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Erector Spinae Plane Block as an Alternative Analgesic Technique in Patients Scheduled for Open Renal Surgery: A Randomized Controlled Study

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Abstract

BACKGROUND: Renal surgeries are accompanied by a moderate to a high degree of intra and postoperative pain. Ultra-sound guided erector spinae plane block (ESPB) represents an alternative method for analgesia in such surgeries as it provides cutaneous and visceral sensory blockade that covers the origin of renal and ureteric pain. Furthermore, it allows the anesthesiologist to limit the use of perioperative opioids and avoiding its possible complications. The use of the ultrasound provides higher safety profile and lower incidence of complication in the block performance.

AIM: In this study, the ultrasound-guided ESPB was investigated as an alternative method to decrease the use of perioperative opioids.

METHODS: The study was designed to be randomized controlled study. 46 patients undergoing open renal surgeries were included and divided into two groups: The ESPB (E) group and the control (C) group. Each group contained 23 patients. After induction of general anesthesia, all patients received ultrasound guided ESPB. Patients of the E group received 25 ml of bupivacaine 0.25% while patients of the C group received 25 ml of normal saline. For all patients; perioperative opioid consumption, 1st analgesic requirement postoperatively, and post-operative numerical rating scale (NRS) for post-operative pain assessment were recorded and analyzed.

RESULTS: As regard the general descriptive data and the duration of surgery, the E and the C groups showed no statistical variations ($p \geq 0.05$). The ESPB significantly prolonged the time to the firstly required analgesic medication. The median value was "300 min" in the E group compared to "30 min" the C group" with a highly significant p-value ($p < 0.001$). The median value of the total morphine consumption in the first 24th h postoperatively was significantly reduced in the E group "9 mg" compared to the C group "18 mg" with p-value ($p < 0.001$) regarding the median value of the intraoperative fentanyl consumption. Patients of the E group consumed 80 mg of fentanyl compared to 180 mg in the C group with $p < 0.001$. The NRS showed that the E group had lower degrees of postoperative pain throughout most of the first 24th h postoperatively. This was shown by lower NRS median values in the E group at NRS: 0, 1, and 2 with highly significant p-value ($p < 0.001$) compared to C group. At NRS (3); there was no statistical significance between the E group and the C group ($p > 0.05$). Afterward, all the time points showed lower median values of NRS in the E group relative to the C group with a highly significant p-value ($p < 0.001$) except for the 24th h postoperatively (NRS: 6) which had a p-value ($p < 0.05$). Furthermore, there were no recorded complications in the two groups.

CONCLUSION: Ultrasound-guided erector spinae block prolonged the time of first analgesic requirement by the patient and reduced perioperative opioid consumption. Furthermore, it decreased pain scores in the first 24 h after open renal surgeries and it proved to be a good alternative analgesic technique in open renal surgery.

Introduction

Open renal surgeries are accompanied by moderate to high degrees of pain during both intra and postoperative times. The erector spinae plane block (ESPB) is an invasive alternative that was exclusively done as a method for analgesia in patients with chronic neuropathic, post-traumatic thoracic pain [1]. ESPB is performed by injecting a local anesthetic (LA) under the erector spinae muscle and into the fascial plane separating this muscle from t transverse processes (TPs). The pattern of spread of the injected LA in both cranial and caudal directions along the fascial plane allows the injected LA to cover multiple dermatomes following a single injection [2].

The ESPB blocks both somatic and visceral sensory sensations by interrupting their signals through spinal and sympathetic fibers [3], [4]. Cadaveric researches on ESPB revealed that a 20 ml injected volume of solution at the 5th thoracic vertebra provided spread for five levels in both cranial and caudal directions while injecting the same amount of LA in the epidural showed spread in 2–3 levels in both cranial and caudal directions [5].

The pain originating from open renal surgeries' incision has complex sources; the pain resulting from

the kidney's manipulation which is transmitted through T10-L1 spinal nerves, the pain originating from the ureters which are innervated by T10-L1 spinal nerves, and the pain coming from the overlying skin which is innervated by T8/10–T11/12. Consequently, the ESPB performed at lower thoracic regions can provide a good analgesic technique for these procedures [6].

This study was developed to evaluate the effectiveness of the ESPB as an alternative method for analgesia in patients scheduled for open renal surgery by comparing it to the conventional use of parenteral analgesics alone.

Methods

This randomized controlled study was designed as a double-blinded, prospective study. It was authorized by Theodor Bilharz Research institute Ethics Committee (19/4/471) on (23rd April 2019). All the participants in the trial signed informed written consent before being subjected to any intervention. The trial was submitted before patients' enrollment at ClinicalTrials.gov, ID: NCT04118101. The registry date was at July 2019. Forty-six patients were enrolled between August 2019 and March 2020, aged from 18 to 60-years-old, both males and females, and have American Society of Anesthesiologists' (ASA) classification of I–II.

Exclusion criteria included patients who had any contradicting factor with regional anesthesia (e.g.; lack of patient consent, coagulopathy, or infection at the puncture site). It include also any patient with known allergy to LAs, body mass index ≥35 kg/m^2, prior flank surgery, duration of surgery (≥ 2.5 h due to surgical complications), and any motor or sensory deficits.

The time of the first required analgesic medication during the 1st post-operative day was marked as the study's primary outcome. The secondary outcomes included: Pain assessment using Numerical Rating Scale (NRS) at the following intervals: Time of discharge to post-anesthesia care unit (NRS: 0) then at 15 min (NRS: 1) and 30 min (NRS: 2) then 1 h (NRS: 3), 6 h (NRS: 4), 12 h (NRS: 5), and 24 h (NRS: 6) after surgery. It also involved; total intraoperative fentanyl consumption (other than induction dose) and total post-operative morphine usage in the first 24 h. Besides, we recorded the occurrence of any ESPB complications such as nerve injury, hematoma formation, LA toxicity, intravascular injection, pneumothorax, and post-operative opioid-related complications.

The randomization process of the participants was automatically done by a computer system. Random numbers were generated. Those numbers were used to randomly allocate patients between the two groups. Each group had 23 patients. Sealed opaque envelopes were used. Each patient was asked to randomly choose an envelope. Each envelope had a group number to which the patient was allocated. The ESPB group patients received ultrasound-guided ESPB was performed before skin incision. On the other hand, the control group's patients received sham ESPB.

On reaching the operating theater, an intravenous (IV) line was inserted and 0.05 mg/kg midazolam IV was given 15 min preoperatively as a premedication. No preoperative analgesics were given. Inside the operative theater, routine basic monitors were applied to the patient.

General anesthesia was initiated using propofol 1.5–2 mg/kg and fentanyl 2 μg/kg and atracurium 0.5 mg/kg. Afterward, endotracheal intubation was done. Maintenance of anesthesia was reached by 1 minimum alveolar concentration of sevoflurane in balanced oxygen air combination (50%:50%) and top-up doses of atracurium. If the mean arterial blood pressure or the heart rate was raised by 20% above the preoperative values, this would be considered inadequate analgesia and will be managed by giving fentanyl 1 μg/kg IV. Intraoperative fentanyl consumption other than the induction dose was recorded for each patient.

Patients were positioned in the lateral decubitus as part of the preparation for surgery and to perform the ESPB under anesthesia. LA injections' preparation and ESPB performance (whether with LA or normal saline) were done by the same investigator. Intraoperative management, data recording (both intra and postoperatively), and post-operative follow-up for patients were done by an anesthesiologist who was unaware of group assignment.

The ultrasound-guided ESPBs' technique

First, the iliac crest was palpated to mark the corresponding L3/4 intervertebral space. Then the thumb was moved upwards till reaching the desired intervertebral space (T10/T11). The selected intervertebral space was marked to identify the site of ultrasound probe application. The ultrasound scan was made while the patient in the lateral position with the operative side upward [7].

After skin sterilization and draping, BK medical Pro Focus 2202 Ultrasound machine with a linear probe was placed on the back. The transducer was first set in the midline with sagittal directed orientation to locate the thoracic spinous processes. The thoracic spinous processes appear as triangular-like shark fins (Figure 1) [8]. The transducer was then moved slowly 3 cm lateral to the spinous processes until visualizing the adjacent TPs. The TPs appear as flat and square acoustic shadows with a very faint line of the pleura visible (goldilocks zone) (Figure 2) [8]. If the transducer is moved too lateral, the ribs will appear as rounded

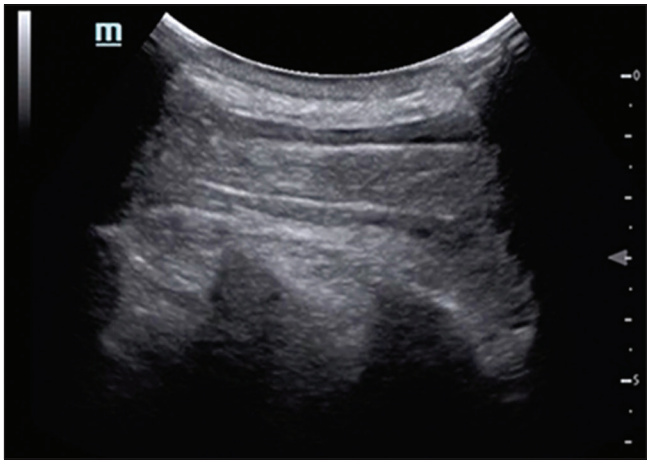

Figure 1: At the midline, the spinous processes appear triangular or like shark fins [8]

acoustic shadows with hyper-echoic intervening pleural lines.

A 22-G echogenic needle was introduced in-plane to the ultrasound probe and moved in a caudal direction till it hits the desired transverse process (T11). Then, the needle was directed slightly cephalic to reach the T10/T11 interspace. The correct position of the needle tip was ensured by inserting 0.5–1 ml of normal saline which raised the erector spinae muscle from the transverse process without piercing the muscle then the block was performed using an injection of 25 ml bupivacaine 0.25%. The surgical procedure was started 15 min after performing the block giving time for the block to take effect. Patients in the control group were injected with 25 mL of normal saline in the ESPB.

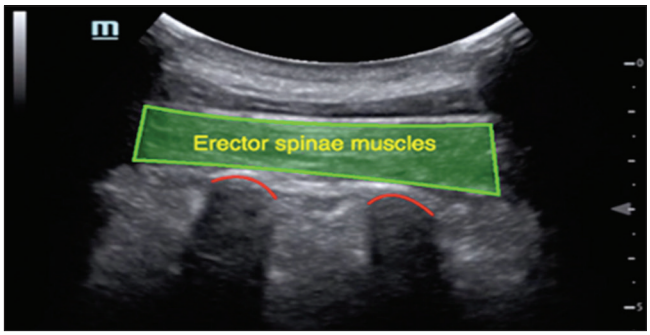

Figure 2: The thoracic transverse processes have a gentle curvilinear contour. This is the target goldilocks zone [8]

After the surgery ends, patients of both groups received ketorolac 30 mg IV and acetaminophen 10 mg IV then endotracheal extubation was done after proper weaning of atracurium using 0.05 μg/kg of neostigmine and 0.02 μg/kg of atropine. Afterward, patients were transferred to the post-anesthesia care unit (PACU). Starting in the PACU, pain assessment was started using NRS at the time of discharge, and rescue medication in the form of intravenous morphine 0.1 mg/kg was given if NRS is more than 4.

Statistical analysis

Sample size

The G-power software was used to estimate the required sample size based on a previous study [9]. The null hypothesis was rejected by recruiting 46 patients in the current study. The power calculation was equal with the population means of the two groups. 23 subjects in each group were required to detect a 10% difference in the time for first analgesic requirements between groups (taking type I or α error of 5%, type II or β error of 20%, and Standard Deviation = 10).

Statistical analysis

The data were expressed as mean ± standard deviation, median and range, and percentages as appropriate. Kolmogorov–Smirnov test and Shapiro–Wilk test were used to identify the normality of the data. The independent student t-test was used to compare the numerically normally distributed data, while the Mann–Whitney test was used to compare the numerically not normally distributed data. For comparing gender, Chi-square (χ^2) test was used. Two-sided $p < 0.05$ was marked as statistical significance. All statistical tests were done using the computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp, Armonk, NY, USA) release 22 for Microsoft Windows.

Results

Forty-nine patients were enrolled and randomized as follows: 24 patients were allocated to ESPB and 25 patients were assigned to the control group. Three patients were excluded (two patients from the C group and one patient from the E group) due to intraoperative bleeding which lengthened the operative time by more than 2.5 h (Figure 3).

The general characteristics of the patients regarding (age and gender and ASA classification) and duration of surgery showed no statistical significance difference (Table 1).

Table 1: The general characteristics and duration of surgery of the two groups

	ESPB (n = 23)	Control (n = 23)	p-value
Age			
Median and	51.00	45.00	0.202
IQR	43.50–60.50	41.00–53.50	
Sex			
Male %	56.5%	52.2%	0.767
Female %	43.5%	47.8%	
Weight			
Median and	90.00	90.00	0.964
IQR	80.00–100.00	80.00–100.00	
Duration of Surgery (min)			
Mean ± standard deviation	119.42 ± 15.05	121.47 ± 11.68	0.498

ESPB: Erector spinae plane block

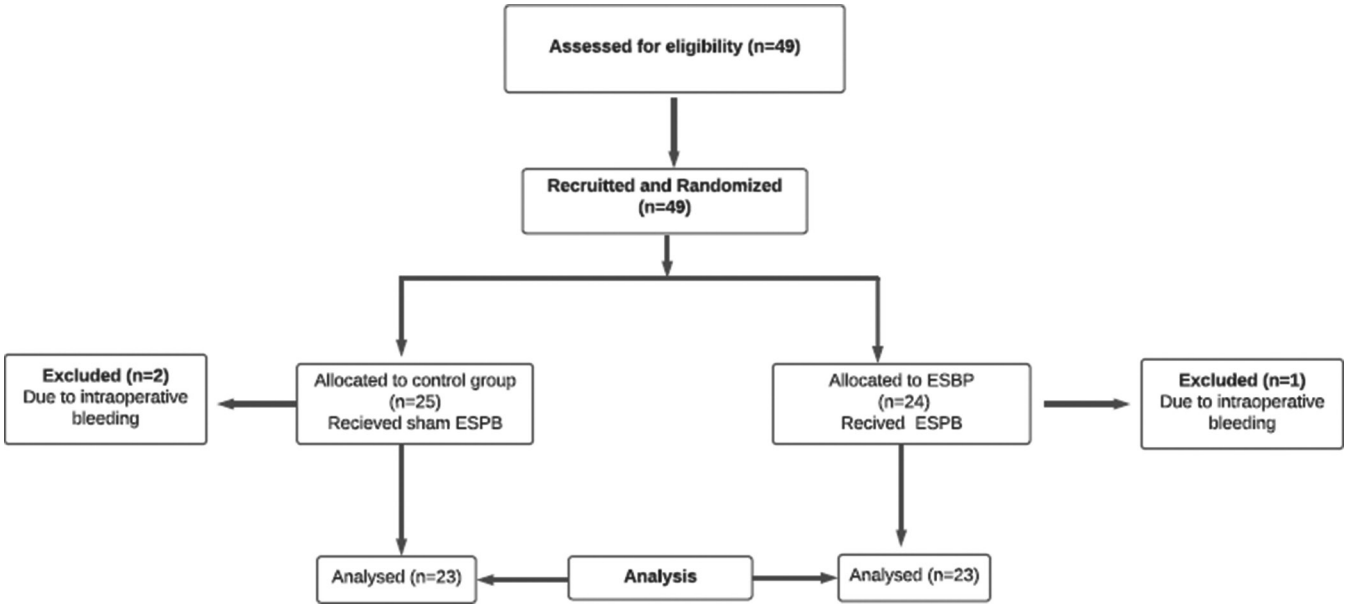

Figure 3: Flow chart

Time of the 1st rescue analgesic requirement was prolonged by the ESPB as shown by its median value "300 min" compared to the control group which had a lower median value "30 min" with a highly significant p-value ($p < 0.001$). Total morphine consumption in the first 24th h postoperatively was significantly reduced in the ESPB group "shown by its median value: 9 mg" compared to higher median value in the control group "18 mg" and it showed a highly significant p-value ($p < 0.001$). ESPB decreased the intraoperative fentanyl consumption. This was proved by ESPB's median value which was significantly lower (80 mg) than control's group median value (180 mg) with p value ($p < 0.001$) (Table 2).

Table 2: Analysis of perioperative analgesic consumption

	ESPB (n = 23)	Control (n = 23)	Mann-Whitney	p-value
Time to 1st rescue analgesia (min)				
Median and	300.00	30.00	0.000	0.000
IOR	240.00–420.00	15.00–42.50		
Total 24th h morphine consumption				
Median and	9.00	18.00	0.000	0.000
IOR	8.00–10.00	16.00–20.00		
Intraoperative Fentanyl consumption				
Median and	80.00	180.00	0.000	0.000
IOR	35.00–97.50	160.00–200.00		

ESPB: Erector spinae plane block

Analysis of NRS showed that the ESPB group had lower degrees of postoperative pain throughout most of the first 24th h postoperatively. This was shown by NRS median values in the E group were significantly lower at time of discharge to the PACU (NRS: 0), 15 min (NRS: 1), and 30 min (NRS: 2) with highly significant p-value ($p < 0.001$) compared to C group. At the 1 h time point (NRS: 3); there was no statistical significance between the ESPB group and the control group. Afterward, all the time points showed lower median values of NRS in the E group relative to the C group with a highly significant p-value ($p < 0.001$) except for the 24th h postoperatively (NRS: 6) which had a p-value ($p < 0.05$) (Table 3).

Table 3: Analysis of NRS at different time points

NRS		ESPB	Control	Mann-Whitney	p-value
NRS (0) (TOD)	Median and IOR	0.00 0.00–0.00	2.00 2.00–3.00	2.000	0.000
NRS (1) (15 min)	Median and IOR	1.00 1.00–1.00	3.00 3.00–4.00	0.000	0.000
NRS (2) (30 min)	Median and IOR	1.00 1.00–2.00	3.00 3.00–3.50	27.500	0.000
NRS (3) (1 h)	Median and IOR	2.00 2.00–3.00	3.00 2.00–3.50	198.500	0.131
NRS (4) (6 h)	Median and IOR	4.00 2.50–4.00	6.00 6.00–7.00	34.000	0.000
NRS (5) (12 h)	Median and IOR	2.00 2.00–2.50	3.00 3.00–3.00	97.000	0.000
NRS (6) (24 h)	Median and IOR	2.00 1.50-2.00	2.00 2.00–3.00	161.000	0.008

NRS: Numerical rating scale, ESPB: Erector spinae plane block, TOD: Time of discharge to PACU

Regarding intra-operative hemodynamics; both heart rate and mean arterial blood pressure measurements had statistically significant lower values in the ESPB group compared to the control group yet all the measurements remained in the clinically accepted ranges. No complications were observed in both groups.

Discussion

Our study showed that ESPB is a good choice for perioperative pain control following open renal surgeries. ESPB delayed the time needed for the first rescue analgesic requirement. In addition to NRS showed decreased values in the ESPB group compared to the control group throughout most of the first 24th h postoperatively. Furthermore, ESPB patients showed lower opioid consumption both intraoperatively and postoperatively than the control group.

ESPB is an analgesic technique that was exclusively done by Forero *et al.* for the management of

patients with thoracic neuropathic pain [1]. Since then, there were growing researches in ESPB concerning the best site of injection, adequate LA concentration, effective volume, and safety of the block.

Concerning the site of injection, the erector spinae muscle has a unique anatomy. It is not a single muscle, it represents three joined muscles: Iliocostalis, longissimus, and spinalis muscles. It has the sacrum and lumbar spinous process as combined origins and inserted upwards in the thoracic and cervical transverse process up to the C2 transverse process. This anatomical feature allows the LA to spread through different levels of the vertebral column [10], [11]. There have been many case reports describing ESPB in thoracic and lumbar regions. For example, ESPB was successfully applied in video-assisted thoracoscopic surgery for thoracotomy pain management [12] and in the cesarean section as postoperative analgesia [13]. Melvin *et al.* showed that ESPB performed at T10/T12 can be an effective pain management technique in lumbar spine surgery [14]. Tulgar and Senturk found that lumbar ESPB performed at the L4 level showed the same effectiveness as epidural analgesia in total hip arthroplasty [15]. In the current study, ESBP was administered at T10/T11 intervertebral space which showed good effectiveness in covering both renal and ureteric pains which are conducted through T8-L2 spinal nerves.

The determination of the safest volume and effective concentration of LA to be used in ESPB has been a matter of debate [16], [17]. From a safer point of view, it is advisable to use a large volume with a low LA concentration; however, some other authors used a lower to moderate volume with a high LA concentration [8]. Another point of concern was the exact volume required to block a single dermatome after bolus injection. As far as our knowledge extends there is no exact identified volume to block one dermatome. Forero *et al.* suggested that 9 dermatomes were the maximum number that could be covered by 30 ml bolus as a single injection in ESPB. [18]. De Cassai and Tonetti concluded that 3.4 mL was enough to cover one dermatome [19]. Based on the previous data; the choice of the LA concentration and volume in our current study was done on the higher safety concerns so 25 ml of 0.25% bupivacaine was injected in ESPB. This volume and concentration showed high effectiveness in covering the desired dermatomes and providing good analgesia throughout the first 24th h postoperatively.

Regarding the safety of ESPB, there were no recorded complications in our study following ultrasound-guided ESPB administration. In general, the literature shows that ESPB is by far a less invasive, safer, and quicker alternative to other regional block techniques (e.g.; paravertebral block). In comparison with ultrasound-guided paravertebral block, it was found that the ESPB is a simpler alternative with the same mechanism of action [20], [21]. The ESPB has a higher safety profile as it reaches the paravertebral space indirectly and provides analgesia without the undesirable risk of pleural puncture and subsequent pneumothorax. Important structures such as nerves and major vessels are at no risk of needle injury during the block placement. Due to lack of vascular injury risk, the ESPB can be performed with highly experienced anesthesiologists in anti-coagulated patients with reasonable safety. The erector spinae muscle can be visualized ultra-soundly with ease in obese patients, making it a good analgesic alternative in those patients [22].

Conclusion

Our study showed that ultrasound-guided erector spinae block prolonged the time of the first analgesic requirement. It also reduced post-operative morphine consumption and pain scores in the first 24 h after open renal surgeries. So it proved to be a good analgesic alternative in open renal surgery patients.

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