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Efficacy of ultrasound-guided thoracic paravertebral block for postoperative analgesia in patients undergoing percutaneous nephrolithotomy

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Abstract

Background: *percutaneous nephrolithotomy (PCNL) is a minimally invasive surgery to treat renal stones. Postoperative pain is distressing to the patient due to the injury to the capsule. Efficacy of ultrasound-guided thoracic paravertebral block at multiple level (T_9–T_{10}, T_{10}–T_{11}, T_{11}–T_{12}) was evaluated to manage postoperative analgesia in percutaneous nephrolithotomy surgeries.*

Methodology: *a prospective randomized double-blind study of 60 cases of the American Society of Anesthesiologists I–II patients who underwent percutaneous nephrolithotomy were allocated into group P (test) and group N (control). Immediately after surgery, group P were given ultrasound-guided paravertebral block at T_9–T_{10}, T_{10}–T_{11}, T_{11}–T_{12} on operated side using 5 ml of 0.25% Levobupivacine at each level, while group N did not receive paravertebral block. The patients were assessed for visual analogue scale (VAS), time for first rescue analgesic, number of rescue analgesics in first 24 hrs postoperatively.*

Results: *VAS pain scale shows significant difference between group P (4.2 + 0.8) and group N (5.3 + 1.1) ($p < 0.05$) at 30 mins, 2, 4, 8 hrs postoperatively. Total opioid consumption at postoperative 2, 6, and 24 hrs was less in group P than group N ($P < 0.05$). Number of rescue analgesics in first 24 hrs post-surgery in group P was 3.0 ± 0.4, and 4.0 ± 1.1 in group N with statistical significant difference ($p = 0.0001$). Total dose of opioid consumption (mg) in group P was 110 ± 40.45, and 155 ± 64.87 mg in group N with statistical significant difference ($p = 0.002$). The group N cases used more opioid than group P, with lower scores for satisfaction ($p < 0.05$). Analgesic consumption in postoperative 24 hrs of group P was less than that of group N ($P = 0.001$). Patient satisfaction score was significantly higher in group P than group N ($P = 0.0001$) in 24 hrs. No nausea and/or vomiting were noted in both groups.*

Conclusion: *ultrasound-guided thoracic paravertebral block had more analgesic, and reduce the requirement of opioids and maintains stable hemodynamics.*

Trial Registry: the trial registration number was CTRI/2021/02/031332.

Abbreviations: *PVB: Paravertebral block; VAS: visual analogue scale; PNCL: Percutaneous nephrolithotomy.*

Key words: *percutaneous nephrolithotomy, ultrasound-guided paravertebral block, postoperative analgesia, visual analogue scale.*

Introduction

Percutaneous nephrolithotomy is a minimal invasive surgery to treat kidney stones.[1] The nephrostomy tube insertion technique for providing patients urinary drainage and homeostasis causes pain, prolongs the hospitalization, and increases the anxiety.[2] Post-operative pain is caused by dilation of renal capsule/parenchymal tract, and peritubal distressing of the nephrostomy tube.[3]

In order to improve the postoperative analgesia in PNCL cases, various methods were adopted, such as injecting opioids, local anesthetic infiltration, or peripheral nerve blockages.[4] It's side effects, such as respiratory depression, nausea, vomiting, and itching, limit its use at high doses.[5] Regional anesthesia such as paravertebral block, intercostal nerve blocks, and erector spinae plane block were reasonably effective.[6,7,8] Ultrasound-guided Paravertebral blocks had low risk and is efficacious in procedures performed unilaterally.[9] A single site injection provides the blocks of 4–6 dermatomes.[10,11] Thoracic paravertebral block can be performed at multiple levels under ultrasound-guided technique. It reduces the dose of the local anaesthetics at each level reducing the complications of high volume of local anaesthetics.[12,13]

Nevertheless there were not enough studies to prove its efficacy in PNCL surgeries. Hence our primary aim was to assess the efficacy of thoracic PVB on analgesic efficacy and rescue analgesia consumption in patients underwent ultrasound-guided PCNL.

Patients and methods

This prospective randomised double-blind study was carried out at Department of Anesthesia, Narayana Medical College Hospital. The study included 60 patients who scheduled for PCNL procedure. Patients who met the inclusion criteria were chosen for the study, and all patients gave their informed consent.

The study included patients with ASA grades I and II who were scheduled for PCNL surgeries under general anaesthesia, patients between the ages of 18 and 60, and patients who could provide valid informed consent.

Patients with hemorrhagic disorders, patients on anticoagulant therapy, spinal cord disease and deformities, current pregnancy, and depressive illness or anxiety disorder were excluded.

Patient randomization

Computer based random selection of patients to one of the two groups was done using a standard randomization code. Group P and group N were allocated 30 patients earch. Standard general anesthesia protocols were followed with Inj Propofol, Inj Atracurium, Inj Tramadol hydrochloride 100 mg/ml, and O_2 + air + sevoflurane for all the patients posted for PCNL. At the end of the surgery before extubation, under strict aseptic conditions ultrasound-guided PVB block given to group P, and group N did not received the block. Ultrasound machine (SONOSITE) with high frequency linear probe (6–13 HZ) covered with sterile sheath and 22G spinal needle was used for blocks. Group P received Paravertebral blockade (PVB) at T_9–T_{10}, T_{10}–T_{11}, T_{11}–T_{12} levels with 5 ml of 0.25 % Levobupivacaine at each level. The US probe was placed in a caudocranial orientation from midline at the T_{11}–T_{12} level. 22G needle was inserted in a caudocradial direction in line with the ultrasound probe orientation. Once the costotransverse ligament was breached, the needle tip enters thoracic paravertebral space.

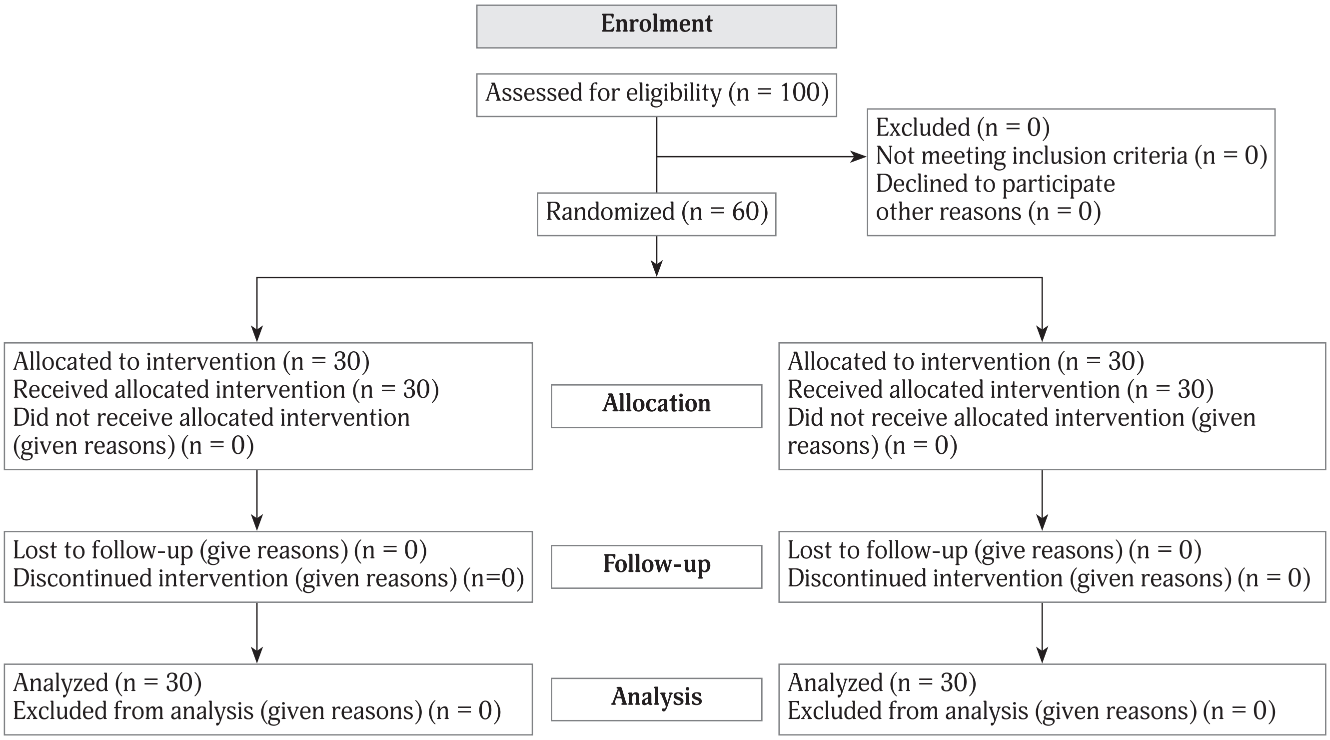
After a negative blood aspiration test, 5ml of local anaesthetic is injected slowly into the TPVS. During the local anaesthetic injection, the pleura was seen being pushed down ventrally. The probe was moved cranially to identify the above paravertebral spaces i.e, T_{10}–T_{11}, T_9–T_{10} and 5 ml local anesthetic was injected into each space. All the PVBs were under taken by the same experienced anesthetist. The visual analogue scale was used to assess postoperative analgesia needs, with 0 indicating no pain and 10 indicating severe pain. Evaluations were performed 30 minutes, 2, 4, 8, 12, and 24 hrs post-surgery. VAS score of ≥ 4 is considered to indicate the need for additional pain relief. Tramadol hydrochloride 100 mg/ml IV/IM was administered to control group. The level of patient comfort was also noted. The occurrence of side effects and the need for additional pain relief were noted. Patient satisfaction was assessed 24 hours after surgery. For this, a scale of 1 to 3 was used, with 1 being unsatisfied and 3 being completely satisfied (excellent). All surgeries were performed by the same urologist.

Statistical analysis

Data were expressed as mean, standard deviation, frequency, or frequency and percentage. To analyze quantitative data, the Statistical Package for the Social Sciences version 20 (IBM, Armonk, NY, USA) was used. The independent samples 't' test was used to compare quantitative normally distributed data in groups, and the Mann – Whitney U test was used to analyze non-normally distributed data. $P < 0.05$ was considered statistically significant.

Results

There was no statistical difference in terms of sex, age, weight, height, or ASA grade ($p > 0.05$) (Table 1). The surgical time ranged between 60 and 120 minutes. During the surgery, both groups P and N used similar opioids ($p > 0.05$). In the post-operative period, group N used more analgesia for pain relief than group P, and they were less satisfied with the procedure ($p < 0.05$).



Flow chart showing patient's recruitment and allocation

Table 1. Demographics, mean time of first rescue analgesia: Number of rescue analgesics in first 24 hrs & Total dose of opioid consumption in 24 hrs postoperatively

	Group P (n = 30)	Group N (n = 30)	P-value
Age (years)	48.9 ± 3.96	48.55 ± 4.65	0.78
Gender (M/F)	10/20	14/16	0.2*
ASA (I/II)	23/7	20/10	0.3*
Height (cm)	159.62 ± 4.11	159.15 ± 3.716	0.8
Body weight (range) kg	54.93 ± 5.1 (44–63)	55.55 ± 4.42 (44–65)	0.6
Surgery time (range) min	69.8 ± 19.5 (60–120)	71.2 ± 17.5 (62–120)	0.12
Anaesthesia time (min)	67.5 ± 18.85	64.25 ± 20.4	0.24#
Hospital stay (day)	2 (1.5–4)	2 (2–4)	1.0#
Intraoperative MAP (mm Hg)	89 (80–100)	86 (75–100)	0.24
Intraoperative HR (bpm)	77.4 (62–92)	82.5 (60–95)	0.4
Mean time of rescue analgesia (min)	486 ± 64	148 ± 67	0.0001
Number of rescue analgesics in first 24 hrs	3.0 ± 0.4	4.0 ± 1.1	0.0001
Total dose of opioid consumption (mg)	110 ±40.45	155 ± 64.87	0.002
Patient satisfaction[@]			
Unsatisfied	0	12(40 %)	0.001
Good	11 (36.6 %)	18 (80 %)	
Excellent	19 (63.4 %)	0	

* Pearson chi-square test, #Mann – Whitney U test, $p < 0.05$ significant.
[@] Satisfaction assessed by anaesthesiologist post-surgery.

Table 2: Visual analogue scale in group P, and group N

Time interval	Group P		Group N		P-value
	Mean	*SD*	*Mean*	*SD*	
30 min	0.6	0.1	1.8	1.1	0.0001
2 hr	1.5	0.7	3.2	0.8	0.0001
4 hr	2.3	0.7	4.2	1.1	0.004
6 hr	3.6	0.493	4.4	0.47	0.002
8 hr	4.2	0.8	5.3	1.1	0.03
10 hr	3.9	0.416	4.1	0.46	0.01
12 hr	4.3	0.9	3.8	0.6	0.0008
14 hr	4.31	0.467	4.1	0.33	0.005
16 hr	4.34	0.478	3.9	0.39	0.04
18 hr	4.47	0.530	3.9	0.386	0.045
20 hr	4.4	0.493	3.4	0.35	0.06
22 hr	4.51	0.50	3.9	0.37	0.56
24 hr	4.8	0.5	4.8	0.6	1.0

VAS scores at 30 mins, 2, 4, and 8 hrs was lower in group P than group N with P-value < 0.05 (Table 2).

At 30 hrs post-operatively, the VAS score was higher during dynamic state than at rest, and the difference was statistically significant. In group N, VAS was higher during movement than at rest. At 2 and 4 hr post-operatively, VAS score was higher in group N, both at rest and in dynamic state, with a statistically significant difference (Table 2).

The VAS score at rest showed a significant difference between groups up to 18 hours post-operatively (p > 0.05). The VAS score at moving state was significantly higher in both groups at 20 hr and 22 hr post-operatively (p > 0.05). At 24 hours post-operatively, neither the resting nor the dynamic VAS scores differed statistically (p > 0.05).

The mean time required for rescue analgesia in group P was 486 minutes, compared to 148 minutes in group N, with a statistically significant difference (p = 0.001). All patients in group N required more analgesia (p < 0.05).

The mean number of rescue analgesics in the first 24 hours in group P was 3.0 + 0.4, compared to 4.0 + 1.1 in group N, with a statistically significant P-value of 0.0001.

The satisfaction score in group P was higher than in group N, with a statistically significant difference (Table 1).

There was no significant difference in intraoperative and postoperative hemodynamic parameters between the two groups (Table 3).

There were no side effects such as hypotension, bradycardia, respiratory problems, nausea, or vomiting in either group of patients.

Discussion

Paravertebral block (PVB) is used in many urological procedures.[12] PVB can achieve adequate somatic and visceral sensory blockade to provide anaesthetic cover for PCNL

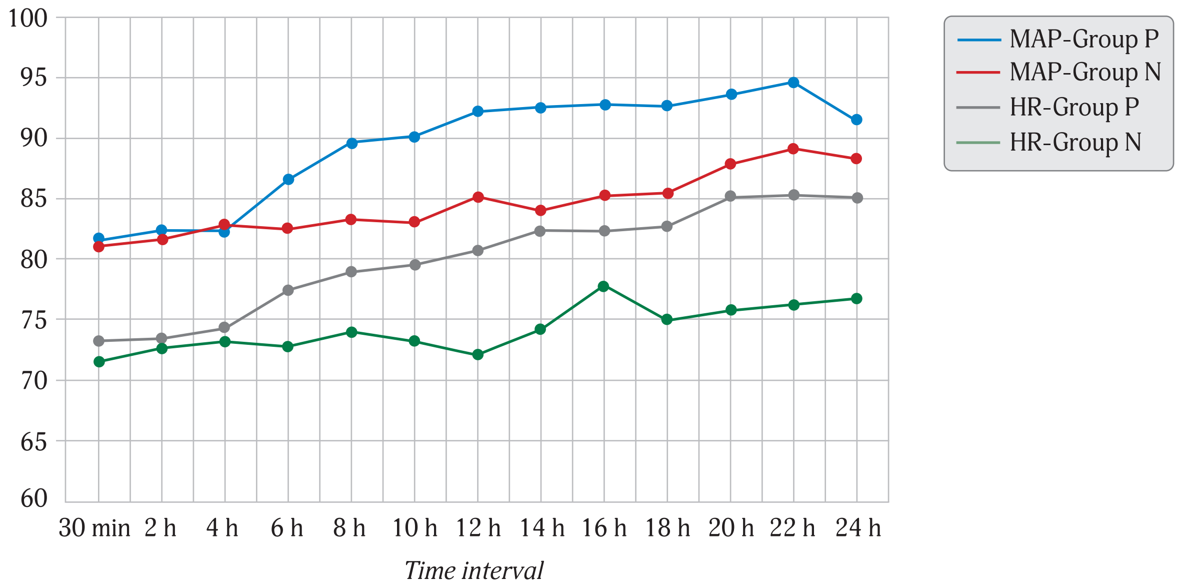


Fig. 1. Comparison of Mean arterial pressure (MAP) and Heart rate (HR) in group P, and group N

Table 3: Comparison of Systolic blood pressure (SBP), Diastolic blood pressure (DBP) in in group P, and group N

		30 min	2 hr	4 hr	6 hr	8 hr	10 hr	12 hr	24 hr
SBP (mm Hg)	Group P	113.2 ± ± 12.8	115.3 ± ± 12.2	114.4 ± ± 12.4	110.7 ± ± 11.8	107.8 ± ± 13.21	109.7 ± ± 12.78	111.69 ± ± 12.8	118.5 ± ± 10.5
	Group N	116.07 ± ± 10.55	116.5 ± ± 12.6	113.8 ± ± 10.9	116.05 ± ± 12.2	117.7 ± ± 11.49	119.00 ± ± 12.35	119.33 ± ± 8.8	119.33 ± ± 7.08
	P-value	0.034*	0.09	0.36	0.05*	0.003*	0.003*	0.15	0.15
DBP (mm Hg)	Group P	72.5 ± ± 12.1	73.53 ± ± 10.1	73.33 ± ± 11.26	72.4 ± ± 11.5	69.33 ± ± 9.53	69.33 ± ± 9.44	71.52 ± ± 9.2	76.55 ± ± 7.12
	Group N	72.4 ± ± 10.2	73.43 ± ± 9.2	72.27 ± ± 9.65	79.33 ± ± 8.44	74.53 ± ± 12.49	76.80 ± ± 10.91	79.2 ± ± 5.9	80.5 ± ± 9.5
	P-value	0.8	1.0	0.34	0.05*	0.03*	0.003*	0.008*	0.007*

* Significant.

with careful planning and the use of a refined block technique guided by ultrasound. PVB has demonstrated the ability to control postoperative pain in a variety of surgical patients while having no discernible effect on motor blockade, bowel movements, or hemodynamic balance.

The current study found that ultrasound-guided PVB was effective against postoperative pain in patients undergoing PCN, and it reduced the need for additional analgesics. Study found that pain scores were lower in patients who were given PVB at multiple levels under ultrasound guidance and these patients had reduced need for rescue analgesia up to 12 hr post-surgery. The patients who administered PVB had better VAS than those in whom not taken the procedure.

The results were in line with other studies in using PVB in PCNL.[14,15]

Yaman et al[15] conducted a study by administering 20 ml of 0.25 % levobupivacaine at T_8–T_9 level as a single administration. They observed that the VAS scores are significantly lower in paravertebral block up to 6 hours post-surgically. In this PVB was given before conduct of general anesthesia and patient in sitting posture. In the present study PVB was given at the end of surgery before extubation and the patient in prone position at multiple levels with 5ml of 0.25 % levobupivacaine at each level. Study found that pain scores were lower for 8 hours postoperatively. This difference may be due to the timing of the block. We conducted the block at the end of the surgery.

Hati polagu et al[13] performed paravertebral block at the levels of T_{11}, T_{12}, and L_1 prior to surgery, but with the patient under general anaesthesia and in the prone position. They injected 5ml of 0.5 % bupivacaine under ultrasound guidance at each level. This study found that analgesia could be maintained for up to 24 hours after surgery. In our study, we observed that pain scores were significantly lower in the PVB group 8 hours after surgery. The difference in duration could be due to drug concentration, as bupivacaine has a longer duration of action than levobupivacaine.

AK et al[12] conducted the study by injecting 0.5 % levobupivacaine at the levels of T_{10}, T_{11}, T_{12}. 4 ml were infiltrated at each level prior to surgery under general anaesthesia. According to the findings of this study, pain at rest as measured by VAS was significantly lower in the PVB group for 2 hours after surgery. In the current case, a paravertebral block of 0.25 % levobupivacaine was administered at the end of surgery under ultrasound guidance at the levels of T_9–T_{10}, T_{10}–T_{11}, and T_{11}–T_{12}. Our study showed that pain relief lasted 12 hours after surgery. The difference could be due to differences in drug volume, timing of the block, and the fact that we perform the block using ultrasound guidance.

Yayik et al compared PVB and peritubal infiltration in PCNL. Up to 24 hours after surgery, VAS scores at rest and movement were significantly lower in the PVB group than in the peritubal group. At the end of surgery, they gave PVB 20 ml of 0.25 % bupivacaine at the T_8–T_9 level.[16] In our study, we used 15 ml of 0.25 % levobupivacaine at various concentrations. The difference in our study is due to a decrease in drug volume, and bupivacaine has a longer duration than bupivacaine.

Another study was conducted by inserting a catheter into the paravertebral space at the level of T_{10} prior to surgery.[12] Catheter insertion was performed on an awake patient who was sitting upright. Prior to surgery, 20 ml of 0.5 % was injected. After 275 minutes, the first rescue analgesia was administered. This indicates that a single injection is insufficient for complete analgesia following surgery for the first 24 hours. Our study used a lower concentration and volume of drug, but it was administered at the end of surgery in the prone position. We had lower VAS scores for the first 8 hours after surgery. Our findings show that using 0.25 % levobupivacaine at multiple levels and 5 ml at each level, the duration of PVB is 8 hrs.

Baldea et al[17] performed PVB at T_{10} with 20 ml of 0.5 % bupivacaine. The block was performed prior to surgery while the patient was sitting and under ultrasound guidance.

Kamble et al[18] compared PVB to 0.5 % bupivacaine and 0.5 % bupivacaine plus 1 mcg/kg clonidine. PVB was administered to awake patients in the sitting position prior to surgery. Clonidine has been shown to provide a higher quality of block and to prolong postoperative analgesia. There were no adjuvants used in this study to treat paravertebral block.

Baik et al[19] performed ultrasound-guided PVB with 0.75 % Ropivacaine for surgical anaesthesia in patients undergoing nephrectomy and concluded that perioperative single thoracic PVB contributes significantly to the reduction of post-surgery pain scores and decreases opioid consumption.

In the current study, we performed ultrasound-guided PVB at multiple levels at the end of surgery, using 0.25 % Levobupivacaine 5ml at each level. Our findings indicated that patients had analgesia for 8 hours after surgery.

Richa Sarora et al compared 0.2 % Ropivacaine and 0.2 % Levobupivacaine for post-operative analgesia with ultrasound-guided PVB in PCNL surgeries. At the end of the surgery, they performed this block at T_{10}–$_{11}$ with 20 ml of either drug. They concluded that the time to first analgesic requirement was longer in the LB group (1.60 + 3.64 h) than in the RB group (0.33 + 1.04 h), but it was not statistically significant.[20]

In the current study, we used ultrasound to guide PVB at T_9–$_{10}$, T_{10}–$_{11}$, and T_{11}–$_{12}$ levels, using 5ml of 0.25 % Levobupivacaine at each level. In the PVB group, the VAS score and opioid consumption decreased significantly.

Rashwan et al. compared the effects of PVB, epidural, and general anaesthesia in patients undergoing PCNL. They assessed both intra-operative hemodynamics and post-operative analgesia and concluded that PVB is more influential than epidural or general anaesthesia in terms of intraoperative hemodynamic stability and reduced analgesic consumption.[21] However, in their study, PVB was administered as a single injection through a catheter using the loss of resistance technique prior to the start of surgery.

Naja et al studied the failure rate and complications following PVB in a large group of patients. They reported a 6.1 % block failure rate, a 6.8 % intravascular placement rate, a 1.0 % epidural/intrathecal spread rate, a 0.8 % pleural puncture rate, and a 0.5 % pneumothorax rate.[22] We found no complications or block failures in this study. This outcome could be attributed to the use of PVB under ultrasound guidance.

Feldzer et al found that after ultrasound-guided PVB for mastectomy, patients developed total spinal anaesthesia. PVB was administered at T_3 by an unsupervised trainee anesthesiologist using the out-of-plane approach technique. The authors proposed that block be performed under the supervision of an experienced anesthesiologist and trainees.[23]

Chelly et al found that a lateral to medial approach is associated with more epidural or intrathecal spread in their study. Furthermore, using multiple levels of local anaesthetics rather than a single level reduces the risk of local spread.[24] Our study found no evidence of epidural or intrathecal spread after the ultrasound-guided PVB, which was performed in a vertico-to-caudal direction with an in-plane technique at multiple levels.

Conclusion

The ultrasound-guided PVB technique provides more effective postoperative analgesia and patient satisfaction in PCNL surgery with no side effects.

Limitations: there were no obvious limitations to our study.

Ethical clearance: the procedure was approved by Institutional ethics committee of Narayana Medical College (IEC/NMC/2021/Anest). Written informed consent was obtained from all patients.

Conflict of interest: the authors have no conflicts of interest to declare.

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Ефективність торакальної паравертебральної блокади під ультразвуковим контролем для післяопераційної аналгезії у пацієнтів, які перенесли черезшкірну нефролітотомію

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Анотація

Довідкова інформація: *Черезшкірна нефролітотомія (PCNL) є малоінвазивною операцією для лікування каменів у нирках. Післяопераційний біль турбує пацієнта через пошкодження капсули. Ефективність торакальної паравертебральної блокади під ультразвуковим контролем на кількох рівнях (T_9–T_{10}, T_{10}–T_{11}, T_{11}–T_{12}) була оцінена для лікування післяопераційної аналгезії під час операцій черезшкірної нефролітотомії.*

Методологія: *проспективне рандомізоване подвійне сліпе дослідження 60 випадків пацієнтів Американського товариства анестезіологів I–II, які перенесли черезшкірну нефролітотомію, були розподілені на групу P (тест) і групу N (контроль). Відразу після операції групі P була проведена паравертебральна блокада під ультразвуковим контролем на T_9–T_{10}, T10–T_{11}, T_{11}–T_{12} на боці операції з використанням 5 мл 0,25% левобупівацину на кожному рівні, тоді як групі N не проводили паравертебральну блокаду. Пацієнтів оцінювали за візуально-аналоговою оцінкою (VAS), час для першого невідкладного анальгетика, кількість невідкладних анальгетиків у перші 24 години після операції.*

Результати: *Оцінка болю за VAS показує суттєву різницю між групою P (4,2 + 0,8) і групою N (5,3 + 1,1) (p < 0,05) через 30 хвилин, 2, 4, 8 годин після операції. Загальне споживання опіоїдів на 2-гу, 6-ту і 24-ту години після операції було меншим у групі P, ніж у групі N (P <0,05). Кількість невідкладних анальгетиків у перші 24 години після операції в групі P становила 3,0 ± 0,4 та 4,0 ± 1,1 у групі N зі статистично значущою різницею (p = 0,0001). Загальна доза споживання опіоїдів (мг) у групі P становила 110 ± 40,45 і 155 ± 64,87 мг у групі N зі статистично значущою різницею (p = 0,002). Випадки групи N використовували більше опіоїдів, ніж група P, з нижчими оцінками для задоволення (p < 0,05). Споживання анальгетиків протягом 24 годин після операції групою P було менше, ніж групою N (P = 0,001). Показник задоволеності пацієнтів значно вищий у групі P, ніж у групі N (P = 0,0,001) за 24 години. В обох групах нудоти та/або блювання не спостерігалося.*

Висновок: *торакальна паравертебральна блокада під ультразвуковим контролем мала більший знеболюючий ефект, знижувала потребу в опіоїдах і підтримувала стабільну гемодинаміку.*

Реєстрація випробувань: *реєстраційний номер випробування був CTRI/2021/02/031332.*

Скорочення: *ПВБ: Паравертебральна блокада; VAS: візуальна аналогова оцінка; PNCL: черезшкірна нефролітотомія.*

Ключові слова: *черезшкірна нефролітотомія, ультразвукова паравертебральна блокада, післяопераційна аналгезія, візуальна аналогова оцінка.*