Also number of and time to rescue analgesia decreased in the ESPB group ($p< 0.05$ and 0.01 respectively). Postoperative/preoperative PEFR ratio was lower and there were more agitated patients in control group ($p<0.05$). Conclusion: ESPB may have additional clinical advantages while providing effective analgesia in patients who underwent PCNL comparing to intravenous analgesia.

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Conclusion: ESPB may have additional clinical advantages while providing effective analgesia in patients who underwent PCNL comparing to intravenous analgesia.

Keywords: erector spinae plane block (ESPB); percutaneous nephrolithotomy (PCNL); Peak expiratory flow rate (PEFR); Riker sedation-agitation scale

What is already known about this topic?

ESPB is an easily applicable and effective block in postoperative pain management of PCNL however, it's uncertain if ESPB provides additional positive outcomes.

What does this article add?

This study shows that the ESPB is an effective block in postoperative pain management of PCNL and it has additional positive outcomes. Pain management with ESPB reduces the incidence of emergence agitation, prevents PEFR reduction comparing to preoperative values in recovery room and provides higher postoperative mean SPO2 values.

INTRODUCTION

Percutaneous Nephrolithotomy (PCNL) is currently the most frequently preferred minimally invasive surgical procedure in the treatment of kidney stones. It is accepted as the first-line treatment for many kidney stones >2 cm, staghorn calculi, or when other methods of management fail [1].

Although PNL is performed as a minimally invasive procedure, it causes severe postoperative pain due to dilatation of the renal capsule and parenchymal canal and peritubal distension of the nephrostomy tube[2]. Effective treatment of postoperative pain allows early mobilization of the patient, shortens the recovery and discharge time, prevents the development of chronic pain, increases satisfaction and long-term quality of life[3].

Pain related to the PCNL may cause nausea and vomiting, and aggressive management with opioids alone can result in respiratory depression[4]. Tramadol is a weak opioid used for postoperative pain relief without causing the respiratory depression seen with other opioids. It has common side effects such as nausea and vomiting and may be insufficient in postoperative analgesia [5]. Poor postoperative pain management increases the risk of postoperative pulmonary complications (PPC). In patients undergoing percutaneous nephrolithotomy, the decrease in inspiratory and vital capacity due to the close proximity of the operation to the diaphragm increases the risk of atelectasis [6]. In addition, unsuccessful pain management can cause postoperative delirium and agitation[7].

ESPB is a periparavertebral regional anesthesia technique applied for the first time in the treatment of thoracic neuropathic pain[8]. ESPB, which is an easily applicable block with low complication rate, has been shown to be effective in postoperative pain management of PCNL in the literature [9-14].

We aimed to investigate the effectiveness of ESPB in postoperative pain management of patients who underwent percutaneous nephrolithotomy operation and to demonstrate the positive outcomes of pain management if there is by recording serial peak expiratory flow rate (PEFR) measurements, the patient's postoperative agitation score (Riker sedation-agitation scale), time to mobilize, and length of hospital stay.

METHODS

This single center, prospective randomized observer blind study was conducted in Health Sciences University Ankara City Hospital between 01/03/20 - 01/08/20, after receiving approval from Institutional Ethics Committee (dated 13/02/20 and numbered E1-20-315) and registered on ClinicalTrials.gov (ID: NCT04474873).

Sixty volunteer patients of both gender, aged 18-65, in the American Society of Anesthesiologists Physical Status Classification (ASA) I-II risk group who were scheluded to undergo PCNL were included in the study. Three patients were excluded because of returning to open surgery.

Exclusion criteria were ASA> II, patients with comorbidities (cardiac, respiratory, hepatic, renal, neurologic, psychiatric), pregnancy, morbid obesity, and also patient's refusal to participate in the study .

After creating 2 sets of 30 unique numbers from 1 to 60 for each group using an internet-based program (www.randomize.org), the patients were randomly allocated to control or ESPB group.

General anesthesia protocol was same between groups. 1.5-2 mg/kg propofol, 0.5 to 1mcg/kg fentanyl and 0.6 mg/kg rocuronium were used for induction and patients were intubated. General anesthesia were maintained with the end-tidal sevoflurane concentration of 2% and 0,2-0.5 µg/kg/min remifentanil. Mechanical ventilation was performed with the tidal volume of 6-8 ml/kg, respiratory rate of 12 breaths/min, exhalation : inhalation = 1:2, and oxygen flow rate of 2.0 L/min during operation. Sugammadex 2mg/kg were used for reversal.

In control group there is no intervention and pain management was continued with intravenous rescue tramadol analgesia. In ESPB group the block was performed with USG (Toshiba Diagnostic Ultrasound System, GM-55402A00E, Japan, 8 mHz linear probe) before general anesthesia induction. The patients were placed in the prone position and after skin cleaning, ESPB was performed at the T11 level using the in-plane technique. Before the procedure, 3 mL of 2% lidocaine was applied locally to the patient's skin. A 21G 100 mm insulated needle 15 (Vygon echoplex, France) was inserted in the cranial-caudal direction until it made contact with the T11 transverse protrusion in the in-plane approach. Hydrodissection was applied with 15 ml saline solution. Then a total of 15mL 0.5% bupivacaine was injected as a local anesthetic. The location of the needle tip was confirmed by removing the erector spina muscle from the bone shadow of the transverse process and observing the distribution of local anesthetic in both cranial and caudal directions (Figure 1).

Analgesic effect was evaluated by pinprick test including T10, T11, T12 nerve distribution segments (Figure 2). A successful ESPB must contain all three segments, otherwise the block was considered unsuccessful and planned to remove from the study.

In both groups, how to use the peak flowmeter (ExpiRite Peak Flow Meter®) was explained to the patients during the preoperative interview and at the postoperative 0th, 6th and 24th hours, the patients were asked to breathe as deeply as they could, and then to breathe into the flowmeter as effectively and rapidly as they could. It was explained to the patients that they should grasp the peak flowmeter with their lips in a sitting position in the bed and blow it in one breath, and that they should not put their tongue on the end of the device during blowing[15]. Measurements were made three times for each visit and the highest value was recorded.

In both groups, 1gr of intravenous paracetamol was administered intraoperatively and at the 8th and 16th hour postoperatively.. Postoperative pain and agitation was evaluated using VAS, Dynamic VAS at 0, 6 and 24 hours and the Riker sedation-agitation scale at 0th Hours after surgery. Peak expiratory flow rate(PEFR) and SPO_2were measured in preoperative examination and at the 0th, 6th, 24th hours postoperatively. In the postoperative period, intravenous tramadol (100mg) was administered as a rescue analgesic when VAS [?] 4. Time and number of the rescue analgesic administrations, number of the nausea and vomiting, mobilization and oral intake time and length of hospital stay were recorded and analyzed in both groups. Duration of surgery, diameter, number and location of the renal Stones were also recorded.

In all patients, the time from stopping sevoflurane inhalation to the awakening was called the awakening time and was recorded. The Riker sedation-agitation scale was used to determine the anxiety level of the patients

in the wake-up service. Postoperative pain was evaluated using VAS and Dynamic VAS (pain with deep breathing and cough-DVAS) at 0, 6 and 24 hours after surgery. For VAS and DVAS, two end descriptions were written on both ends of a 100 mm line, and patients were asked to indicate where their condition was appropriate by drawing a line or by putting a dot or mark on this line. Pain due to Foley catheter application was also evaluated. The evaluations was done by a blinded observer independent of the study. Patient and surgeon satisfaction in both groups was evaluated as "1. very satisfied, 2. satisfied, 3. dissatisfied, 4. very dissatisfied" with the four-option Likert measurement system.

Statistical Analysis

Data analysis was performed using IBM SPSS 25.0 (Armonk, NY: IBM Corp.) statistical package program.

Chi-Square test was used to compare qualitative data as well as descriptive statistical methods (frequency, percentage, mean, standard deviation, median, min-max. IQR) while evaluating the study data.

The compliance of the data to normal distribution was evaluated by Kolmogorov-Smirnow and Shapiro-Wilk tests.

In the research, in the evaluation of the quantitative data with normal distribution; Independet Samples t test (t test in independent groups) and Repeated Measures Anova (repeated measures analysis of variance) were used for the comparison of repeated measurements.

Post-hoc Tukey HSD test was used to find the source of the difference in cases where there was a difference in multiple comparisons.

Mann-Whitney U test was used to evaluate data that did not show normal distribution.

Relationships between variables were evaluated using the Pearson Correlation Test.

Statistical significance level was accepted as $\alpha = 0.05$.

Power analysis was made with G * Power 3.1.9.4 statistical package program. As n1 = 28, n2 = 29, α = 0.05, Effect Size (d) = 0.87; power = 90%.

RESULTS

There was no differences in patients characteristics between groups (Table 1). VAS and DVAS values were lower in the ESPB group at the 0^{th}, 6^{th}, 24^{th}hours ($p<0.05$) but pain related to the urinary catheter was similar between groups(Table 2,3). Number of the agitated patients in recovery room were higher in the control group (11(39.3%); 4(13.8%), $p<0.005$)(table 4).

Number of and time to rescue analgesia (100mg tramadol) were lower in ESPB group within 24 hours ($p<0.005$) but oral intake time, mobilization time and length of hospital stay were similar between groups (Table 5)

The ratio of preoperative PEFR: Postoperative PEFR in the recovery room (0^{th} hour) were lower in control group comparing to control group (64,5%, 74,8%; respectively, $p<0.005$) but it was similar in the later hours (table 6). SpO_2 values of the patients were similar until 24^{th} hour but lower in control group in the 24^{th} hour($p<0.05$) (Table 6)

DISCUSSION

This study shows that ESPB may be applied for postoperative pain management of the PCNL, improves outcomes such as reducing the incidence of emergence agitation and preventing PEFR reduction comparing to preoperative values in recovery room. ESPB provided low VAS and DVAS values within the first 24 hours, and the mean SPO_2values of the patients were found to be higher at the 24th hour compared to the control group.

Regional analgesia is an important element of successful postoperative pain-management since they reduce the consumption of opioids which have a high profile of side effects such as respiratory depression, nausea,

vomiting, and slowing bowel movements [16]. Trend in postoperative pain management has turned from epidural analgesia to the paravertebral, truncal and recently erector spinae plane block since it can be applied easily and has fewer complications[17,18].

ESPB was defined by Forero et al. for the treatment of neuropathic chest pain in 2016 and has become popular as a postoperative pain treatment in many surgical procedures. It is a good alternative because of its relatively easy application compared to paravertebral blocks and it does not have complications such as pneumothorax, subarachnoid injection, urinary retention and hypotension.

There is a rapidly expanding literature on the efficacy of the ESPB in postoperative pain management of the PCNL [9-14]. Our study may contribute to the relevant literature in several points. We ruled out potential confusion in the subjective evaluation of the patients by questioning the pain caused by the urinary catheter. We comprehensively investigated the pain using serial PEFR measurements and DVAS in association with its features that may be related to cough, respiration and mobilization in addition to the subjective and one-dimensional VAS scale. Additionaly we investigated the positive outcomes of the pain management with serial PEFR-SpO_2measurements, assesing recovery agitation, mobilization, oral intake and discharge time.

After thoracic and upper abdominal surgeries, it has been shown that pain affects respiratory muscles and impairs respiratory functions. Pain can reduce vital capacity, may cause development of atelectasis and postoperative hypoxemia [19].

PEFR is an inexpensive, easily accessible respiratory function test that reflects vital capacity. PEFR value may decrease in the early postoperative period due to pain [19]. In PNL surgery, Hosseini et al.[4] investigated the effectiveness of peritubal ketamine infiltration and Imani et al.[20]also investigated the analgesic efficacy of ropivacaine infiltration and its effects on PEFR values. In these studies, it was shown that PEFR values decreased significantly in the early postoperative period after PNL, but pain management with peritubal infiltration did not affect PEFR values positively [4,20].

Although there are many predisposing factors in the pathogenesis of recovery agitation after urological surgery, a high level of relationship between pain and postoperative agitation has been reported[7].

Our study showed that ESPB provides effective pain management and improves patient outcomes by preventing agitation and negative effects on early pulmonary functions.

For all that there are several limitations of our study. Patient controlled analgesia methods may be preferred instead of intermittent intravenous rescue tramadol analgesia. It can be assumed that this can reduce adverse outcomes of the intermittent bolus intravenous opioids. The exclusion of patients with ASA> II and the small sample size may have caused not to measure the effect of ESPB on length of hospital stay and mobilization time.

CONCLUSION

ESPB is an effective alternative in postoperative pain management for PCNL. It provides sufficient analgesia within the first 24 hours after surgery and may reduce adverse outcomes related to the pain such as emergence agitation and PEFR reduction

COMPETING INTERESTS

No external funding and no competing interests declared.

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Table 1: Comparison of the patient characteristics between control and ESPB group

		Control (n=28)	**ESPB (n=29)**	**P**
Gender	Female	7 (25,0%)	7 (24,1%)	1,000 [a]
	Male	21 (75,0%)	22 (75,9%)	
Age (Year)		52,0 ± 10,5	53,0 ± 10,4	0,719 [b]
Weight (kg)		78,9 ± 13,4	79,3 ± 13,5	0,915 [b]
Height (cm)		170,5 ± 9,8	169,9 ± 6,2	0,806 [b]
BMI (kg/m^2)		27,1 ± 3,8	27,4 ± 4,2	0,744 [b]
ASA	I	2 (7,1%)	2 (6,9%)	1,000 [a]
	II	26 (92,9%)	27 (93,1%)	
Operation time(min)		155,0 (115,5 - 174,8)	*140,0 (115,5 - 170,0)*	*0,363*[c]
Awakening time (min)		*8,0 (5,0 - 10,8)*	*9,0 (5,0 - 10,0)*	*0,981*[c]
Renal stone diameter(cm)		*2,1 (1,5 - 3,0)*	*2,5 (2,0 - 3,2)*	*0,215*[c]
Number of the stones		*2,0 (1,0 - 4,0)*	*2,0 (1,0 - 4,0)*	*0,961*[c]

[a]: Chi-Square Test (n / %),[b]: Independent Samples t Test (Mean ± SD),[c] Mann-Whitney U Test (Median / IQR)

Table 2: Comparison of the patients' assesments of pain between groups according to the visual analog scale scores(VAS)

VAS	**Control (n=28)**	**ESPB (n=29)**	**P***
Recovery unit	**6,7 ± 2,1**	**3,0 ± 2,2**	**0,000**
6th hour	**4,6 ± 2,2**	**2,8 ± 1,9**	**0,002**
24th Hour	**2,9 ± 2,2**	**1,3 ± 1,4**	**0,001**
VAS for Urinary catheter pain	**2,4 ± 4,0**	**3,5 ± 3,8**	0,314

[*]: Independent Samples t Test (Mean ± SD)

Table 3: Comparison of the patients' assesments of pain between groups according to the dynamic visual analog scale (DVAS) score

DVAS	**Control (n=28)**	**ESPB (n=29)**	**P***
Recovery unit	**7,6 ± 2,0**	**3,8 ± 2,3**	**0,000**
6th hour	**5,4 ± 2,2**	**3,9 ± 2,4**	**0,020**
24th Hour	**4,2 ± 2,7**	**2,0 ± 2,3**	**0,002**

[*]: Independent Samples t Test (Mean ± SD)

Table 4: Comparison of the groups according to the Riker agitation sedation scale

	Control (n=28)	**ESPB (n=29)**	**P***
RIKER[?] 4	**17 (%60,7)**	**25 (%86,2)**	**0,027**
RIKER >4	**11 (%39,3)**	**4 (%13,8)**	

**: Chi-Square Test*

Table 5: Comparison of the postoperative characteristics between groups

		Control (n=28)	**ESPB (n=29)**	**P**
Time to Rescue Analgesia(h)	**Time to Rescue Analgesia(h)**	**0,41 (0,16 - 1,43)**	**1,60 (0,75 - 5,05)**	**0,004**
Number of the rescue analgesic	**Number of the rescue analgesic**	**2,00 (2,00 - 3,00)**	**2,00 (1,00 - 2,00)**	**0,046**
Mobilization time (h)	**Mobilization time (h)**	**22,0 (18,9 - 24,0)**	**21,0 (17,8 - 24,5)**	**0,930**
Oral intake time(h)	**Oral intake time(h)**	**20,5 (17,4 - 23,0)**	**18,0 (10,3 - 21,0)**	**0,092**
Length of hospital stay (day)	**Length of hospital stay (day)**	**2,5 (2,0 - 4,0)**	**2,0 (2,0 - 4,5)**	**0,913**

**: Mann-Whitney U Test (Median / IQR)*

Table 6: Comparison of the rate of change in PEFR values and postoperative SPO_2 values between groups

	Control (n=28)	**ESPB (n=29)**	**P***
PEFR0/ $PEFR_{preop}(\%)$ [1]	64,5 ± 15,4	74,8 ± 19,0	**0,029**
PEFR6 / $PEFR_{preop}(\%)$ [2]	73,5 ± 17,4	79,6 ± 15,7	0,167
PEFR24 / $PEFR_{preop}(\%)$ [3]	79,5 ± 18,7	84,5 ± 15,8	0,286
P**	**0,000**	**0,018**	
Difference	1-2/1-3	1-3	
SpO_2 (Recovery Room)	95,1 ± 3,1	96,5 ± 2,0	0,051
SpO_2 (Postop 6.h)	95,9 ± 2,9	96,6 ± 2,0	0,276
SpO_2 (Postop 24. h)	95,8 ± 2,9	97,2 ± 1,3	**0,027**

**: Independent Samples t Test (Mean ± SD), **: Repeated Measures Anova Test*

Figure 1: USG image of the Erector Spinae Plane Block application.

Figure 2: Dermatomal distribution of the sensory block evaluated by pinprick test.