

ORIGINAL PAPER

Comparative study between ultrasound guided erector spinae block versus thoracic paravertebral block versus quadratus lumborum block for postoperative analgesia after open renal surgeries: A prospective randomized controlled study

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Summary

Background: Open renal surgeries are associated with significant postoperative pain, which may delay recovery and increase opioid requirements. Ultrasound-guided regional anesthesia techniques such as erector spinae plane block (ESPB), thoracic paravertebral block (PVB), and quadratus lumborum block (QLB) have emerged as effective components of multimodal analgesia.

Objective: To compare the analgesic efficacy of ESPB, PVB, and QLB versus systemic analgesia in patients undergoing elective open renal surgeries.

Methods: This prospective, randomized, controlled study included 48 patients (ASA I-II) undergoing open renal surgery. Patients were allocated into four groups (n = 12 each): ESPB, PVB, QLB (each received 20 ml of 0.25% bupivacaine), and control (IV morphine). Postoperative pain was assessed using the visual analogue scale (VAS) at 2, 4, 6, 12, 18, and 24 hours. Total 24-hour morphine consumption and patient satisfaction were recorded.

Results: VAS scores were significantly lower in all block groups compared to the control group at all-time points ($p < 0.001$), with no significant differences among ESPB, PVB, and QLB.

Total morphine consumption was highest in the control group (25.0 ± 4.5 mg), followed by ESPB (12.0 ± 3.2 mg), PVB (10.0 ± 2.8 mg), and QLB (8.0 ± 2.5 mg) ($p < 0.001$). Patient satisfaction was significantly higher in the block groups, particularly in the QLB group.

Conclusions: ESPB, PVB, and QLB provide effective postoperative analgesia and reduce opioid consumption after open renal surgeries. QLB demonstrated the most favorable opioid-sparing effect, although all techniques showed comparable analgesic efficacy.

KEY WORDS: Erector spinae block; Thoracic paravertebral block; Quadratus lumborum block; Postoperative analgesia; Open renal surgeries.

INTRODUCTION

Nephrectomy is performed for renal malignancies and kidney donation. Despite the increasing use of laparoscopic techniques, open surgery remains common and is associated with significant postoperative pain that may persist as chronic pain. This pain results from muscle spasm, activation of spinal pain pathways, and inflammatory responses (1). Laparoscopic nephrectomy, either partial or radical, is a common surgical procedure for renal cancer. Although it is less invasive than open surgery, it is still associated with significant acute postoperative pain, especially in the early recovery period (2). Opioids are commonly used as first-line analgesics; however, they may cause adverse effects such as nausea, vomiting, pruritus, and respiratory depression. Therefore, multimodal analgesia is recommended, with peripheral nerve blocks playing a key role in improving pain control and reducing opioid consumption (3). Open nephrectomy is associated with significant acute postoperative pain and a risk of chronic pain due to inflammatory responses, activation of spinal pain pathways, and reflex muscle spasm. Therefore, regional anesthesia techniques are widely used to reduce opioid consumption and improve postoperative outcomes (4). The erector spinae plane block (ESPB), introduced by Forero *et al.* in 2016, is an ultrasound-guided fascial plane block that allows local anesthetic spread to multiple dermatomes and the paravertebral space, providing effective analgesia in thoracic and abdominal surgeries (5). Similarly, the quadratus lumborum block (QLB), first described by Blanco in 2007 and later modified into several approaches, provides somatic and visceral analgesia and has been widely used in abdominal surgeries to improve postoperative pain control (6). Renal surgeries are commonly associated with acute postoperative pain, with an incidence of about 10 to 70% and relief from this pain is achieved in under 50% of patients. Effective postoperative analgesia facilitates early mobility and quick recovery and promotes patient comfort. Using ultrasonographic technologies in regional anesthesia has

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made nerve block use easier, resulting in the application of numerous new interfascial blocks, described as follows (7, 8). Renal transplantation is the most effective surgical treatment for patients with end-stage renal disease. However, most patients report moderate to severe pain after the procedure. Continuing perioperative pain causes excessive stress responses, prolongs recovery time, and delays functional recovery of the transplanted kidney.

Anesthesiologists need to pay special attention to improve the quality of rehabilitation through the effective control of postoperative pain (9, 10). The aim of the study to evaluate the analgesic effect of US-guided ESP block, thoracic paravertebral block and quadratus lumborum block in patients undergoing elective renal operations.

PATIENTS AND METHODS

This was randomized, controlled, single-blinded study, conducted in urology operating room, AL-Azhar university hospitals. Forty-eight patients of both sex aged from 25-65 years in period of the study between June 2023 to February 2026 scheduled for elective open renal surgeries under general anesthesia were enrolled in this study. The procedure was explained to the patient and informed written consent was signed after his agreement then the patient was classified to one of three groups: ESP group (n = 12): Received erector spinae plane block (20 ml of 0.25% bupivacaine).

PV group (n = 12): Received thoracic paravertebral block (20 ml of 0.25% bupivacaine). QLB group (n = 12): Received quadratus lumborum block (20 ml of 0.25% bupivacaine). Control group (n = 12): Received morphine (0.1 mg/kg. IV).

Inclusion criteria: Adult patients of both sex, (25-65 years) undergoing elective open renal surgeries with ASA (I and II) score.

Exclusion criteria: Patient's refusal, Patients with ASA (III and IV) score, Coagulopathy to be cancelled if (INR > 1.4, Platelets count < 100x10⁹), Infection at the injection site and allergy to local anesthetics.

Preoperative assessment

The patient was asked about his medical and surgical history in and fasting hours (8 hrs) and full examination was performed including airway examination and standard lab investigations. The *visual analogue score* (VAS) was explained to the patient as it was used as a measurement tool for assessment of postoperative pain. After that, the intravenous access was secured with 18-gauge cannula and Premedication (midazolam 2 mg IV) was given 10 minutes before operation.

Intraoperative period

The patient was put in the supine position and monitored with ECG, noninvasive arterial blood pressure, capnography and pulse oximetry (SpO₂). Preoxygenation using 100% O₂ with a face mask then induction of GA by fentanyl (1 µg/kg), propofol (2 mg/kg), atracurium (0.5 mg/kg) slowly while the effects of the drugs on cardiovascular and respiratory systems were monitored then the airway was secured with cuffed endotracheal tube. GA was maintained by isoflurane (1.15%) and atracurium

(0.1 mg/kg). Ventilation was maintained by relaxant anesthesia and controlled ventilation with tidal volume 6-8 ml/kg, respiratory rate 12-16, FIO₂ 40%, IE ratio 1:2, PEEP 5 CmH₂O and Pmax 40 CmH₂O. The patient was repositioned with careful hands in the lateral position (with the side to be blocked uppermost) for ESPB or PVB block to be performed before skin incision.

Technique of ESPB

Landmark-guided ESPB can be performed with the patient in lateral position. Aim of the study was deposit *local anesthetic* (LA) into the fascial plane deep to erector spinae muscle which blocks the dorsal and ventral rami of the spinal nerve depending on the level of injection and the amount of local anesthetic injected. The spinous process of the vertebra and a point 3 cm lateral to it were marked at the appropriate level before performing the block. Under aseptic precautions, the needle was inserted and advanced perpendicular to the skin in all planes to contact the transverse process of the vertebra. The transverse process of the thoracic vertebra lies at a variable depth of 2-4 cm from the skin depending on the build of the individual. At this point, the needle tip lies between the erector spinae muscle and transverse process. After negative aspiration, local anesthetic was injected (20 ml of 0.25% bupivacaine). The drug injected in this plane spreads in the longitudinal axis to both cephalad and caudal direction over several levels as the erector spinae fascia extends from nuchal fascia to the sacrum.

Technique of PVB

In lateral position, Convex ultrasound probe was placed parallel to the vertebral spine at T4 level and shifted 2-3 cm laterally to obtain the appropriate visualization. Following the identification of pleura, transverse process and paravertebral space, the needle was inserted cranial to caudal direction using inplane approach. After confirming the displacement of pleura with 1 ml of LA, 20 ml of 0.25% bupivacaine was administered for the block.

Technique of (QL) block

Low-frequency ultrasound with a curved probe (6:15 MHzs) (Sonosite M Turbo, Fujifilm, Bothel Washington USA) was utilized in all patients, and a 22-gauge spinal needle (BD Quink spinal needle) was used to administer the local anesthetic injection. The injection was performed with the patient in the lateral position. The needle tip was carefully positioned at the anterolateral border of the QL muscle at its junction with the transversalis fascia (QL1). Subsequently, the needle was placed between QLM and the erector spinae muscle (QL2) and between QL and the psoas muscle (QL3). After ensuring the correct position of the needle, an injection of 0.25 ml/kg of 0.25% bupivacaine, along with 1.5 mg dexamethasone and 100 mg magnesium sulfate, was administered at each site of the QL muscle under ultrasound guidance.

The surgeries started 20 minutes after preformation of the block and duration of anesthesia and surgeries was recorded. The vital signs were monitored all through for early prediction of any adverse events regarding heart rate, blood pressure, volume status or complications of the blocks like hypotension, vascular puncture, local

anesthetic toxicity, pleural puncture or pneumothorax to be properly managed in case of its occurrence. After the end of operation, residual neuromuscular block was reversed by anticholinesterase (neostigmine 0.04 mg/kg IV) with anticholinergic (atropine 0.4 mg per 1mg neostigmine) till adequate recovery from the muscle relaxant was established and spontaneous ventilation was regained. The patient was ventilated with 100 % oxygen just prior to extubation. Extubation was performed when the patient was either deeply anesthetized or awake. A face mask with 100 % O₂ was applied till the patient was stable enough for transportation to the recovery room.

Postoperative period

In the recovery, the patient was monitored all through by pulse oximeter, ECG and non-invasive arterial blood pressure. Oxygen therapy was applied by oxygen mask in case of O₂ saturation < 92%. The patient received paracetamol (1 gm/8 hrs IV) as a regular analgesia. Postoperative pain was assessed by the (VAS) score. If the VAS was 4 or more, a rescue morphine dose (0.02 mg/kg IV) to be repeated every 20 minutes to maintain a resting VAS < 3. The VAS score was applied by the investigator at 2, 4, 6, 12, 18, and 24 hours postoperatively and the total 24-hours morphine consumption was recorded. The patient was discharged pain free after 1 hour. If the visual analogue scale (VAS) was 4 or more, a morphine increment (0.02 mg/kg IV) was added to maintain a resting VAS < 3 and the total 24-hours morphine consumption were recorded.

RESULTS

Forty-eight patients of both sex and aged from 21-65 years in period of the study between June 2023 to February 2026 scheduled for elective open renal surgeries under general anesthesia were enrolled in this study. There was no statistically significant difference between the studied groups regarding baseline demographic and operative

characteristics. The mean age was comparable among the ESP, PV, QLB, and control groups, with no significant difference detected between groups ($p = 0.075$). Similarly, sex distribution, ASA physical status, duration of operation, and type of operation were not significantly different among the four groups ($p = 0.801$, 0.620 , 0.475 , and 0.536 , respectively). These findings indicate that the studied groups were well matched at baseline (Table 1). Postoperative VAS scores were significantly different between the studied groups at all assessed time points. At 2, 4, 6, 12, 18, and 24 hours postoperatively, the ESP, PV, and QLB groups showed significantly lower VAS scores compared with the control group ($p < 0.001$ for all comparisons). Post hoc analysis showed that the ESP, PV, and QLB groups shared the same significance letter, indicating no statistically significant difference between the three block groups, while the control group had a different letter, indicating significantly higher pain scores. These findings suggest that all three regional block techniques provided superior postoperative analgesia compared with conventional systemic analgesia alone (Table 2). The total morphine consumption during the first 24 postoperative hours differed significantly between the studied groups ($p < 0.001$). The control group showed the highest morphine requirement, with a mean consumption of 25.0 ± 4.5 mg, compared with 12.0 ± 3.2 mg in the ESP group, 10.0 ± 2.8 mg in the PV group, and 8.0 ± 2.5 mg in the QLB group. Post hoc analysis demonstrated that morphine consumption was significantly higher in the control group compared with all block groups. Among the regional block groups, QLB showed the lowest morphine consumption, followed by PV and ESP. The PV group was not significantly different from either the ESP or QLB group, while the QLB group showed significantly lower morphine consumption than the ESP group (Table 3). The patient satisfaction differed significantly between the studied groups ($p = 0.034$). Excellent satisfaction was more frequent among patients receiving regional blocks, particularly in the QLB group 9 patients (75.0%), followed by the ESP group 8

Table 1.
Comparison of Baseline data between studied groups.

Variable	ESP group N = 12	PV group N = 12	QLB group N = 12	Control group N = 12	P value
Age, years					
Mean $\pm$ SD	45.0 $\pm$ 11.0	41.0 $\pm$ 10.0	49.0 $\pm$ 9.0	51.0 $\pm$ 9.0	0.075
Range	28-61	25-58	32-63	35-65	
Sex, n (%)					
Male	5 (41.7%)	4 (33.3%)	3 (25.0%)	5 (41.7%)	0.801
Female	7 (58.3%)	8 (66.7%)	9 (75.0%)	7 (58.3%)	
ASA physical status, n (%)					
ASA I	4 (33.3%)	3 (25.0%)	6 (50.0%)	5 (41.7%)	0.620
ASA II	8 (66.7%)	9 (75.0%)	6 (50.0%)	7 (58.3%)	
Duration of operation, min					
Mean $\pm$ SD	112.0 $\pm$ 14.8	119.0 $\pm$ 16.2	115.0 $\pm$ 15.1	121.0 $\pm$ 14.5	0.475
Range	90-135	95-145	92-140	98-148	
Type of operation, n (%)					
Nephrectomy	1 (8.3%)	0 (0.0%)	2 (16.7%)	1 (8.3%)	0.536
Renal stone surgery	11 (91.7%)	12 (100.0%)	10 (83.3%)	11 (91.7%)	

Table 2.

Comparison of Visual analogue score (VAS) at 2, 4, 6, 12, 18, and 24 hours postoperatively between studied groups.

Variable	ESP group N = 12	PV group N = 12	QLB group N = 12	Control group N = 12	P value
2 hr					
Mean $\pm$ SD	2.2 $\pm$ 0.6(a)	2.0 $\pm$ 0.68(a)	1.9 $\pm$ 0.54 (a)	4.2 $\pm$ 0.85(b)	< 0.001*
Range	1-3	1-3	1-3	2-5	
4 hr					
Mean $\pm$ SD	2.5 $\pm$ 0.5(a)	2.3 $\pm$ 0.54(a)	2.1 $\pm$ 0.51(a)	4.7 $\pm$ 0.81(b)	< 0.001*
Range	1-3	1-3	1-3	3-6	
6 hr					
Mean $\pm$ SD	2.8 $\pm$ 0.63(a)	2.6 $\pm$ 0.6(a)	2.4 $\pm$ 0.58(a)	5.0 $\pm$ 0.92(b)	< 0.001*
Range	2-4	2-3	2-3	3-6	
12 hr					
Mean $\pm$ SD	2.9 $\pm$ 0.67(a)	2.7 $\pm$ 0.61(a)	2.5 $\pm$ 0.45(a)	4.8 $\pm$ 0.78(b)	< 0.001*
Range	2-4	2-4	2-3	2-6	
18 hr					
Mean $\pm$ SD	2.6 $\pm$ 0.52(a)	2.4 $\pm$ 0.51(a)	2.2 $\pm$ 0.49(a)	4.3 $\pm$ 0.65(b)	< 0.001*
Range	1-3	1-3	1-3	2-5	
24 hr					
Mean $\pm$ SD	2.3 $\pm$ 0.46(a)	2.2 $\pm$ 0.57(a)	2.0 $\pm$ 0.42(a)	3.9 $\pm$ 0.78(b)	< 0.001*
Range	1-3	1-3	1-3	1-5	

Data are presented as mean $\pm$ SD and range. P value was calculated using one-way ANOVA. Different superscript letters indicate statistically significant differences between groups based on post hoc pairwise comparison. Groups sharing the same letter are not significantly different.

* Significant at $p < 0.05$.

Table 3.

Comparison of Total morphine requirements in 24h between studied groups.

Variable	ESP group N = 12	PV group N = 12	QLB group N = 12	Control group N = 12	P value
Total morphine consumption in 24 h	12.0 $\pm$ 3.2 (b)	10.0 $\pm$ 2.8 (a, b)	8.0 $\pm$ 2.5 (a)	25.0 $\pm$ 4.5 (c)	< 0.001*
Mean $\pm$ SD range	6-16	5-14	3-11	17-31	

Data are presented as mean $\pm$ SD and range. P value was calculated using one-way ANOVA. Different superscript letters indicate statistically significant differences between groups based on post hoc pairwise comparison. Groups sharing the same letter are not significantly different.

* Significant at $p < 0.05$.

Table 4.

Comparison of patient's satisfaction between studied groups.

Patients' satisfaction	ESP group N = 12	PV group N = 12	QLB group N = 12	Control group N = 12	P value
Excellent	8 (66.7%)	7 (58.3%)	9 (75.0%)	2 (16.7%)	0.034*
Good	3 (25.0%)	4 (33.3%)	3 (25.0%)	5 (41.7%)	
Poor	1 (8.3%)	1 (8.3%)	0 (0.0%)	5 (41.7%)	

patients (66.7%) and the PV group 7 patients (58.3%), compared with only 2 patients (16.7%) in the control group. Poor satisfaction was more frequent in the control group 5 patients (41.7%) compared with the ESP and PV groups 1 patient each (8.3%), while no patients in the QLB group reported poor satisfaction. These findings indicate that regional block techniques were associated with better postoperative patient satisfaction compared with the control group (Table 4).

Discussion

The current study showed that there were no significant differences between the ESP, PV, QLB, and control

groups regarding baseline demographic and operative characteristics. Age, sex distribution, ASA status, operation duration, and type of surgery were comparable among all groups (all $p > 0.05$), indicating good baseline matching. In alignment with, *Elsayed et al.* (7), who aimed to fill this gap by comparing the effectiveness of these 3 techniques in pelvi-ureteric surgeries, they reported that there were no statistically significant differences between the ESPB, TPVB, and QLB groups regarding age, gender distribution, ASA physical status, or duration of surgery (all $p > 0.05$). This indicates that the three groups were well matched at baseline and comparable in demographic and operative characteristics. In agreement with, *Elkhodary et al.* (1), who aimed to compare analgesic

effectiveness of ESPB versus QLB type III in open nephrectomy surgeries, they found that there were no statistically significant differences between the studied groups regarding demographic data and operative characteristics. Age, sex distribution, ASA physical status, and duration of surgery were comparable among the control, ESPB, and QLB groups (all $p > 0.05$), indicating that the groups were well matched at baseline. As well as, *Abd Ellatif & Abdelnaby* (6), who aimed to compare the effectiveness of ESPB and anterior *Quadratus Lumborum* block (QLB III) as a postoperative analgesic for open nephrectomy, they found that there were no statistically significant differences between the studied groups regarding age, ASA physical status, or operative time (all $p > 0.05$), indicating good baseline comparability. However, a statistically significant difference was observed in sex distribution among the groups ($p = 0.039$). In addition to, *Zhang et al.* (3), who aimed to compare the analgesic efficacy of ESPB versus QLB following laparoscopic nephrectomy, they revealed that there were no statistically significant differences between the quadratus lumborum block and erector spinae plane block groups regarding baseline characteristics. Age, sex distribution, and ASA classification were comparable between both groups, indicating good baseline balance and homogeneity (absolute standardized differences < 0.2 for most variables). The present study reported that postoperative VAS scores were significantly lower in the ESP, PV, and QLB groups compared with the control group at all-time points ($p < 0.001$). There was no significant difference between the three block groups, while the control group had higher pain scores, indicating that all regional blocks provided better analgesia than systemic analgesia alone. In agreement with, *Skladzien et al.* (11), who aimed to facilitate early postoperative recovery, they found that VAS scores at 2, 6, and 12 hours postoperatively were significantly lower in both the QLB and ESP groups compared with the control group ($p < 0.05$), while no significant difference was found between the QLB and ESP groups, indicating comparable analgesic efficacy of both techniques.

Our result demonstrated that total morphine consumption in the first 24 hours was significantly higher in the control group compared with all block groups ($p < 0.001$). Among the regional techniques, the QLB group had the lowest morphine use, followed by PV and ESP, with overall better opioid-sparing effect than the control group. In agreement with, *Elsayed et al.* (7) they found that there was a statistically significant difference in the time of performing the block among the studied groups ($p < 0.001$), with ESPB requiring significantly less time compared with TPVB and QLB, while no significant difference was found between TPVB and QLB ($p = 0.558$). However, there was no statistically significant difference between the three groups regarding total morphine consumption in the first 24 hours postoperatively ($p = 0.520$), indicating comparable analgesic efficacy. In supporting with, *Elkhodary et al.* (1) they reported that total morphine consumption in the first 24 hours was significantly higher in the control group compared to both ESPB and QLB groups ($p < 0.001$), while no significant difference was found between ESPB and QLB ($p = 0.771$).

Also, *Abd Ellatif & Abdelnaby* (6), they found that there was a statistically significant difference in total postoperative morphine consumption among the studied groups ($p < 0.001$), with both QLB and ESPB groups requiring significantly lower morphine doses compared to the control group. However, there was no statistically significant difference between the QLB and ESPB groups ($p > 0.05$), indicating comparable analgesic efficacy between both techniques. In addition to, *Abdelgalil et al.* (12), who aimed to evaluate the ESPB efficacy in controlling acute postoperative pain in open nephrectomy for renal malignancies, they found that postoperative morphine consumption in the first 48 hours was significantly lower in Group E compared with Group C ($p < 0.001$), indicating better postoperative analgesia and reduced opioid requirement in Group E. Our study showed that patient satisfaction was significantly higher in the regional block groups compared with the control group ($p = 0.034$). The QLB group showed the highest rate of excellent satisfaction, followed by ESP and PV, while the control group had the lowest satisfaction and highest rate of poor outcomes, indicating better overall satisfaction with regional analgesia techniques. In accordance with, *Elkhodary et al.* (1), they found that patient satisfaction showed a statistically significant difference between the studied groups ($P < 0.001$), with the highest satisfaction rates observed in the QLB group (80%) followed by the ESPB group (72%), while the control group had the lowest satisfaction level, with most patients reporting fair satisfaction.

In contrast with, *Elsayed et al.* (7), they revealed that patient satisfaction showed no statistically significant difference among the ESPB, TPVB, and QLB groups ($p = 0.727$). Although a higher proportion of patients were extremely satisfied in the ESPB group, overall satisfaction levels were comparable between the three groups, indicating similar patient-reported outcomes across all regional techniques.

DECLARATIONS

Ethical approval and consent for participate: The study had been approved by Institutional Review Board (IRB) (No. 00394/2023) with accepted at clinical trial registration (NCT05890248) at June 2023.

<https://clinicaltrials.gov/show/NCT05890248>

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CONCLUSIONS

Ultrasound-guided ESP, PV, and QLB blocks are effective multimodal analgesic techniques in patients undergoing elective renal surgery. They provide superior postoperative pain control, significantly reduce opioid (morphine) consumption, and improve patient satisfaction compared with systemic analgesia alone. Among the three techniques, QLB showed the most favorable overall outcomes in terms of analgesia and opioid-sparing effect, although all blocks demonstrated comparable efficacy in pain score reduction.

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