

Comparison of the efficacy of erector spinae plane block and peritubal infiltration of levobupivacaine for postoperative analgesia following percutaneous nephrolithotomy

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Abstract

Background and Aims: Erector spinae plane (ESP) block is a simple and safe interfascial plane block reported to provide good analgesia after thoracolumbar surgeries. We compared its efficacy with conventional peritubal local anesthetic infiltration following percutaneous nephrolithotomy (PCNL).

Material and Methods: A total of 60 adult patients posted for elective PCNL were randomly allocated into two groups. Postoperatively, Group I received ultrasound (US) guided peritubular infiltration block with 20 ml of 0.25% levobupivacaine and Group II received US guided ESP block with 20 ml of 0.25% levobupivacaine. The two groups were compared for the time to first rescue analgesic (Injection tramadol), number of rescue analgesic demands, total analgesic consumption in first 24 hours, VAS (rest and dynamic) scores and the adverse effects. The data were analyzed by unpaired t-test and Mann Whitney U test.

Results: The time to first rescue analgesic demand was significantly longer in Group II (6.93 ± 2.15 h vs. 16.21 ± 7.53 h). The VAS scores (rest and dynamic) at eight and twelve hours of measurement were significantly lower in Group II ($P < 0.05$). The number of analgesic demands were less in group II (2.97 ± 0.49 vs. 1.00 ± 1.05). The total analgesic consumption in first 24 hours was less in Group II (148.33 ± 24.51 mg vs. 51.92 ± 45.78 mg).

Conclusion: ESP block is a very effective and safe technique to provide prolonged duration of postoperative analgesia following PCNL. Peritubal local anesthetic infiltration is also a reliable technique for postoperative analgesia.

Keywords: Erector spinae plane block, levobupivacaine, percutaneous nephrolithotomy, peritubal infiltration, postoperative analgesia, ultrasound

Introduction

Percutaneous nephrolithotomy (PCNL) is a minimally invasive procedure used for large renal stones. Small incision than open nephrolithotomy and lesser surgical time is associated with less morbidity and early ambulation. However, the nephrostomy tube put at the end is responsible for the local inflammatory reaction leading to pain and discomfort. This pain is of both visceral (kidney and ureter)

and somatic (incision site and nephrostomy tube tract) origin. Though various methods including opioids, non-steroidal anti-inflammatory drugs (NSAIDs) and different regional analgesia techniques have been described in the literature for postoperative pain management, there is still a continuous search to find an ideal way. Opioids and NSAIDs though effective, are not free from side effects and are also not a good choice in patients with renal dysfunction.^[1,2] Local infiltration, paravertebral block, epidural analgesia or intercostal nerve

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How to cite this article: Lomate P, Jadhav VR, Yadav A. Comparison of the efficacy of erector spinae plane block and peritubal infiltration of levobupivacaine for postoperative analgesia following percutaneous nephrolithotomy. *J Anaesthesiol Clin Pharmacol* 2021;37:574-9.

Submitted: 19-Jan-2020

Revised: 12-Mar-2020

Accepted: 14-Jun-2020

Published: 06-Jan-2022

Access this article online	
Quick Response Code:	Website: www.joacp.org
	DOI: 10.4103/joacp.JOACP_430_19

blocks provide good analgesia but are not always favorable due to technical difficulty or unpredictable duration of analgesia.^[3] Ultrasound (US) guided peritubal infiltration block is a simple and well established technique where local anesthetic is infiltrated along the course of nephrostomy tube from skin up to the renal capsule to achieve both somatic and visceral analgesia.^[4] This technique is reported to provide good postoperative pain relief, but the duration of action is short. US guided erector spinae plane (ESP) block, an interfascial plane block, is recently found to be useful in thoracic neuropathic pain management.^[5] It is reported to be a safe, simple and effective technique where for both sensory and visceral analgesia is achieved by blocking dorsal and ventral rami of spinal nerve roots. Various studies and case reports have come forward stating the effectiveness of this block for postoperative analgesia following different types of thoracoabdominal surgeries including PCNL.^[6]

Till date, there are no studies comparing peritubal infiltration block and ESP block for postoperative analgesia after PCNL. We designed this study with the aim of comparison of the analgesic efficacy of these two techniques with the hypothesis that the ESP block will provide more effective postoperative pain control than peritubal infiltration block after PCNL. This hypothesis was tested by comparing the duration of analgesia, which was our primary objective. The secondary objectives were to compare the number of rescue analgesics required, total consumption of rescue analgesics, VAS scores and complications in a 24 hour period.

Material and Methods

This prospective randomized double blind study was carried out in 60 ASA grade I and II patients of either sex, aged 18-60 years posted for elective percutaneous nephrolithotomy (PCNL) under general anesthesia (GA) [Figure 1]. This parallel designed (allocation ratio 1:1) study was conducted in a tertiary care unit from April 2018 to August 2019 after obtaining hospital ethical committee approval (BVDUMC&H/Sangli/IEC/305/18) and informed written consent from the patients for study and publications. Patients having any cardiorespiratory, neurological or psychiatric illness, coagulation abnormalities, known sensitivity to local anesthetics were excluded from the study. Other exclusion criteria included renal stones which required more than one puncture, supracostal puncture, intraoperative excessive bleeding, surgical time more than three hours and obesity (BMI >30 kg/m²).

All patients received balanced technique of GA after applying monitors for heart rate, electrocardiography (ECG) and pulse

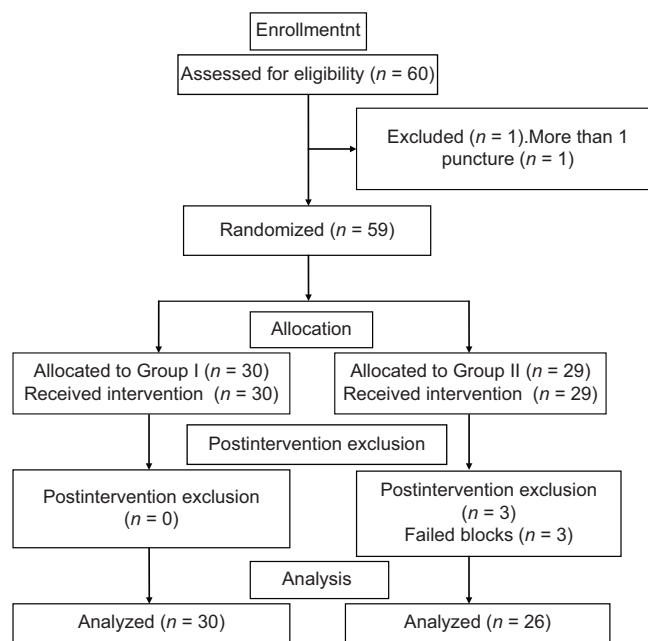


Figure 1: Consort flow diagram

oximetry (SpO₂). All patients were informed about the use of visual analog scale (VAS) score with zero indicating no pain and ten indicating the worst imaginable pain. After sedating with injection fentanyl 1 µmg/kg IV, all patients were induced with injection propofol 2mg/kg IV, intubated with appropriately sized endotracheal tube (Portex) after achieving neuromuscular blockade with 2 mg/kg succinyl choline. Anesthesia was maintained with 40% O₂, 60% N₂O mixture, sevoflurane and injection atracurium. At the end of the surgery and just before reversal, all patients received allocated interventions. The patients were randomly divided into two equal groups (n = 30 each) by a computer-generated random list and allocation concealment was done by using sealed envelopes. The person generating the random allocation sequence and enrolling the participants to interventions were blinded from the one doing intervention. Group I patients received peritubal infiltration block and group II patients were given erector spinae plane (ESP) block by using 20 ml of 0.25% levobupivacaine in each group. In group I, a 23G spinal needle was passed along the nephrostomy tube tract up to the renal capsule at 6 and 12 O' clock positions under ultrasound (US) guidance. At each position 10 ml of 0.25% levobupivacaine was infiltrated along renal capsule, muscles, subcutaneous tissue and skin. In group II, for giving ESP block, a high frequency linear probe of 13-6 MHz (Sonosite M turbo US machine) was kept parallel to the vertebral axis at the level of the eighth rib. Then the probe was moved from lateral to medial direction transversely till rounded shadow of rib gets transited into a rectangular shape of transverse process (TP). At this position, a 23G spinal needle was introduced in-plane in a cranio-caudal direction towards the

TP. Once the needle hit the TP, 2-3 ml of normal saline was injected to confirm the interfascial spread. Then 20 ml of 0.25% levobupivacaine was injected and a cranio-caudal spread of the drug along with lifting of the erector spinae muscle was observed.

The trachea was extubated uneventfully in supine position after reversing the effect of neuromuscular blocking agents with appropriate doses of neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg) and then the patients were shifted to the recovery room (RR). Postoperative pain scores were assessed by using a visual analogue scale score at rest (VAS) and during deep breathing and coughing (dynamic VAS score) at 0, 1, 2 and 4 hours; and thereafter every 4th hour till 24 hours. Assessment of pain scores was started 15 minutes after extubation when patient became fully conscious and oriented. This time was considered as a zero time. At the same time, the side effects like nausea, vomiting and complications like pneumothorax, haemothorax, hematoma, if any, were also noted. Duration of analgesia was considered as the time taken between zero time and the first analgesic demand by the patient. Injection tramadol 1mg/kg IV was given as a rescue analgesic at VAS \geq 4 with a maximum dose 400 mg in 24 hours. Number of rescue analgesics required and total analgesic consumption in 24 hours were also recorded. The patients who required rescue analgesic in the immediate postoperative period were excluded from the study and those interventions were considered as failed blocks.

The confounding variables like use of adjuvants and co-administration of multimodal analgesia, which may interfere with study results were eliminated. Patients with history of drug use/abuse, psychiatric disorders or chronic pain were also excluded. We used shorter acting opioid, fentanyl intraoperatively to avoid its influence on outcome of block efficacy.

Sample size was calculated after doing a pilot study with 10 patients in each group. It showed a mean duration of analgesia of 7.2 (\pm 1.64) hours in group I and 16.4 (\pm 4.77) hours in group II. With a 5% α level of significance and 90% power of the test to detect a difference of 9.2 hours between the 2 groups, minimum sample size calculated by using a statistical formula was 26 per group. Considering the possible dropouts, 30 patients were recruited in each group. Statistical analysis was done by using SPSS version 22 for Windows (IBM – Chicago). Mean and standard deviation was calculated for continuous variables, whereas the median was obtained for VAS scores. The unpaired t-test was applied to compare continuous variables of two independent groups and non-parametric test – Mann Whitney U test was applied for comparison of two independent ordinal variables. We used

Kolmogorov—Smirnov test to find out if data was normally distributed. Post hoc power analysis for primary outcome was 100% (or 1.00). $P < 0.05$ is considered as statistically significant.

Results

Demographic data of two groups were comparable and non-significant [Table 1]. Sixty patients were enrolled for the study, out of which 56 patients were analyzed [Figure 1]. The mean duration of postoperative analgesia was significantly prolonged in group II than in group I. It was 6.93 ± 2.15 hours in group I and 16.8 ± 2.14 hours in group II, which was statistically significant [$P = 0.00$] [Table 2]. The VAS scores at rest and dynamic VAS scores were significantly lower in group II than in group I at 8 and 12 hours [$P = 0.00$] [Tables 3 and 4]. The number of rescue analgesics required and total consumption of tramadol in 24 hours were less in group II than in group I [$P = 0.00$] [Table 2]. The incidence of nausea and vomiting was low in both the groups and was statistically insignificant. No patient in either group developed pneumothorax, haemothorax or wound hematoma [Table 5].

Discussion

In this prospective randomized double blind study the efficacy of erector spinae plane (ESP) block was compared with the peritubal local anesthetic infiltration block for postoperative analgesia in patients who have undergone percutaneous nephrolithotomy (PCNL) under general anesthesia (GA). Acute postoperative pain should be managed effectively to avoid undesirable outcomes like tachycardia, hypertension and delayed mobilization.^[7]

The local inflammatory reaction produced by nephrostomy tube and some neuronal pathways of pain can be blocked by subcutaneous infiltration of local anesthetic agents, but it does not provide visceral pain relief.^[8,9] In our study we performed ultrasound (US) guided peritubal infiltration of 0.25% levobupivacaine from skin to the renal capsule in group I population for postoperative pain control. In one

Table 1: Demographics

Parameters	Group I (n=30) mean \pm SD	Group II (n=26) mean \pm SD	P
Age (yrs)	44.1 \pm 10.68	45.41 \pm 8.65	0.605
Sex (M:F)	19:11	20:9	
Weight (kg)	57.9 \pm 6.42	56.55 \pm 6.5	0.427
Height (cm)	168.6 \pm 3.97	169.35 \pm 3.36	0.440
Duration of surgery (min)	98.83 \pm 23.4	94.31 \pm 17.31	0.401

SD-standard deviation. $P < 0.05$ is statistically significant

Table 2: Comparison of analgesic demands

Parameters	Group I (n=30) mean±SD	Group II (n=26) mean±SD	P
Mean time for first rescue analgesic (h)	6.93±2.15	16.8±2.14	*0.00
Mean number of demands in 24 hours	2.97±0.49	1.00±1.05	*0.00
Total tramadol consumption in 24 hours (mg)	148.33±24.51	51.92±45.78	*0.00

SD-standard deviation, *statistically significant, RR-recovery room

Table 3: Comparison of VAS scores at rest (Median IQR)

Postoperative hours	Group I (n=30)	Group II (n=26)	P
VAS 0	1 (0-2)	1 (0-5)	0.779
VAS 1	2 (0-2)	1 (0-5)	*0.02
VAS 2	2 (1-3)	1 (0-4)	*0.032
VAS 4	2 (1-5)	1 (0-3)	*0.000
VAS 8	5 (4-6)	1 (1-3)	*0.000
VAS 12	4 (3-5)	2 (1-5)	*0.000
VAS 16	4.5 (3-5)	4 (2-5)	*0.000
VAS 20	3 (2-5)	4 (3-5)	*0.000
VAS 24	2.5 (2-4)	2 (1-4)	0.077

VAS - Visual Analogue Scale, IQR - Interquartile range, *statistically significant

Table 4. Comparison of Dynamic VAS scores (Median IQR)

Postoperative hours	Group I (n=30)	Group II (n=26)	P
VAS 1	2 (0-2)	1 (0-5)	*0.005
VAS 2	2 (0-3)	1 (0-5)	*0.01
VAS 4	2 (1-5)	1 (0-4)	*0.00
VAS 8	3 (2-6)	1 (0-3)	*0.00
VAS 12	6 (3-7)	2 (1-4)	*0.00
VAS 16	4 (4-5)	3 (1-5)	*0.00
VAS 20	5 (4-6)	5 (3-6)	*0.00
VAS 24	3 (2-5)	4 (3-5)	*0.00
VAS 24	3 (2-6)	2 (1-4)	*0.00

VAS - Visual Analogue Scale, IQR - Interquartile range, *statistically significant

Table 5: Comparison of side effects

Parameters	Group I (n=30) mean±SD	Group II (n=26) mean±SD	P
Nausea/vomiting (no. of patients)	2	1	0.58
Haematoma	0	0	
Pneumothorax	0	0	
Haemothorax	0	0	

SD - standard deviation

study PCNL was performed under sole renal capsular block with 2% xylocaine where authors found that most of the pain was felt during renal capsular and parenchymal dilatation.^[10] Hence, local anesthetic infiltration along the whole tract of nephrostomy tube from skin to the renal capsule is recommended to achieve adequate analgesia. In a similar study this technique was found to produce prolonged duration of postoperative analgesia and reduction in first 24 hours total analgesic consumption following PCNL.^[11] Our study results are consistent with this study. Parikh *et al.*^[12] added injection

morphine to 0.25% ropivacaine for peritubular infiltration and found opioid-induced extension of postoperative analgesia. However in another study the fluoroscopy guided intercostal nerve block (ICNB) was found to be more effective than the conventional peritubular infiltration block following PCNL.^[13]

Due to the advent of US into the practice of anesthesia, various interfascial plane blocks have been introduced for acute and chronic pain management.^[13-16] The ESP block is a recently described simple and safe block where local anesthetic is injected deep to the erector spinae muscle and above the transverse process. As the erector spinae fascia extends from nuchal fascia to the sacrum, a plane is created in a craniocaudal direction and hence a wide area is blocked to provide extensive unilateral analgesia after various thoracoabdominal surgeries.^[17-19] Due to its wide margin of safety and good analgesia potential with blocking of desired neurotomes, we studied and compared the efficacy of ESP block with the conventional peritubular infiltration block. We believe that the prolonged duration of analgesia produced in our study after ESP block as compared to that after the peritubular infiltration block was due to the comparatively slow absorption of local anesthetics from the interfascial plane than from the inflamed and anatomically disturbed tissues around the nephrostomy tube.^[20] It has shown that the drug spreads to the paravertebral space through the costotransverse foramina and blocks ipsilateral dorsal and ventral rami of spinal nerve roots to provide both somatic and visceral analgesia.^[19,21] The duration of analgesia is always longer when local anesthetic is injected into the non-injured area than into the surgically injured area due to the “windup” phenomenon of impulse transmission through afferent and efferent neurons.^[22]

There are few case reports showing the usefulness of ESP block in thoracic, abdominal and some urological surgeries. Kim *et al.* inserted a catheter into the erector spinae plane at T8 level for postoperative analgesia after PCNL and noted reduced pain scores and opioid consumption for five days.^[23] In our study, we performed single shot ESP block to achieve prolonged duration of analgesia. There are no study reports as to what level block should be performed for PCNL surgery. Considering the nerve root values of kidneys (T10-L1) and ureter (T10-L2) and the site of incision, we performed the ESP block at T8 vertebral level. In one case series the authors successfully administered the ESP blocks at T2, T5

and T7 levels for sensory blockade of cervical, thoracic and lumbar dermatomes respectively.^[6] In another case series, a low ESP block performed at T8 level was found to be an useful alternative to epidural analgesia for perioperative pain management during lower abdominal surgeries like nephrectomy, renal transplant, prostatectomy and laparoscopic cholecystectomy.^[24] In one of the cadaveric dye studies, a wide spread of dye from T2 to L2 was observed after injection at T7 level.^[25] Hence, we believe that the block performed at T8 vertebral level covers sufficient neurotomes to provide effective analgesia after PCNL, however more studies are required to come to the conclusion.

As ESP block provides prolonged postoperative analgesia than the peritubal infiltration block, it allows the patients to breathe and cough properly that helps to prevent respiratory complications like atelectasis and pneumonia. It also helps to wean off the mechanical ventilation.^[26]

There are studies showing hundred percent success rate of peritubular infiltration block.^[4,11,12] Our study findings are matching with these studies. However we reported 3 cases of failed blocks in group II. Finding the specific cause of failed blocks is difficult to this date as still there are controversies as to the exact spread of local anesthetics through the erector spinae plane. Some authors believe that the drug spreads from the ESP to the paravertebral space through the costotransverse foramina or the connective tissue and ligaments.^[5,25,27] However, according to other authors, the analgesia achieved after the ESP block was not due to the paravertebral spread but due to the blocking of the lateral cutaneous branches of intercostal nerves, resulting in inadequate analgesia.^[21] We claim that the factors like inter-individual variability in the spread of drug, patency of costotransverse foramina, and other anatomical apertures through which drug has to spread, the vertebral level of block, volume and concentration of local anesthetics, unintentional intramuscular spread of drug and technical expertise are probably responsible for the success/failure rates of ESP blocks.^[25,27] We demand more studies to find the exact cause of failure and the solution over it.

The ESP block is believed to be a very safe block as there are no structures at risk of needle injury in its close vicinity. It is free from the complications associated with epidural analgesia, paravertebral block or ICNB like hypotension, epidural spread and pneumothorax, respectively.^[28,29]

To date, this is the first study to evaluate and compare the analgesic efficacy of peritubular infiltration block and ESP block for postoperative analgesia after PCNL. Its prospective randomized design, appropriate calculation of sample size from pilot study, complete follow-up of study population and

proper use of protocol to avoid bias are some strengths of our study. Our study results could become a basis for future studies.

Small sample size, single-center design and absence of control group are some of the limitations of our study. We also did not include patients with double kidney puncture. We failed to document cutaneous sensory test to study the range of area covered after ESP block. We did not register the trial with a trial registry prospectively which is understood as important.

Conclusion

From our study it is concluded that the erector spinae plane (ESP) block is superior to peritubal infiltration block with respect to the duration of postoperative analgesia, number of rescue analgesics required and total analgesic consumption in first 24 hours after percutaneous nephrolithotomy. However we recommend further studies to correlate the success rate of ESP block with the level of block, multiple level blocks or the volume and concentration of local anesthetic drugs.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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