

A Study to Compare and Evaluate the Analgesic Efficacy of Erector Spinae Block and Anterior Quadratus Lumborum Block Using Levobupivacaine in Renal Surgeries

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Abstract

Background: Regional anesthesia techniques have gained prominence in perioperative pain management for renal surgeries. Both erector spinae plane (ESP) block and anterior quadratus lumborum (QLB) block offer promising alternatives for postoperative analgesia.

Objective: To compare and evaluate the analgesic efficacy of ultrasound-guided ESP block versus anterior QLB using levobupivacaine in patients undergoing renal surgeries.

Methods: This prospective, randomized, double-blind study included 80 patients (ASA I-III) scheduled for elective renal surgeries. Patients were randomly allocated into two groups: Group E (ESP block, n=40) and Group Q (anterior QLB, n=40). Both groups received 0.25% levobupivacaine (20ml) under ultrasound guidance. Primary outcomes included postoperative pain scores using Visual Analog Scale (VAS) at rest and movement at 2, 4, 8, 12, and 24 hours. Secondary outcomes included time to first analgesic request, total morphine consumption, patient satisfaction scores, and complications.

Results: Both groups demonstrated significant reduction in postoperative pain scores compared to historical controls. Group E showed statistically significant lower VAS scores at rest at 2 hours (2.1±0.8 vs 2.8±1.1, p=0.002) and 4 hours (2.3±0.9 vs 3.1±1.2, p=0.001) compared to Group Q. Time to first analgesic request was longer in Group E (8.2±2.1 hours) versus Group Q (6.4±1.8 hours, p=0.001). Total 24-hour morphine consumption was significantly lower in Group E (12.4±3.2mg) compared to Group Q (16.8±4.1mg, p<0.001). Patient satisfaction scores were higher in Group E (8.7±1.1) versus Group Q (7.9±1.3, p=0.003). No major complications were reported in either group.

Conclusion: ESP block provides superior analgesic efficacy compared to anterior QLB in renal surgeries, with longer duration of analgesia, reduced opioid consumption, and higher patient satisfaction scores. Both techniques demonstrate excellent safety profiles.

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Introduction

Renal surgeries, including nephrectomy, nephrolithotomy, and pyeloplasty, are associated with significant postoperative pain due to the surgical approach involving muscle layers, fascial planes, and potential intercostal nerve involvement. Traditional pain management strategies have relied heavily on systemic opioids, which are associated with numerous adverse effects

including respiratory depression, nausea, vomiting, constipation, and potential for addiction [1,2]. The multimodal approach to perioperative pain management has evolved to incorporate regional anesthetic techniques that can provide effective analgesia while minimizing opioid-related side effects.

Regional anesthesia techniques have gained increasing popularity in the management of postoperative pain following renal surgeries. These techniques not only provide excellent analgesia but also contribute to enhanced recovery after surgery (ERAS) protocols by reducing opioid consumption, facilitating early mobilization, and improving patient satisfaction [3,4]. Among the various regional anesthetic techniques available, interfascial plane blocks have emerged as valuable tools in the anesthesiologist's armamentarium.

The erector spinae plane (ESP) block, first described by Forero *et al*. in 2016, is a relatively novel interfascial plane block that has shown promising results in providing analgesia for various surgical procedures involving the thorax, abdomen, and pelvis [5]. The ESP block involves the injection of local anesthetic into the fascial plane between the erector spinae muscle and the transverse processes of vertebrae, resulting in blockade of both the dorsal and ventral rami of spinal nerves through spread of the local anesthetic to the paravertebral space [6,7].

The quadratus lumborum (QL) block, particularly the anterior approach (also known as QLB type 2), was first described by Blanco *et al*. and has gained recognition for its effectiveness in providing analgesia for lower abdominal and lumbar surgeries [8,9]. The anterior QLB involves injection of local anesthetic anterior to the quadratus lumborum muscle, with the spread pattern potentially affecting the lumbar plexus and providing somatic and visceral pain relief [10,11].

Levobupivacaine, the S-enantiomer of bupivacaine, has become the preferred local anesthetic for regional blocks due to its reduced cardiotoxicity and neurotoxicity compared to racemic bupivacaine while maintaining similar analgesic efficacy [12,13]. Its longer duration of action makes it particularly suitable for postoperative pain management in major surgical procedures.

The choice between ESP block and anterior QLB for renal surgeries remains a topic of debate among anesthesiologists. While both techniques have demonstrated efficacy in various abdominal procedures, there is limited comparative data specifically for renal surgeries. Understanding the relative merits of these two approaches is crucial for optimizing perioperative pain management strategies.

The anatomical considerations for renal surgery pain management are complex. The surgical approach typically involves a flank incision that may extend from the costal margin to the iliac crest, potentially involving multiple dermatomes from T10 to L2. The pain experienced by patients undergoing renal surgery has both somatic and visceral components, requiring comprehensive analgesic coverage [14,15].

Previous studies have investigated the efficacy of various regional anesthetic techniques for renal surgeries, including paravertebral blocks, intercostal blocks, and wound infiltration techniques. However, the emergence of newer interfascial plane blocks like ESP and QLB has provided additional options that may offer advantages in terms of safety, ease of performance, and analgesic efficacy [16,17].

The ultrasound-guided approach to performing both ESP and anterior QLB has improved the safety and success rates of these techniques. The clear visualization of anatomical structures and real-time needle guidance has made these blocks more accessible to anesthesiologists and has contributed to their increasing adoption in clinical practice [18,19].

This study aims to provide evidence-based guidance for anesthesiologists by directly comparing the analgesic efficacy of ESP block and anterior QLB using levobupivacaine in patients undergoing renal surgeries. The primary objective is to determine which technique provides superior postoperative analgesia, while secondary objectives include assessment of opioid-sparing effects, patient satisfaction, and safety profiles.

2. Materials and Methods

2.1 Study Design and Ethics

This study was designed as a prospective, randomized, double-blind, controlled clinical trial to ensure the highest level of scientific evidence. The prospective nature allowed for planned data collection with predetermined endpoints, while the randomized design minimized selection bias by ensuring equal probability of assignment to either treatment group. The double-blind methodology ensured that both patients and outcome assessors remained unaware of group allocation, thereby eliminating observer bias and placebo effects that could influence pain reporting.

The study was conducted at the Department of Anesthesiology, over a 12-month period from January 2023 to December 2023. This duration allowed for adequate patient recruitment while maintaining consistency in surgical techniques and perioperative care protocols. The study protocol underwent rigorous ethical review and was approved by the Institutional Ethics Committee (Protocol No: IEC/2023/ANE/001), ensuring compliance with international ethical standards for human research as outlined in the Declaration of Helsinki.

To ensure transparency and prevent selective reporting, the study was prospectively registered with the Clinical Trials Registry of India (CTRI/2023/01/049123) before patient enrollment began. This registration included all primary and secondary endpoints, ensuring that all outcomes would be reported regardless of statistical significance.

Written informed consent was obtained from all participants before enrollment, following a detailed explanation of the study procedures, potential risks, benefits, and the voluntary nature of participation. Patients were informed of their right to withdraw from the study at any time without affecting their medical care.

2.2 Study Population

The study population was carefully selected to ensure homogeneity and minimize confounding variables while maintaining external validity for the target population undergoing renal surgery.

Detailed Inclusion Criteria

Age Range (18-70 years): This age range was selected to include adult patients while excluding elderly patients who might have altered pharmacokinetics of local anesthetics or increased comorbidities that could confound results. The lower limit excluded pediatric patients who require different dosing and have different pain assessment challenges.

ASA Physical Status I-III: The American Society of

Anesthesiologists physical status classification was used to ensure patients were suitable for the planned procedures. ASA I patients (normal healthy patients) provided a baseline for comparison, ASA II patients (mild systemic disease) represented the majority of surgical patients, and ASA III patients (severe systemic disease that is not incapacitating) were included to maintain external validity. ASA IV patients were excluded due to increased perioperative risks that could confound outcomes.

Elective Renal Surgeries: The study focused on three main types of renal procedures:

- **Open Nephrectomy:** Complete removal of the kidney, typically performed through a flank incision extending from the costal margin to the iliac crest
- **Nephrolithotomy:** Surgical removal of kidney stones, involving incisions that may vary depending on stone location
- **Pyeloplasty:** Surgical reconstruction of the renal pelvis, typically requiring precise dissection and reconstruction

These procedures were selected because they share similar anatomical approaches and pain patterns, involving dermatomes T10-L2, making them suitable for comparison of the two regional anesthetic techniques.

BMI Range (18-35 kg/m²): Body Mass Index restrictions were implemented to ensure adequate ultrasound visualization for block performance. Underweight patients (BMI <18) might have altered pharmacokinetics, while morbidly obese patients (BMI >35) present technical challenges for ultrasound-guided procedures due to increased tissue depth and reduced image quality.

VAS Understanding: Patients' ability to understand and use the Visual Analog Scale was essential for reliable pain assessment. This was evaluated during the preoperative visit through explanation and practice with the scale.

Detailed Exclusion Criteria

Patient Refusal or Consent Issues: Patients who declined participation or were unable to provide informed consent due to cognitive impairment, language barriers, or other factors were excluded to ensure ethical research conduct.

Allergy to Local Anesthetics: Known hypersensitivity to amide local anesthetics (levobupivacaine) or any study medications could result in serious adverse reactions, making participation unsafe.

Coagulopathy or Bleeding Disorders: Patients with inherited or acquired bleeding disorders, or those on anticoagulant therapy, were excluded due to increased risk of bleeding complications during needle insertion for regional blocks.

Injection Site Infection: Active infection at or near the proposed injection sites could lead to deeper tissue infection or abscess formation following needle insertion.

Severe Hepatic or Renal Dysfunction: These conditions could alter local anesthetic metabolism and clearance, potentially leading to systemic toxicity or prolonged effects that could confound outcome measures.

Chronic Pain Conditions or Opioid Use: Patients with pre-existing chronic pain or chronic opioid use have altered pain perception and opioid tolerance, which could significantly confound postoperative pain assessments and analgesic requirements.

Pregnancy or Lactation: Excluded due to potential effects of medications on the fetus or nursing infant, and ethical considerations regarding research in pregnant women.

Psychiatric Disorders: Conditions that could prevent reliable pain assessment or cooperation with study procedures were excluded to ensure data quality.

Previous Spine Surgery: Prior surgical procedures at the block sites could result in altered anatomy, scar tissue formation, or nerve damage that might affect block success or safety.

2.3 Randomization and Blinding

The randomization process was meticulously designed to ensure equal distribution of patients between groups while maintaining allocation concealment. Computer-generated randomization was performed using a validated random number generator with variable block sizes (4, 6, and 8) to prevent prediction of future allocations. This approach ensured balanced group sizes throughout the recruitment period.

The sealed envelope technique was implemented with opaque, sequentially numbered envelopes containing group allocation. Each envelope was prepared by a statistician not involved in patient care and was opened only after patient enrollment and completion of baseline assessments. This method-maintained allocation concealment until the moment of intervention.

Group Allocation:

- **Group E (ESP block):** 40 patients receiving ultrasound-guided erector spinae plane block
- **Group Q (Anterior QLB):** 40 patients receiving ultrasound-guided anterior quadratus lumborum block

Blinding Strategy: The double-blind design was implemented through careful planning:

- **Patient Blinding:** Patients were unaware of which block technique they received, as both procedures were performed under standardized conditions with similar positioning and preparation
- **Outcome Assessor Blinding:** All postoperative assessments were performed by research personnel unaware of group allocation
- **Data Analyst Blinding:** Statistical analysis was performed with coded group identifiers, with the code broken only after analysis completion

The anesthesiologist performing the blocks could not be blinded due to the nature of the different techniques required. However, this person was not involved in any postoperative assessments to maintain outcome assessor blinding.

2.4 Anesthetic Technique

A standardized anesthetic protocol was essential to ensure that differences in outcomes could be attributed to the regional anesthetic technique rather than variations in general anesthesia management.

Preoperative Preparation: All patients underwent comprehensive preoperative evaluation including medical history, physical examination, laboratory investigations, and anesthetic assessment. Premedication was standardized to reduce anxiety and provide baseline sedation:

- **Alprazolam 0.5mg orally:** Administered 2 hours preoperatively to reduce anxiety without significantly affecting pain perception or recovery
- **Ranitidine 150mg orally:** H2-receptor antagonist to

reduce gastric acidity and volume, decreasing aspiration risk

Standard Anesthetic Protocol:
Monitoring: Continuous monitoring was established before induction and maintained throughout the procedure:

- **Electrocardiography (ECG):** Continuous cardiac rhythm monitoring
- **Non-invasive Blood Pressure:** Automated measurements every 3-5 minutes
- **Pulse Oximetry:** Continuous oxygen saturation monitoring
- **End-tidal CO_2:** Capnography for ventilation monitoring and early detection of complications

Anesthetic Induction:

- **Propofol 2-2.5mg/kg:** Intravenous induction agent providing smooth onset of anesthesia
- **Fentanyl 2mcg/kg:** Short-acting opioid for intraoperative analgesia
- **Atracurium 0.5mg/kg:** Non-depolarizing neuromuscular blocking agent for muscle relaxation and intubation

Anesthetic Maintenance:

- **Sevoflurane 1-2%:** Volatile anesthetic agent titrated to maintain appropriate depth of anesthesia (MAC 0.8-1.2)
- **O_2/Air mixture:** Maintaining FiO_2 0.4-0.5 to ensure adequate oxygenation
- **Additional Atracurium:** Administered as needed to maintain neuromuscular blockade

Intraoperative Analgesia:

- **Fentanyl boluses (1mcg/kg):** Administered for hemodynamic changes suggesting inadequate analgesia (heart rate or blood pressure >20% above baseline)

2.5 Block Technique
Both regional anesthetic techniques were performed by experienced anesthesiologists with more than 2 years of experience in ultrasound-guided regional anesthesia to ensure consistent technique and minimize learning curve effects.

Erector Spinae Plane (ESP) Block Technique (Group E)
Patient Positioning: Patients were placed in lateral decubitus position with the surgical side uppermost. This position provided optimal access to the posterior thoracolumbar region while ensuring patient comfort and stability.
Equipment and Preparation:

- **Ultrasound System:** High-frequency linear probe (5-10 MHz) for optimal resolution of superficial structures
- **Sterile Technique:** Complete sterile preparation with draping and sterile ultrasound probe cover
- **Needle:** 22G Quincke spinal needle (100mm length) for adequate penetration depth

Anatomical Identification: The ultrasound probe was placed longitudinally (sagittal plane) over the T12 vertebral level, approximately 3cm lateral to the spinous process. Key anatomical structures identified included:

- **Transverse Process:** Hyperechoic bony landmark appearing as a horizontal line
- **Erector Spinae Muscle:** Hyperechoic muscle bundle superficial to the transverse process
- **Pleura:** Deep hyperechoic line representing the parietal pleura (safety landmark)

Needle Insertion and Injection: The needle was inserted using an in-plane approach from caudal to cephalad direction, advancing until the tip contacted the transverse process. The correct position was confirmed by:

- **Bone Contact:** Tactile feedback and ultrasound visualization of needle tip against transverse process
- **Hydrodissection:** Small volume injection (2-3ml) to confirm correct fascial plane location

Following negative aspiration to exclude intravascular placement, 20ml of 0.25% levobupivacaine was injected incrementally with repeated aspiration. Correct spread was confirmed by real-time visualization of local anesthetic separating the erector spinae muscle from the transverse process, creating a hypoechoic (dark) area in the fascial plane.

Anterior Quadratus Lumborum Block Technique (Group Q):
Patient Positioning: Patients were positioned supine with the ipsilateral side elevated using a pillow or wedge to improve access to the lateral abdominal wall.
Equipment and Preparation: Similar sterile preparation and equipment as ESP block, with emphasis on optimal probe positioning for lateral abdominal wall visualization.
Anatomical Identification: The ultrasound probe was placed transversely above the iliac crest at the mid-axillary line. Key anatomical structures identified included:

- **Quadratus Lumborum Muscle:** Rectangular hypoechoic muscle deep to the abdominal wall muscles
- **Psoas Major Muscle:** Large hypoechoic muscle medial to quadratus lumborum
- **Transversalis Fascia:** Hyperechoic fascial layer surrounding the abdominal cavity

Needle Insertion and Injection: The needle was inserted using an in-plane approach from posterior to anterior, advancing through the abdominal wall muscles toward the quadratus lumborum muscle. The target was the fascial plane anterior to the quadratus lumborum muscle, adjacent to the psoas major muscle.
Following negative aspiration, 20ml of 0.25% levobupivacaine was injected with real-time ultrasound visualization to confirm appropriate spread anterior to the quadratus lumborum muscle.

2.6 Outcome Measures
The outcome measures were carefully selected to provide comprehensive assessment of analgesic efficacy and safety.

Primary Outcomes
Postoperative Pain Scores: The Visual Analog Scale (VAS) was used as the primary pain assessment tool. This 10-point scale (0 = no pain, 10 = worst possible pain) is well-validated and widely accepted for pain research. Pain was assessed in two conditions:

- **At Rest:** Patient lying comfortably without movement
- **During Movement:** Patient performing standardized movements (deep breathing, coughing, turning)

Assessment Time Points: Pain scores were recorded at 2, 4, 8, 12, and 24 hours postoperatively to capture both early and sustained analgesic effects. These time points were selected based on the expected duration of action of levobupivacaine

and typical recovery patterns.

Secondary Outcomes

Time to First Analgesic Request: Defined as the time from completion of surgery until the patient's first request for additional pain medication. This measure indicates the duration of effective analgesia from the regional block.

Total Morphine Consumption: Cumulative morphine equivalents consumed in the first 24 hours postoperatively, including both patient-controlled analgesia (PCA) use and rescue medications. This measure reflects the opioid-sparing effect of the regional anesthetic techniques.

Patient Satisfaction Scores: Assessed using a 0-10 numerical rating scale (0 = completely dissatisfied, 10 = completely satisfied) at 24 hours postoperatively. This measure captures the overall patient experience with pain management.

Postoperative Nausea and Vomiting (PONV): Incidence and severity of nausea and vomiting, which may be related to opioid consumption or surgical factors.

Time to First Mobilization: Time from surgery completion until the patient first ambulated, reflecting functional recovery.

Length of Hospital Stay: Total duration of hospitalization, which may be influenced by pain control and recovery speed.

Block-Related Complications: Any adverse events potentially related to the regional anesthetic technique, including but not limited to bleeding, infection, nerve injury, or local anesthetic systemic toxicity.

2.7 Postoperative Pain Management

A standardized multimodal analgesic protocol was implemented to ensure consistent pain management across all patients while allowing assessment of the additional benefit provided by regional anesthesia.

Baseline Analgesic Regimen

Paracetamol (Acetaminophen) 1g IV every 6 hours: This non-opioid analgesic was administered regularly to all patients as part of multimodal analgesia. Paracetamol provides effective analgesia with minimal side effects and serves as the foundation of postoperative pain management.

Patient-Controlled Analgesia (PCA)

Morphine PCA Parameters:

- **Bolus Dose:** 1mg morphine per activation
- **Lockout Interval:** 5 minutes between doses to prevent overdosing
- **Background Infusion:** None, to better assess actual opioid requirements
- **4-Hour Limit:** Maximum 20mg to ensure safety

Rescue Analgesia

Morphine 0.1mg/kg IV: Administered by nursing staff when VAS pain scores exceeded 4 despite regular medications and PCA use. This threshold represents moderate pain requiring intervention.

2.8 Statistical Analysis

The statistical analysis plan was developed a priori to ensure appropriate methodology and prevent data dredging.

Sample Size Calculation

Sample size determination was based on pilot study data showing mean VAS pain scores of 3.2±1.4 for ESP block and 4.1±1.6 for anterior QLB. Using these parameters:

- **Effect Size:** 0.9-point difference in VAS scores (clinically meaningful difference)
- **Alpha Level (α):** 0.05 (5% chance of Type I error)
- **Power (1-β):** 80% (80% chance of detecting true difference)
- **Statistical Test:** Two-sided t-test for independent samples

The calculation yielded a requirement of 36 patients per group. To account for potential dropouts, protocol violations, or missing data (estimated at 10%), the sample size was increased to 40 patients per group, for a total of 80 patients.

Statistical Software and Methods

Statistical analysis was performed using SPSS version 26.0 (IBM Corporation, Armonk, NY, USA), a widely validated statistical software package.

Data Presentation and Analysis

Continuous Variables: Presented as mean ± standard deviation for normally distributed data, or median (interquartile range) for non-normally distributed data. Normality was assessed using the Shapiro-Wilk test.

Categorical Variables: Presented as frequencies and percentages.

Statistical Tests

Continuous Variables

- **Student's t-test:** For normally distributed data with equal variances
- **Welch's t-test:** For normally distributed data with unequal variances
- **Mann-Whitney U test:** For non-normally distributed data

Categorical Variables

- **Chi-square test:** For variables with expected frequencies ≥5 in all cells
- **Fisher's exact test:** For variables with small expected frequencies

Repeated Measures Analysis

- **Repeated Measures ANOVA:** For pain scores over time, allowing assessment of between-group differences, time effects, and group-time interactions

Statistical Significance

P-value <0.05 was considered statistically significant for all analyses. Confidence intervals (95% CI) were calculated for effect estimates to provide information about precision and clinical relevance of findings.

Handling of Missing Data

Missing data patterns were analyzed, and appropriate imputation methods were considered if necessary. However, the study design aimed to minimize missing data through rigorous follow-up protocols.

3. Results

3.1 Patient Demographics and Baseline Characteristics

A total of 80 patients were enrolled and randomized (40 in each group). All patients completed the study without any

protocol violations. Demographic characteristics were similar between groups (Table 1).

Table 1: Patient Demographics and Baseline Characteristics

Variable	Group E (n=40)	Group Q (n=40)	P-value
Age (years)	48.2±12.4	51.1±14.2	0.312
Gender (M/F)	24/16	22/18	0.689
BMI (kg/m²)	26.4±3.8	27.1±4.2	0.421
ASA (I/II/III)	18/18/4	16/20/4	0.764
Surgery type			0.582
- Nephrectomy	22 (55%)	25 (62.5%)	
- Nephrolithotomy	12 (30%)	10 (25%)	
- Pyeloplasty	6 (15%)	5 (12.5%)	
Surgery duration (min)	142±28	148±32	0.364

3.2 Primary Outcomes - Pain Scores

Pain Scores at Rest

ESP block demonstrated significantly lower VAS scores at rest compared to anterior QLB at 2 hours (2.1±0.8 vs 2.8±1.1, p=0.002) and 4 hours (2.3±0.9 vs 3.1±1.2, p=0.001). The difference became non-significant at 8, 12, and 24 hours (Table 2).

Pain Scores During Movement

Similar patterns were observed for pain scores during movement, with Group E showing lower scores at 2 hours (3.2±1.1 vs 4.1±1.4, p=0.001) and 4 hours (3.4±1.2 vs 4.3±1.5, p=0.003) compared to Group Q (Table 2).

Table 2: VAS Pain Scores (Mean ± SD)

Time	Group E (Rest)	Group Q (Rest)	P-value	Group E (Movement)	Group Q (Movement)	P-value
2h	2.1±0.8	2.8±1.1	0.002*	3.2±1.1	4.1±1.4	0.001*
4h	2.3±0.9	3.1±1.2	0.001*	3.4±1.2	4.3±1.5	0.003*
8h	2.8±1.1	3.2±1.3	0.142	3.9±1.3	4.2±1.6	0.361
12h	3.1±1.2	3.4±1.4	0.291	4.1±1.4	4.4±1.7	0.387
24h	2.9±1.1	3.2±1.3	0.248	3.8±1.3	4.1±1.5	0.342

*Statistically significant (p<0.05)

3.3 Secondary Outcomes

Time to First Analgesic Request

Group E demonstrated significantly longer time to first analgesic request (8.2±2.1 hours) compared to Group Q (6.4±1.8 hours, p=0.001).

Total Morphine Consumption

24-hour morphine consumption was significantly lower in Group E (12.4±3.2mg) compared to Group Q (16.8±4.1mg, p<0.001).

Patient Satisfaction

Patient satisfaction scores were significantly higher in Group E (8.7±1.1) compared to Group Q (7.9±1.3, p=0.003).

Table 3: Secondary Outcomes

Outcome	Group E (n=40)	Group Q (n=40)	P-value
Time to first analgesic (hours)	8.2±2.1	6.4±1.8	0.001*
24h morphine consumption (mg)	12.4±3.2	16.8±4.1	<0.001*
Patient satisfaction (0-10)	8.7±1.1	7.9±1.3	0.003*
Time to mobilization (hours)	12.6±2.8	14.2±3.4	0.021*
Hospital stay (days)	3.2±0.8	3.6±1.1	0.058
PONV incidence	8 (20%)	14 (35%)	0.127

*Statistically significant (p<0.05)

3.4 Safety and Complications

No major complications were reported in either group. Minor complications included temporary numbness at injection site (2 patients in Group E, 1 patient in Group Q) and mild bruising (1 patient in each group). No cases of pneumothorax, vascular puncture, or local anesthetic systemic toxicity were observed.

4. Discussion

This study provides valuable evidence comparing the analgesic efficacy of ESP block and anterior QLB using levobupivacaine in patients undergoing renal surgeries. The results demonstrate that ESP block offers superior analgesic efficacy in the early postoperative period, with lower pain scores, longer duration of analgesia, reduced opioid consumption, and higher patient satisfaction scores.

4.1 Analgesic Efficacy

The superior analgesic efficacy of ESP block observed in this study can be attributed to its unique mechanism of action and anatomical spread pattern. The ESP block involves injection of local anesthetic into the fascial plane between the erector spinae muscle and the transverse processes of vertebrae. From this location, the local anesthetic spreads both cranially and caudally along the fascial plane and can reach the paravertebral space through foraminal and soft tissue communications [(20,21].

The extensive cranio-caudal spread of local anesthetic following ESP block has been demonstrated in cadaveric and radiological studies, showing coverage of multiple dermatomes with a single injection [22,23]. This widespread coverage is particularly advantageous for renal surgeries, which typically involve incisions spanning multiple dermatomes from T10 to L2.

In contrast, the anterior QLB primarily targets the anterior aspect of the quadratus lumborum muscle, with the local anesthetic potentially spreading to involve the lumbar plexus. While this provides effective analgesia for lower abdominal procedures, the dermatomal coverage may be more limited compared to ESP block [24,25].

4.2 Duration of Analgesia

The significantly longer time to first analgesic request observed with ESP block (8.2±2.1 hours) compared to anterior QLB (6.4±1.8 hours) suggests a more prolonged analgesic effect. This finding is consistent with previous studies investigating ESP block for various surgical procedures [26,27].

The prolonged duration of ESP block may be related to the anatomical characteristics of the fascial plane injection site. The relatively tight fascial compartment between the erector spinae muscle and transverse processes may serve as a reservoir for local anesthetic, allowing for sustained release and prolonged blockade [28,29].

4.3 Opioid-Sparing Effect

The significant reduction in 24-hour morphine consumption observed with ESP block (12.4±3.2mg vs 16.8±4.1mg) demonstrates a clinically meaningful opioid-sparing effect. This reduction of approximately 26% in opioid consumption has important implications for patient recovery and side effect profile.

Reduced opioid consumption is associated with decreased incidence of opioid-related adverse effects such as respiratory depression, sedation, nausea, vomiting, constipation, and pruritus. This contributes to improved patient comfort, earlier mobilization, and potentially shorter hospital stay [30,31].

4.4 Patient Satisfaction

Higher patient satisfaction scores with ESP block reflect the overall superior analgesic experience provided by this technique. Patient satisfaction in the postoperative period is influenced by multiple factors including pain control, side effects, and functional recovery. The combination of better pain control and reduced opioid-related side effects likely contributes to the higher satisfaction scores observed with ESP block [32,33].

4.5 Safety Profile

Both ESP block and anterior QLB demonstrated excellent safety profiles in this study, with no major complications reported. The interfascial plane injection sites for both techniques are relatively distant from major vascular and neural structures, contributing to their favorable safety profiles [34,35].

The ESP block is performed with the needle tip positioned against bone (transverse process), providing a definitive end-point and reducing the risk of deeper penetration. The anterior QLB, while slightly more complex due to the need to navigate between muscle layers, also demonstrated excellent safety when performed under ultrasound guidance [36,37].

4.6 Clinical Implications

The findings of this study have important clinical implications for anesthesiologists managing patients undergoing renal surgeries. The superior analgesic efficacy of ESP block, combined with its excellent safety profile and relative technical simplicity, makes it an attractive option for perioperative pain management.

The opioid-sparing effects of ESP block align with current trends toward multimodal analgesia and enhanced recovery after surgery (ERAS) protocols. Reduced opioid consumption can contribute to faster recovery, earlier mobilization, and potentially shorter hospital stays [38,39].

4.7 Technical Considerations

The ultrasound-guided approach used in this study for both techniques contributes to their safety and efficacy. Real-time visualization of anatomical structures, needle advancement, and local anesthetic spread enhances the success rate and reduces the risk of complications [40,41].

The ESP block technique is generally considered easier to learn and perform compared to some other regional anesthetic techniques due to its superficial location and clear anatomical landmarks. The transverse process provides a reliable bony landmark, and the fascial plane is usually well-defined on ultrasound imaging [42,43].

4.8 Limitations

Several limitations of this study should be acknowledged. First, the study was conducted at a single center with a relatively homogeneous patient population, which may limit the generalizability of findings to other populations and settings. Second, the study focused on open renal surgeries, and the results may not be directly applicable to laparoscopic or robotic procedures.

The assessment of pain was limited to 24 hours postoperatively, and longer-term outcomes such as chronic pain development were not evaluated. Additionally, the study did not include objective measures of sensory blockade, such as pinprick testing, which could have provided additional insight into the mechanism and extent of blockade.

4.9 Future Directions

Future research should focus on several areas to further optimize the use of these regional anesthetic techniques in renal surgery. Comparative studies including other regional techniques such as paravertebral blocks or thoracic epidural anesthesia would provide valuable information for clinical decision-making.

Investigation of optimal local anesthetic concentration, volume, and adjuvants for both ESP and QLB could help maximize analgesic efficacy while minimizing side effects. Long-term follow-up studies examining the impact of these techniques on chronic pain development and patient-reported outcomes would also be valuable.

The application of these techniques to minimally invasive renal surgeries, including laparoscopic and robotic procedures, represents another important area for future research.

5. Conclusion

This randomized controlled trial demonstrates that ultrasound-guided ESP block provides superior analgesic efficacy compared to anterior QLB in patients undergoing renal surgeries. ESP block resulted in significantly lower pain scores in the early postoperative period, longer duration of analgesia, reduced opioid consumption, and higher patient satisfaction scores.

Both techniques demonstrated excellent safety profiles with no major complications observed. The findings support the

use of ESP block as an effective component of multimodal analgesic strategies for renal surgery patients. The superior analgesic efficacy, combined with opioid-sparing effects and high patient satisfaction, makes ESP block a valuable tool for optimizing perioperative pain management in this patient population.

The results of this study contribute to the growing evidence base supporting the use of interfascial plane blocks in abdominal surgery and provide guidance for anesthesiologists in selecting appropriate regional anesthetic techniques for renal surgery patients. The integration of ESP block into enhanced recovery protocols may contribute to improved patient outcomes and faster recovery following renal surgeries.

Further research is warranted to optimize technique parameters, evaluate long-term outcomes, and explore the application of these techniques to minimally invasive renal procedures. The continued evolution of regional anesthetic techniques holds promise for further improvements in perioperative pain management and patient care.

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