

ORIGINAL PAPER

Effectiveness and safety of ultrasound-guided quadratus lumborum block combined with low-dose spinal anesthesia versus general anesthesia in percutaneous nephrolithotomy: A randomized controlled trial

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Summary

This study aimed to explore the potential benefits and safety considerations of combining ultrasound-guided quadratus lumborum block (QLB) with low-dose spinal anesthesia (LDSA) versus general anesthesia (GA) for individuals undergoing percutaneous nephrolithotomy (PCNL). This prospective randomized controlled trial included 70 adult patients undergoing PCNL, divided into Group Q (QLB + LDSA, n = 35) and Group G (GA, n = 35). Primary outcomes included postoperative pain, assessed using the Visual Analog Scale (VAS), and opioid consumption, measured by pethidine usage. Secondary outcomes included patient satisfaction, stone clearance rates, hemoglobin and creatinine changes, and adverse events. Multivariate regression analysis identified predictors of outcomes. Postoperative pain scores were significantly lower in Group Q during the first 8 postoperative hours (all $p < 0.001$). Median pethidine consumption was lower in Group Q (70 mg vs. 105 mg, $p < 0.001$). Group Q demonstrated superior patient satisfaction, with 82.8% of individuals rating their experience as "satisfied" or "very satisfied," markedly exceeding the 8.6% observed in Group G ($p < 0.001$). Stone clearance outcomes were comparable between the groups, with no statistically significant difference in residual stone burden ($p = 0.348$).

No significant differences were observed in postoperative hemoglobin levels (Group Q: 11.5 ± 0.6 g/dL vs. Group G: 11.5 ± 0.6 g/dL, $P = 1.0$) or serum creatinine levels (Group Q: 1.0 ± 0.2 mg/dL vs. Group G: 1.0 ± 0.2 mg/dL, $p = 0.611$). In PCNL procedures, QLB in conjunction with LDSA demonstrates superior postoperative analgesia, reduced opioid requirements, and improved patient satisfaction while maintaining comparable perioperative and urological outcomes.

KEY WORDS: Percutaneous nephrolithotomy; Quadratus lumborum block; Low-dose spinal anesthesia; Postoperative analgesia; Opioid consumption.

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INTRODUCTION

Percutaneous nephrolithotomy (PCNL) remains the foremost therapeutic approach for addressing large, complex, and multiple renal calculi, consistently demonstrating superior efficacy in cases where stone burden exceeds 2 cm. This minimally invasive procedure offers several advantages, including reduced trauma, lower intraoperative blood loss, and a favorable safety profile (1).

However, despite these benefits, PCNL is frequently associated with significant postoperative challenges such as severe pain, intestinal paralysis, and surgical stress, which can delay recovery and early mobilization (2).

General anesthesia (GA) remains the most commonly used anesthetic method for PCNL, offering reliable intraoperative conditions (3). However, its limitations, particularly in elderly and high-risk patients, include potential complications with patient positioning, interference with respiratory and circulatory systems, and delayed recovery due to the slower metabolism of anesthetic agents in certain populations (4).

To address these challenges, alternative anesthesia techniques are being explored for their ability to provide effective and safe pain management. Quadratus lumborum block (QLB) has emerged as a promising regional anesthesia technique. It provides prolonged analgesia for abdominal wall and visceral pain, with effects lasting 24 to 48 hours postoperatively, promoting early recovery and reducing opioid consumption. Several QLB approaches have been developed, including QL1, QL2, QL3, and QL4, based on the anatomical site of local anesthetic injection, all of which show potential in improving postoperative outcomes (5).

Although QLB has demonstrated promising analgesic efficacy in abdominal and urological surgery, evidence comparing QLB combined with low-dose spinal anesthesia against general anesthesia in PCNL remains limited. Therefore, this randomized controlled trial aimed to com-

pare the efficacy and safety of these two anesthetic strategies. This study aimed to investigate the comparative effectiveness and safety profile of ultrasound-guided QLB combined with low-dose spinal anesthesia (LDSA) versus GA in the anesthetic management of patients undergoing PCNL.

PATIENTS AND METHODS

Study design

This prospective randomized controlled trial was carried out on 70 adult patients undergoing PCNL at *Benha University Hospitals*. Ethical approval was obtained from the *Institutional Review Board*, and written informed consent was secured from all participants before enrollment.

Eligibility criteria

Patients were eligible for inclusion if they were aged 21–60 years, of either gender, categorized as ASA class I or II, and demonstrated normal mental state, compliance, and normal organ function. Patients were excluded if they refused participation, had a history of mental illness, coagulation dysfunction, severe organ disease, anatomical renal abnormalities, or were pregnant.

Ethics

The study was conducted in accordance with the Declaration of Helsinki and was approved by the *Research Ethics Committee (REC)*, *Faculty of Medicine, Benha University, Egypt* (approval code: RC 5-12-2023). Written informed consent was obtained from all participants prior to enrolment.

Randomization and blinding

Patients were randomized in a 1:1 ratio using a computer-generated sequence. Allocation concealment was achieved using sequentially numbered opaque sealed envelopes. While the researcher performing the procedures was aware of the group assignments, outcome assessors and data analysts remained blinded to ensure unbiased data interpretation.

Study outcomes

The primary outcomes were postoperative pain intensity assessed using the *visual analog scale (VAS)* and postoperative opioid consumption measured by total pethidine requirements.

Secondary outcomes included patient satisfaction, stone-free rate, perioperative changes in hemoglobin and serum creatinine levels, blood transfusion requirements, and anesthesia-related adverse events.

Study population

A total of 70 patients scheduled for PCNL were recruited and randomly allocated into two groups: Group Q ($n = 35$), which received QLB combined with LDSA, and Group G ($n = 35$), which received GA.

Preoperative assessment

A comprehensive preoperative evaluation was conducted for all patients, encompassing a detailed clinical history, physical examination, and radiological assessment via non-

contrast pelvi-abdominal CT. Laboratory workup included complete blood count, renal and hepatic function tests, and coagulation studies, with electrocardiograms and echocardiograms performed for cardiac evaluation.

Anesthetic techniques

Group Q: Quadratus lumborum block with low-dose spinal anesthesia

Patients in this group received spinal anesthesia using a 25-gauge spinal needle at the L3–L4 intervertebral space. A combination of 5 mg bupivacaine and 25 µg fentanyl was administered intrathecally. QLB was then performed using ultrasound guidance, targeting the QL1, QL2, and QL3 injection sites. A mixture of 1.5 mg dexamethasone, 0.25 mL/kg of 0.25% bupivacaine, and 100 mg magnesium sulfate was injected at each site. Patients were monitored continuously for vital signs, including blood pressure (BP), heart rate (HR), and oxygen saturation (SpO₂).

Group G: General anesthesia

Patients in this cohort received an induction regimen comprising intravenous propofol (2 mg/kg), midazolam (0.05 mg/kg), fentanyl (1 µg/kg), and atracurium (0.5 mg/kg). Anesthesia was maintained using isoflurane, with incremental atracurium doses administered every 20 minutes to sustain muscle relaxation. Analgesia was achieved using morphine (0.1 mg/kg). Following endotracheal intubation, mechanical ventilation was commenced. Intraoperative monitoring included BP, HR, SpO₂, and end-tidal CO₂ levels.

Surgical technique

The supine position was adopted, with the contralateral leg relaxed in lithotomy and the ipsilateral leg fully extended in parallel with the trunk. The procedure was performed without the use of a shoulder bolster, flank elevation, or buttock bridge. Upon completion of cystoscopy, a ureteral catheter was placed within the ipsilateral pelvicalyceal system, and a Foley catheter was subsequently inserted. A retrograde pyelogram was then performed.

For calyceal puncture, a 16 G LP needle was used for our patients. Clean urine aspiration was confirmed before inserting a Sensor wire into the collecting system. Serial dilatation was performed using Alken dilators. A 24 Fr nephroscope (*Richard Wolf*) with a 30 Fr Amplatz sheath was used during the procedure. A pneumatic lithotripter was employed for stone fragmentation, enabling the expulsion of smaller fragments via flushing, while larger pieces were extracted using grasper forceps.

Upon achieving stone clearance, a nephrostomy tube (26 Fr) was placed in all patients and initially kept closed for two hours postoperatively before being connected to a urine collection bag. The Foley catheters were removed on the first postoperative day. The nephrostomy tube was typically removed one day after catheter removal.

One week postoperatively, the flank stitch was removed, and patients underwent a CT scan to assess for residual stones. If no significant residual stones (≤ 4 mm) were detected, the double J stent was removed two weeks later. In cases requiring an auxiliary procedure, the stent was retained until postoperative imaging confirmed no significant residual stones.

Intraoperative monitoring

In both groups, intraoperative vital parameters, including HR, BP, and SpO₂, were documented at baseline and subsequently at 10-minute intervals throughout the procedure. Any deviations from normal ranges were managed accordingly.

Postoperative management

Postoperative pain was assessed using the *visual analog scale* (VAS) at 30 minutes, 1 hour, 2 hours, 4 hours, 8 hours, 12 hours, and 24 hours after surgery.

Postoperative pain was evaluated using a standard 10 cm horizontal VAS, where 0 indicated “no pain” and 10 indicated “the worst imaginable pain.” Patients were instructed preoperatively on how to use the scale and were asked to select a number that best represented their pain intensity at each time point. While the scale allowed for continuous values, responses were typically recorded in whole numbers, as decimal values were not captured during data collection (6). Pethidine consumption was recorded for postoperative analgesia requirements.

Patient satisfaction was assessed 24 hours postoperatively using a 5-point Likert-like verbal rating scale. Each patient was asked in Arabic, “How do you evaluate your experience with analgesic management intra- and postoperatively?” Responses were recorded as follows: 5 = very satisfied, 4 = satisfied, 3 = neutral, 2 = unsatisfied, and 1 = very unsatisfied (7).

Anesthesia-related adverse events, including needle trauma, bleeding, muscle weakness, and hemodynamic instability, were recorded. Surgical outcomes, including postoperative stone-free rates, were also documented in both groups. The stone-free rate was assessed postoperatively by CT, categorizing patients based on residual stone size. A measurement of 0 mm indicated no residual stones, defining an absolute stone-free status. Residual stones between 0 and 2 mm were considered non-significant, as were those measuring

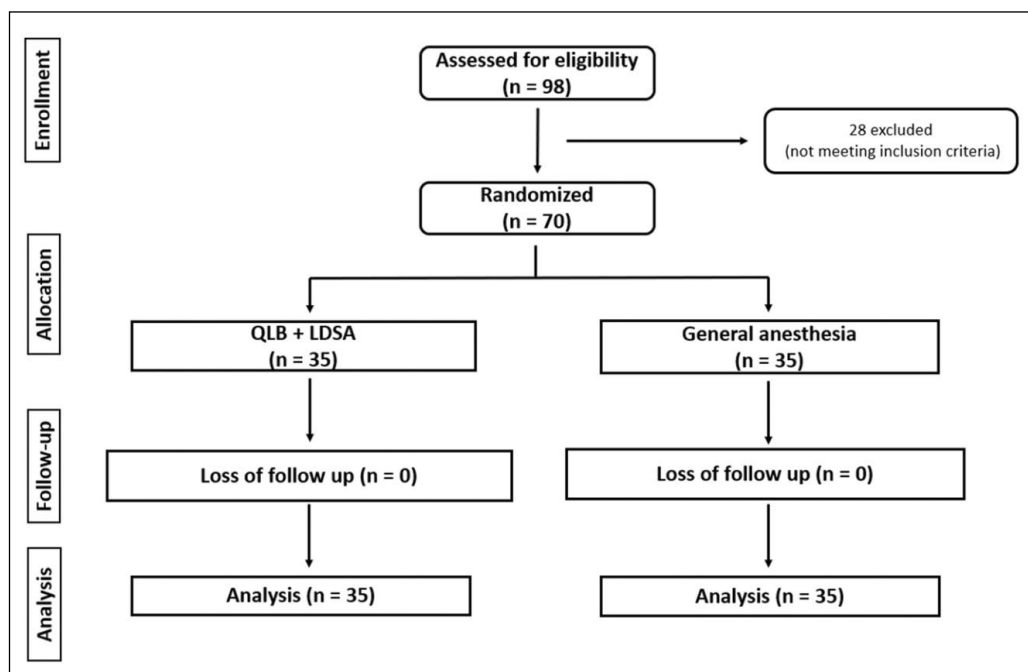
greater than 2 mm but up to 4 mm. However, residual stones exceeding 4 mm were classified as significant. Additionally, four cases in both groups required *extracorporeal shock wave lithotripsy* (ESWL) postoperatively, which served as the necessary auxiliary procedure.

Sample size calculation

G*Power software (version 3.1.9.7) was utilized to determine the appropriate sample size, based on prior research by Raman and Prabha (8), which demonstrated a large effect size in analgesic consumption between groups. To ensure sufficient statistical power, a minimum sample of 60 patients (30 per group) was required to detect an effect size of $d = 0.8$, with an alpha level of 0.05 and power of 0.80.

Statistical methods

SPSS version 28 (IBM, Armonk, New York, United States) was utilized for statistical analysis and data processing. The normality of quantitative data was assessed via the Shapiro-Wilk test and graphical visualization methods. Normally distributed variables were reported as mean $\pm$ standard deviation, whereas non-normally distributed variables were summarized as median and range. Categorical data were presented as frequencies and percentages. Between-group comparisons of quantitative variables were performed using the independent t-test or the Mann-Whitney U test, depending on data distribution. The Chi-square test or Fisher's exact test was applied for categorical data analysis. Predictors of patient dissatisfaction were identified through multivariate logistic regression analysis. The odds ratios with 95% confidence intervals were calculated. To determine the factors associated with pethidine consumption, a multivariate linear regression analysis was conducted. The results were expressed as regression coefficients with 95% confidence intervals. Statistical tests were two-sided, and significance was set at $p < 0.05$.



RESULTS

A total of 98 cases underwent eligibility assessment for this trial, with 28 failing to meet the inclusion criteria. The remaining 70 participants were then randomized equally into two groups: QLB + LDSA ($n = 35$) and GA ($n = 35$). All cases were followed up, and none were lost to follow-up. The data from all 70 patients were included in the final statistical analysis (Figure 1).

Figure 1.
Consort flow diagram of the enrolled patients.

Table 1.
Demographic characteristics of the studied groups.

		Group Q (n = 35)	Group G (n = 35)	P-value
Age (years)	Mean $\pm$ SD	40 $\pm$ 5	42 $\pm$ 7	0.228
Gender				
Males	n (%)	17 (48.6)	16 (45.7)	0.811
Females	n (%)	18 (51.4)	19 (54.3)	
BMI (kg/m ²)	Mean $\pm$ SD	24 $\pm$ 2	24 $\pm$ 2	1.0
ASA				
I	n (%)	21 (60)	20 (57.1)	0.808
II	n (%)	14 (40)	15 (42.9)	
Stone site				
Pelvis	n (%)	28 (80)	34 (97.1)	0.055
Lower calyx	n (%)	22 (62.9)	18 (51.4)	0.334
Upper calyx	n (%)	5 (14.3)	7 (20)	0.526
Stone size (cm)	Mean $\pm$ SD	3.2 $\pm$ 0.7	3.1 $\pm$ 0.6	0.519
Stone side				
Right	n (%)	16 (45.7)	18 (51.4)	0.632
Left	n (%)	19 (54.3)	17 (48.6)	
Surgical time (min)	Mean $\pm$ SD	71 $\pm$ 8	71 $\pm$ 7	1
Previous urological surgeries	n (%)	2 (5.7)	5 (14.3)	0.428
Hemoglobin (g/dL)	Mean $\pm$ SD	14 $\pm$ 1.2	13.5 $\pm$ 1.2	0.123
Creatinine (mg/dL)	Mean $\pm$ SD	1 $\pm$ 0.2	1 $\pm$ 0.2	0.611

SD: Standard deviation; BMI: Body mass index; ASA: American Society of Anesthesiologists; n: Number; min: Minutes.

Demographics

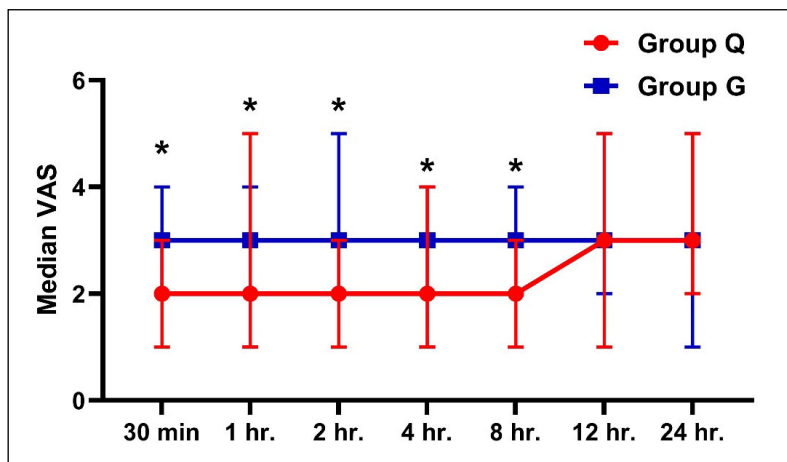
The two study groups demonstrated comparability across multiple baseline characteristics, including age ($p = 0.228$), gender ($p = 0.811$), body mass index (BMI) ($p = 1.0$), ASA classification ($p = 0.808$), stone location ($p = 0.055$ – 0.526), stone size ($p = 0.519$), stone laterality ($p = 0.632$), operative duration ($p = 1.0$), history of prior urological procedures ($p = 0.428$), hemoglobin level ($p = 0.123$), and serum creatinine level ($p = 0.611$) (Table 1).

Mean arterial pressure, heart rate, and VAS

MAP and HR measurements at various time points revealed no statistically significant differences between Group Q and Group G (Table 2). The VAS scores demonstrated significant variations between Group Q and Group G at 30 minutes, 1 hour, 2 hours, 4 hours, and 8 hours post-intervention, with lower median scores consistently observed in Group Q ($p < 0.001$). At 30 minutes, the median VAS score was 2 (range 1–3) in Group Q compared to 3 (range 2–4) in Group G. At 1 hour, the median score was 2 (range 1–5) in Group Q versus 3 (range 1–4) in Group G.

Table 2.
Mean arterial pressure (MAP) and heart rate (HR) at baseline and follow-up, and postoperative visual analog scale (VAS) scores in the studied groups.

		Baseline	At 30 min	At 1 hr.	At 2 hr.	At 4 hr.	At 8 hr.	At 12 hr.	At 24 hr.
MAP									
Group Q	Mean $\pm$ SD	70 $\pm$ 3	70 $\pm$ 2	69 $\pm$ 2	69 $\pm$ 2	70 $\pm$ 2	71 $\pm$ 4	75 $\pm$ 9	72 $\pm$ 5
Group G	Mean $\pm$ SD	71 $\pm$ 4	71 $\pm$ 4	70 $\pm$ 2	70 $\pm$ 2	70 $\pm$ 2	72 $\pm$ 3	77 $\pm$ 2	74 $\pm$ 4
P-value		0.136	0.098	0.069	0.371	0.344	0.207	0.209	0.096
HR									
Group Q	Mean $\pm$ SD	78 $\pm$ 3	78 $\pm$ 3	78 $\pm$ 3	78 $\pm$ 3	77 $\pm$ 4	85 $\pm$ 8	86 $\pm$ 9	87 $\pm$ 9
Group G	Mean $\pm$ SD	80 $\pm$ 5	79 $\pm$ 4	79 $\pm$ 4	78 $\pm$ 4	78 $\pm$ 4	87 $\pm$ 10	88 $\pm$ 10	89 $\pm$ 10
P-value		0.051	0.374	0.405	0.81	0.263	0.283	0.406	0.361
VAS									
Group Q	Median (range)	2 (1–3)	2 (1–5)	2 (1–3)	2 (1–4)	2 (1–3)	3 (1–5)	3 (2–5)	
Group G	Median (range)	3 (2–4)	3 (1–4)	3 (2–5)	3 (1–4)	3 (2–4)	3 (2–5)	3 (1–5)	
P-value			< 0.001*	< 0.001*	< 0.001*	< 0.001*	< 0.001*	0.534	0.718



At 2 hours, Group Q had a median score of 2 (range 1–3), while Group G had a median of 3 (range 2–5). Similar trends were noted at 4 and 8 hours, with Group Q exhibiting lower scores of 2 (range 1–4 and 1–3, respectively) compared to 3 (range 1–4 and 2–4, respectively) in Group G. Conversely, no significant differences were detected at 12 hours ($p = 0.534$) or 24 hours ($p = 0.718$) (Table 2, Figure 2).

Figure 2.
Visual analog scale in the studied groups at different time points.

Table 3.
Patients' outcomes in the studied groups.

		Group Q (n = 35)	Group G (n = 35)	P-value
Patients' satisfaction				
Very unsatisfied	n (%)	0 (0)	7 (20)	< 0.001*
Unsatisfied	n (%)	3 (8.6)	21 (60)	
Neutral	n (%)	3 (8.6)	4 (11.4)	
Satisfied	n (%)	20 (57.1)	3 (8.6)	
Very satisfied	n (%)	9 (25.7)	0 (0)	
Pethidine consumption (mg)	Median (range)	70 (0-130)	105 (50-160)	< 0.001*
Blood transfusion	n (%)	1 (2.9)	0 (0)	
Stone Clearance				
Grade A (0 mm)	n (%)	7 (20)	12 (34.3)	0.348
Grade B (1-2 mm)	n (%)	20 (57.1)	13 (37.1)	
Grade C (3-4 mm)	n (%)	5 (14.3)	5 (14.3)	
Grade D (> 4 mm)	n (%)	3 (8.6)	5 (14.3)	
Sedation	n (%)	5 (14.3)	-	-

n: Number; mg: Milligrams.

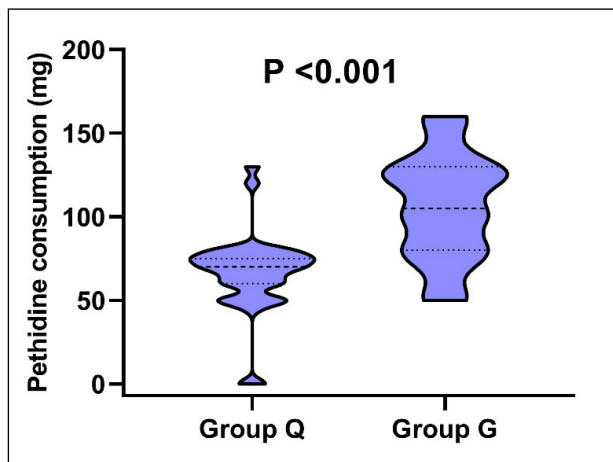
Patients' outcomes

Patients' satisfaction levels significantly differed between the groups ($p < 0.001$). In Group Q, most patients were satisfied (57.1%) or very satisfied (25.7%), with no patients reporting being very unsatisfied. In contrast, in Group G, 20% were very unsatisfied, and 60% were unsatisfied, while only 8.6% were satisfied, and none were very satisfied. Regarding pethidine consumption, Group Q had a significantly lower median consumption (70 mg, range 0-130 mg) compared to Group G (105 mg, range 50-160 mg) ($p < 0.001$) (Table 3, Figure 3).

Five patients (14.3%) in Group Q received supplemental fentanyl and propofol sedation for intraoperative comfort; no patients in Group G received supplemental sedation (Table 3).

However, there was no significant difference in the need for blood transfusion, as only one patient (2.9%) in Group Q required transfusion, while none in Group G did ($p = 1$) (Table 3).

Figure 3.
Pethidine consumption in the studied groups.



Stone clearance did not differ significantly between the study groups ($p = 0.348$). Grade A clearance (0 mm residual stones) was achieved in 20% of Group Q and 34.3% of Group G. Most patients in both groups had Grade B clearance (1-2 mm residual stones), with a slightly higher proportion in Group Q (57.1%) than in Group G (37.1%). Grade C (3-4 mm residual stones) occurred in 14.3% of patients in both groups, while Grade D (> 4 mm residual stones) was slightly more common in Group G (14.3%) compared to Group Q (8.6%) (Table 3).

Prediction of patient dissatisfaction

Multivariate logistic regression analysis was performed to identify predictors of patient dissatisfaction. The model indicated that QLB was significantly associated with a reduced likelihood of dissatisfaction, with an odds ratio of 0.015 (95% CI: 0.003-0.08, $p < 0.001$), after adjusting for age, gender, BMI, and ASA classification (Table 4).

Prediction of pethidine consumption

Multivariate linear regression analysis was performed to predict pethidine consumption. The model showed that QLB was associated with an approximately 40 mg reduction in pethidine consumption ($B = -39.583$, 95% CI: -53.032 to -26.133, $p < 0.001$), after adjustment for age, gender, BMI, and ASA classification (Table 5).

Table 4.
Multivariate logistic regression analysis to predict patient dissatisfaction.

	OR (95% CI)	P-value
Age (years)	1.109 (0.981-1.253)	0.099
Gender	1.227 (0.279-5.405)	0.787
BMI (kg/m ²)	1.111 (0.791-1.56)	0.544
ASA	0.686 (0.145-3.248)	0.635
Quadratus lumborum block	0.015 (0.003-0.08)	< 0.001*

OR: Odds ratio; CI: Confidence interval; BMI: Body mass index; ASA: American Society of Anesthesiologists.

Table 5.
Multivariate linear regression analysis to predict pethidine consumption.

	B (95% CI)	P-value
Age (years)	-0.008 (-1.116-1.099)	0.988
Gender	-4.472 (-17.844-8.901)	0.507
BMI (kg/m ²)	3.03 (-0.017-6.078)	0.051
ASA	4.611 (-9.234-18.455)	0.508
Quadratus lumborum block	-39.583 (-53.032 to -26.133)	< 0.001*

B: Regression coefficient; CI: Confidence interval; BMI: Body mass index; ASA: American Society of Anesthesiologists.

Discussion

QLB, first introduced by *Blanco et al.* (9), is an advanced regional anesthesia technique derived from the TAP block. By depositing local anesthetic near the thoracolumbar fascia, QLB facilitates the spread to the paravertebral space, effectively providing both somatic and visceral analgesia (10). This mechanism allows QLB to block abdominal wall nerves and thoracic spinal nerve roots, making it versatile for pain management across various surgical procedures. It has been successfully applied in abdominal surgeries, orthopedic procedures (11), and urological surgeries like PCNL (2, 12), offering prolonged analgesia, reduced opioid consumption, and minimized systemic side effects. These advantages make QLB an appealing alternative to traditional anesthesia techniques. In this randomized controlled trial, QLB combined with LDSA demonstrated superior outcomes compared to GA in PCNL. Postoperative outcomes in the QLB + LDSA group revealed significantly lower pain scores, diminished opioid consumption, and enhanced patient satisfaction. As surgical incisional pain is absent preoperatively, baseline VAS scores would not reflect the postoperative pain experience. Therefore, we considered the first VAS score measured at 30 minutes postoperatively as the initial baseline for our analysis.

From a urological perspective, the technique did not compromise procedural efficacy, with comparable stone clearance grades observed between the groups.

Additionally, careful adherence to urological protocols, such as nephrostomy tube placement, postoperative imaging for residual stones, and stent removal, ensured optimal surgical outcomes. The synergistic effects of QLB and LDSA not only provided effective intraoperative anesthesia but also enhanced recovery, offering a safer and more efficient alternative to GA, particularly for high-risk patients.

The results of previous studies align with our findings, indicating that QLB provides effective postoperative analgesia with low VAS scores and lower opioid consumption. *Abouelgreed et al.* (13) reported that LDSA combined with QLB offered stable intraoperative hemodynamic parameters, low VAS scores for up to 24 hours, and high patient satisfaction (91.6% rated 4 or 5 on a 5-point Likert Scale) in patients undergoing PCNL. Furthermore, they demonstrated comparable outcomes regarding stone size and site, with a high success rate in stone clearance and no significant complications. Hemoglobin and creatinine levels in our study were consistent with those reported by *Abouelgreed et al.* (13), indicating minimal blood loss and preserved renal function. They revealed the efficacy and safety of QLB combined with LDSA as an alternative to GA in PCNL procedures.

Accumulating evidence from recent studies supports the efficacy of QLB in decreasing opioid requirements and optimizing postoperative pain management. *Turkan et al.* (14) found significantly lower morphine (7 mg vs. 12.5 mg, $p < 0.001$) and intraoperative remifentanyl consumption (1082 µg vs. 1561 µg, $p < 0.001$) in QLB group compared to controls. Similarly, *Chen et al.* (12) and *Kılıç and Bulut* (15) reported a notable reduction in intraoperative sufentanil consumption and sustained pain relief for up to 48 hours in PCNL patients who received QLB.

Raman and Prabha (8) reported that QLB resulted in prolonged analgesia, lower pain scores, and reduced tramadol consumption (84.7 mg vs. 175 mg, $p < 0.001$) compared to placebo, with better patient satisfaction. Additional evidence from studies by *Okmen et al.* (16) and *Peksoz et al.* (17), confirmed that QLB significantly lowered postoperative VAS scores and opioid requirements across various surgeries, including PCNL and laparoscopic procedures.

Blanco et al. explored the efficacy of anterior and posterior QLB in their studies (18, 19). In their 2015 investigation on post-cesarean analgesia, they concluded that QLB significantly enhanced pain management and reduced morphine requirements. They identified the optimal block site as the posterior of the QL muscle, noting that the posterior injection was closer to the internal organs and provided better visualization—one of the key advantages of this technique (18). In another study, they compared the efficacy of posterior QLB with the TAP block, reporting that QLB provided longer-lasting analgesia and significantly reduced opioid consumption compared to the TAP block (19).

In a systematic review and meta-analysis by *Jin et al.* (20), the *quadratus lumborum* (QL) block was found to significantly reduce opioid requirements in cesarean delivery and renal surgery, with analgesic effects lasting up to 24 hours postoperatively. Similarly, a meta-analysis by *Li et al.* (21) revealed that QLB not only significantly reduced opioid consumption during the first 24 hours after surgery but also decreased static pain scores at 6, 12, and 24 hours postoperatively.

In the current study, although preoperative VAS scores were not recorded, this was intentional, as patients had not yet experienced incisional surgical pain. Therefore, preoperative pain levels would not accurately reflect postoperative discomfort. We considered the first postoperative VAS score measured at 30 minutes as the reference baseline for pain assessment. Nonetheless, we acknowledge that individual differences in pain thresholds may exist, which could potentially influence postoperative pain reporting.

In the current work, surgical time was reported as the duration from skin incision to completion of the procedure. However, we did not account for the time required to perform the anesthesia techniques, including ultrasound-guided QLB, spinal anesthesia, or general anesthesia induction. The additional time needed for regional blocks or spinal procedures may vary and could influence preoperative stress or anxiety, potentially affecting postoperative pain perception. This unmeasured variable represents a limitation and may contribute to procedural variability not captured in our data.

Additionally, the five patients in Group Q who received supplemental sedation (fentanyl and propofol) for intraoperative comfort may have experienced different levels of satisfaction. While this number was small, sedation may have influenced subjective perceptions of the perioperative experience, either positively or negatively. Therefore, its possible impact on satisfaction scores was noted and discussed as a factor that could have affected patient-reported outcomes.

Despite the promising findings, this study has some limi-

tations. It was conducted at a single center with a relatively small sample size, which may limit generalizability. Preoperative VAS scores were not recorded, which could have helped account for individual pain threshold variability. Anesthesia preparation time, including QLB and spinal anesthesia, was not measured and may have influenced perioperative stress and pain perception. Additionally, five patients in the QLB group received sedation, which may have affected satisfaction scores. Lastly, the satisfaction scale, although commonly used, was not formally validated in Arabic. In addition, detailed analysis of anesthesia-related adverse events was not performed, which may have limited assessment of the full safety profile. Future studies should address these points with larger samples, validated tools, and longer follow-up.

CONCLUSIONS

QLB in conjunction with LDSA represents a viable and effective anesthetic approach for PCNL, providing enhanced postoperative pain control, reduced opioid requirements, and improved patient satisfaction while maintaining comparable perioperative and urological outcomes.

DECLARATIONS

Ethical approval and consent to participate: The study was conducted in accordance with the Declaration of Helsinki and was approved by the Research Ethics Committee (REC), Faculty of Medicine, Benha University, Egypt (approval code: RC 5-12-2023). Written informed consent was obtained from all participants prior to enrollment.

Consent for publication: Not applicable.

Availability of data and material: The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: MAA, study conception and design and supervision of patient recruitment; AAET and ZME, anesthetic planning, perioperative management, and data interpretation; HMA, scientific review, manuscript editing, critical revision of intellectual content, preparation of the submission package, and journal correspondence; KE and MAEG, manuscript review, data interpretation, and critical revision. All authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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REFERENCES

1. Sun W, Niyazi S, Gao X, et al. Safety and effectiveness of percutaneous nephrolithotomy for patients with stones in a solitary kidney: a meta-analysis. *Indian J Surg* 2024; 86:39-56.
2. Paneque T, Richey J, Abdelrazek A, et al. Current advances in pain regimens for percutaneous nephrolithotomy: a comprehensive review. *Can Urol Assoc J* 2023; 17:E388-94.
3. Indra Rachman R, Birowo P, Nurullah G, et al. General versus spinal anesthesia in percutaneous nephrolithotomy: a systematic review and meta-analysis. *F1000Res* 2023; 12:281.
4. Oner S, Onen E, Caglayan V, et al. The effect of anesthesia type on the outcomes of percutaneous nephrolithotomy in elderly males. *Ann Med* 2023; 55:2238185.
5. Mao Y, Zhao W, Hao M, et al. Ultrasound-guided quadratus lumborum block at the lateral supra-arcuate ligament versus subcostal transversus abdominis plane block for postoperative analgesia following open hepatectomy: a randomized controlled trial. *J Pain Res* 2023; 16:1429-40.
6. Shukla BB, Malviya D, Kumar S, et al. Comparative evaluation of visual analogue scale and pupillary diameter for post-operative pain: an observational study. *Indian J Anaesth* 2023; 67:S93-8.
7. Collins K, O'Cathain A. The continuum of patient satisfaction: from satisfied to very satisfied. *Soc Sci Med* 2003; 57:2465-70.
8. Raman R, Prabha R. Quadratus lumborum block for patients undergoing percutaneous nephrolithotomy: a randomized controlled study. *Anesth Essays Res* 2021; 15:174-8.
9. Blanco R. 271: TAP block under ultrasound guidance: the description of a "no pops" technique. *Reg Anesth Pain Med* 2007; 32:130.
10. Tamura T, Kitamura K, Yokota S, et al. Spread of quadratus lumborum block to the paravertebral space via intramuscular injection: a volunteer study. *Reg Anesth Pain Med* 2018; 43:372-7.
11. Liao W, Wu X, Yin S, et al. Comparison of postoperative analgesia effects between subcostal anterior quadratus lumborum block and transversus abdominis plane block in bariatric surgery: a prospective randomized controlled study. *Trials* 2024; 25:522.
12. Chen L, Ji J, Tian Y, et al. Retrospective study of quadratus lumborum block for postoperative analgesia in patients undergoing percutaneous nephrolithotomy. *BMC Anesthesiol* 2020; 20:217.
13. Abouelgreed TA, Elgarhy AM, Elatreisy A, et al. Is quadratus lumborum block combined with low dose-spinal anesthesia an effective alternative to general anesthesia in patients undergoing percutaneous nephrolithotomy? *Arch Ital Urol Androl* 2023; 95:11584.
14. Turkan H, Kaya C, Turunc E, et al. Effects of anterior quadratus lumborum block versus erector spinae plane block on postoperative acute pain in percutaneous nephrolithotomy: a prospective, observational study. *BMC Anesthesiol* 2024; 24:322.
15. Kılıç E, Bulut E. Quadratus lumborum block III for postoperative pain after percutaneous nephrolithotomy. *Turk J Anaesthesiol Reanim* 2018; 46:272-5.
16. Ökmen K, Metin Ökmen B, Topal S. Ultrasound-guided posterior quadratus lumborum block for postoperative pain after laparoscopic cholecystectomy: a randomized controlled double blind study. *J Clin Anesth* 2018; 49:112-7.
17. Peksoz U, Celik M, Alici HA, et al. The effect of transmuscular quadratus lumborum block on postoperative opioid consumption in patients undergoing percutaneous nephrolithotomy: a randomized controlled study. *Cureus* 2021; 13:e18344.
18. Blanco R, Ansari T, Girgis E. Quadratus lumborum block for

postoperative pain after caesarean section: a randomised controlled trial. *Eur J Anaesthesiol* 2015; 32:812-8.

19. Blanco R, Ansari T, Riad W, Shetty N. Quadratus lumborum block versus transversus abdominis plane block for postoperative pain after cesarean delivery: a randomized controlled trial. *Reg Anesth Pain Med* 2016; 41:757-62.

20. Jin Z, Liu J, Li R, et al. Single injection quadratus lumborum block for postoperative analgesia in adult surgical population: a systematic review and meta-analysis. *J Clin Anesth* 2020; 62:109715.

21. Li Y, Lin C, Liu J. Ultrasound-guided quadratus lumborum block for postoperative analgesia in renal surgery: a systematic review and meta-analysis of randomized controlled trials. *J Anesth* 2022; 36:254-64.

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