

ORIGINAL ARTICLE

Quadratus Lumborum Block Versus Erector Spinae Plane Block for Pain Management During Shock Wave Lithotripsy: Prospective Randomized Controlled Study

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Background	Urinary tract calculi affect approximately 12% of patients, often causing significant pain during shock wave lithotripsy (SWL). This study aims to compare the analgesic efficacy of the Quadratus Lumborum Block (QLB) and the Erector Spinae Plane Block (ESPB) in managing pain during SWL.
Methods	This prospective randomized controlled trial involved 156 patients aged 18-60 with renal pelvic stones <2.5cm. Participants were randomized into three groups: QLB, ESPB, and control. Pain levels were assessed using the Visual Analog Scale (VAS) at multiple time points, and opioid consumption was recorded.
Results	The QLB group demonstrated significantly lower median VAS scores compared to the control group at all points ($p<0.01$). The ESPB group also showed improved pain relief compared to controls, particularly at 10-20 minutes ($p<0.01$). The first analgesic request was significantly delayed in the QLB group (median 25min) compared to the ESPB (15min) and control (12.5min) groups ($p<0.001$). Both regional blocks resulted in reduced opioid consumption.
Conclusion	Both QLB and ESPB are effective analgesic techniques for managing pain during SWL, with QLB providing superior pain control and opioid-sparing effects. These findings support the implementation of regional anesthesia protocols to enhance patient comfort and treatment outcomes in SWL procedures.
Keywords	Analgesia, Erector Spinae Plane Block, Pain Management, Quadratus Lumborum Block, Shock Wave Lithotripsy.
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INTRODUCTION

Urinary tract calculi are among the most prevalent benign urological disorders, affecting approximately 12% of patients, with a recurrence rate nearing 50%^[1,2]. The success of renal stone treatment is influenced by various factors, notably the pain experienced during shock wave lithotripsy (SWL) and individual pain tolerance^[3].

Pain may arise when shock waves from the lithotripter impact both superficial structures (like skin and muscle) and deeper structures (including ribs, subcostal nerves, the sciatic nerve, and the kidney capsule). Three primary factors that determine pain propagation at these sites include shock wave pressure, the focal area size, and the shock wave distribution at the skin entry point^[3]. A smaller

skin aperture can enhance shock wave density, leading to increased energy density and, consequently, greater pain^[4]. Analgesia for SWL-induced pain is usually managed with standard analgesics, such as diclofenac or COX-2 inhibitors, which may also facilitate stone passage^[5]. Various alternative analgesic techniques have been explored, yielding mixed outcomes.

The Quadratus Lumborum Block (QLB), initially described by Blanco^[6], is a posterior abdominal wall interfascial block conducted solely under ultrasound (US) guidance. It primarily targets T7-L1 nerve fibers. There are four QLB variations, including the Quadratus Lumborum 3 (QL3) block, where local anesthetic is administered anterior to the QL muscles specifically, between the QL and psoas major muscles. Research has indicated its efficacy in managing postoperative pain following hip surgeries^[7].

The Erector Spinae Plane Block (ESPB) was first applied for thoracic neuropathic pain by Forero *et al.*,^[8]. Its popularity has since surged for managing postoperative pain in breast surgeries^[9,10], thoracic procedures^[11], chronic shoulder pain^[12], and upper abdominal surgeries^[13]. Like QLB, ESPB is an ultrasound-guided interfascial plane block, involving the injection of anesthetic between the anterior surface of the erector spinae muscle and the transverse processes of adjacent vertebrae. Some case reports suggest performing ESPB at the lumbar level, which has been shown to provide blockades from C7-T2 to L2-L3^[14].

This study aims to compare the analgesic effects of the US-guided QLB and ESPB blocks concerning opioid consumption and patient-reported pain scores during SWL.

PATIENTS AND METHODS

This prospective randomized controlled clinical trial was conducted from March 2022 to March 2024.

A total of 156 patients met the inclusion criteria and were randomized into three groups, with ongoing follow-up throughout our study.

Inclusion criteria encompassed patients aged 18-60 years, of either sex, with ASA status I and II, and renal pelvic stones measuring less than 2.5cm indicated for intervention with stone density from 750 to 1000H.U. Exclusion criteria included ASA status greater than II, stone size exceeding 2.5cm, coagulopathy, chronic pain, long-term NSAID or opioid use, substance addiction, known local anesthetic allergies, pre-existing infections at the block site, acute urinary tract infection, renal insufficiency, renal congenital anomalies, distal ureteral obstruction, previous failed intervention previous renal surgery.

Ethical approval was obtained from the Our University Ethical Committee, and informed written consent was secured from all participants meeting the inclusion criteria. Ethical committee approval No. (SVU.MED. AIP029.4.23.590).

Randomization:

Patients were subsequently randomized using a computer-based program into three groups: group QLB received unilateral QLB III, group ESPB received ESPB, and the third group was the Control group, as depicted in the accompanying flowchart.

Demographic data (age, sex, weight) were recorded, and all patients underwent a complete blood count, coagulation profile, blood sugar analyses, serum creatinine assessment, serum electrolytes, and evaluations of liver functions.

In both block groups (QLB and ESPB), patients were admitted to an operating room adjacent to the SWL facility 30 minutes prior to the procedure. Baseline heart rate, which means arterial pressure (MAP), and oxygen saturation (SO₂) were monitored throughout the block procedure. Patients were positioned in the lateral decubitus position with the target stone side facing upwards. The ultrasound probe and the operative field were sterilized.

In group QLB:

After visualizing the anterior abdominal wall muscles, the curvilinear ultrasound (US) probe was positioned laterally to identify the transverse processes, quadratus lumborum muscle, and psoas muscle. A trans-muscular approach to the quadratus lumborum muscle was employed, with 2ml of 2% lidocaine injected subcutaneously using a 27-gauge needle. Subsequently, a 22-gauge sonovisible needle was advanced into the space between the psoas and quadratus lumborum fascia. Successful placement of the needle was confirmed by injecting 2ml of normal saline. The block was performed by administering 25ml of 0.25% bupivacaine at a dosing rate of 0.3–0.4ml/kg through the same needle. After 20 minutes, the sensory blockade was evaluated via a pinprick test; if loss of sensation was noted at the T7-L1 dermatome, the block was deemed successful, and the patient was then transferred to the SWL room.

In group ESPB:

Following the same positioning, sterilization, and draping protocols, a linear US probe was employed to visualize the erector spinae muscles situated beneath the trapezius muscle. A 27-gauge needle was used to perform a subcutaneous injection of 2ml of 2% lidocaine. Then, a 22-gauge sonovisible needle was carefully inserted medially, in-plane with the ultrasound probe. Once the

needle was positioned beneath the anterior fascia of the erector spinae muscle, 2ml of normal saline was injected to confirm its location. This was followed by a 25ml injection of 0.25% bupivacaine at a dosing rate of 0.3–0.4ml/kg. After a 20-minute waiting period, sensory blockade was assessed via a pinprick test; successful loss of sensation at the T7-L1 dermatome warranted the patient's transfer to the SWL room.

In Control group, patients were admitted to the SWL procedure as per standard protocol.

Upon arrival in the SWL room, all patients were educated about visual analog scale (VAS) and trained on pain assessment. Pain levels in all groups were assessed using VAS prior to administering a premedication dose of 30mg intravenous ketorolac 30 minutes before the procedure. At the start of the SWL, 0.5–1mg of midazolam was administered over two minutes. VAS scores were documented every 10 minutes throughout the procedure, with a dose of 25mcg fentanyl administered if the VAS score reached 4 or above. The first instance of analgesic requirement was recorded, alongside the cumulative dose of fentanyl given during the procedure.

The Dornier Gemini Lithotripter® is a fully integrated electromagnetic shock wave source equipped with both fluoroscopic and ultrasonic guidance capabilities. For energy delivery, we utilized a focal plane with a diameter of 12mm, measuring the effective energy in millijoules (mJ). The procedure commenced at energy level E1, corresponding to the lowest output of 16.0mJ, and gradually increased to energy level E5, which equals 41.0mJ. To optimize results without exceeding a total of 110 joules (J), we initiated the session at a conservative pace.

All patients were positioned supine during treatment. Stone localization was accomplished using ultrasound in every case of the study, intentionally avoiding fluoroscopic localization to minimize radiation exposure.

The SWL session began at energy level E1, delivering the first 250 shocks, and subsequently progressed to the next energy level for an additional 250 shocks. The voltage then gradually escalated to a maximum of E5. Shock waves were delivered at a frequency of 70 shocks per minute. The number and energy of the shock waves were adjusted as necessary to achieve adequate stone fragmentation or until the maximum allowable number of shocks was reached. Each session was capped at 2,600 shocks or a total energy output of 1000 J.

Follow-up KUB and ultrasound assessments were conducted after 2 weeks to ascertain whether the patient required an additional session of SWL.

Adverse effects related to the regional block, including local anesthetic toxicity, bleeding, hematoma at the puncture site, or block failure, were documented.

The primary outcomes included comparisons of the analgesic effects of QLB and ESPB, evaluated through the following metrics: VAS scores: collected pre-SWL and during the procedure at time intervals of 5, 10, 15, 20, 25 and 30 minutes. First analgesic requirement: recorded along with the cumulative fentanyl dosage. While secondary outcomes included: stone fragmentation analysis: parameters such as the maximum and mean energy of shock waves, total shock power (in joules), frequency, the number of shock waves, stone characteristics, and the clearance rate of SWL were observed. The duration of the regional block, defined as the time taken from the initiation of the ultrasound scan to the completion of the local anesthetic injection. Patient satisfaction was evaluated using a five-point scale, with 1 representing 'unsatisfied' and 5 indicating 'completely satisfied'.

Sample size:

The study was powered for the primary outcome: mean postoperative VAS pain score (with rescue-analgesic consumption analyzed as a secondary outcome). Prior RCTs in SWL patients reported large, standardized differences between regional blocks (QLB and ESPB) and conventional analgesia (effect size $d \approx 0.8$ – 1.0) in VAS scores^[30,31]. Translating $d \approx 0.90$ to the ANOVA scale gives an effect size of $f \approx 0.45$; to be conservative, we planned with a slightly smaller effect size of $f = 0.35$ (medium-to-large effect size).

Using G*Power v3.1.9.2 with a one-way ANOVA test to detect differences between the three groups ($\alpha = 0.05$; power = 0.95), the required total sample size was 132 (44 per group). Allowing for 10% attrition, the inflated target was 147 (≈ 49 per group). We enrolled 156 participants (52 per group), exceeding the inflated requirement and thereby preserving $\geq 95\%$ power for the prespecified effect size.

Statistical analysis:

Data was analyzed using Statistics Package for Social Sciences (SPSS) version 27. Normality test (Kolmogorov-Smirnov and Shapiro-Wilk test) was performed, and all continuous were not normally distributed.

Continuous data were expressed as mean $\pm$ standard deviation for parametric data or median and Interquartile range [Median (IQ)] for non-parametric data. The Kruskal-Wallis H “H” test and the significance values have been adjusted by the Bonferroni correction “Bon” for multiple tests because the variables were not normally distributed,

Friedman's Two-Way Analysis of Variance by Ranks test "Fri" was used to compare between more than two intervals follow-up times in related samples among each group.

Nominal data were expressed as percentage; differences between the two groups or more were detected using one of the following:

- If <20% of expected cell counts is <5, we report the p -value of the Chi Square test "Chi".

- If >20% of expected cell counts is <5, we need to use another test:

- If 2X2(each variable has only 2 categories), we use Fisher's exact test "FE".

- If more than 2X2, use the Exact test "E".

A two-tailed $p < 0.05$ was considered statistically significant.

RESULTS

This study, 245 patients were assessed for eligibility, 21 patients did not meet the criteria, and 12 patients refused to participate in the study. Patients were followed up and analyzed statistically (Figure 1).

Our study included 156 patients (50 had QLB block, 50 had ESPB block, 56 was Control group) with comparable baseline demographics. No significant differences were observed in age ($p = 0.780$), weight ($p = 0.426$), or stone size ($p = 0.992$) across groups, ensuring balanced comparisons. Notably, ASA scores differed significantly (ESPB: median 1 [IQR: 1–1] vs. QLB: 2. [1–2], $p < 0.001$), suggesting variations in comorbidity profiles that may warrant further investigation (Table 1).

Both groups demonstrated superior pain control postoperatively, with significantly lower median VAS scores than the Control group at all time points. The comparison between ESPB group and QLB group showed significant difference in favor of ESPB group demonstrating higher pain control at 15min and 20min ($p < 0.001$, $P < 0.009$ respectively). Friedman tests confirmed significant within-group pain escalation over time ($p < 0.001$), underscoring the need for early intervention (Table 2).

Patients receiving the ESPB block required delayed first analgesic request (median: 25min [IQR: 20–30]) compared to QLB (15min [10–25]) and Control (12.5min [10–15]) ($p < 0.001$). Total fentanyl consumption was also lowest in the ESPB group (50mcg [25–50] vs. 125mcg [100–175] in Control, $p < 0.001$). As for QLB group, Total fentanyl was also significantly lower than Control (50mcg

[50–75], $p < 0.001$) reinforcing both QLB and ESPB opioid-sparing effect. Though consumption was lower in ESPB group Vs QLB group, it was statistically insignificant ($p < 0.168$) (Table 3).

SWL Outcomes:

The study demonstrated superior outcomes for patients receiving regional analgesia compared to controls:

Regarding First-Session Success Rates: regional analgesia groups achieved significantly higher success rates in only one session (70% ESPB, 74% QLB) versus 42.9% in Control ($p < 0.001$). Control patients require additional treatment sessions more frequently ($p < 0.001$).

Stone Clearance Efficacy: Both ESPB and QLB groups showed markedly better clearance rates (94% ESPB, 96% QLB) compared to Control group (75%, $p = 0.001$).

Patients with regional analgesia tolerated higher mean energy levels per session (100 J ESPB, 103 J QLB) versus Control (85 J). A statistically significant difference was observed in fever rates between QLB group and Control ($p = 0.038$). There was no statistically significant difference between ESPB and QLB groups regarding complications. The ESPB group reported the highest satisfaction (median: 5 [IQR: 4–5] vs. Control: 3 [2–4], $p < 0.001$), aligning with its favorable pain control and safety profile, though compared to QLB group, it was statistically insignificant (Table 4).

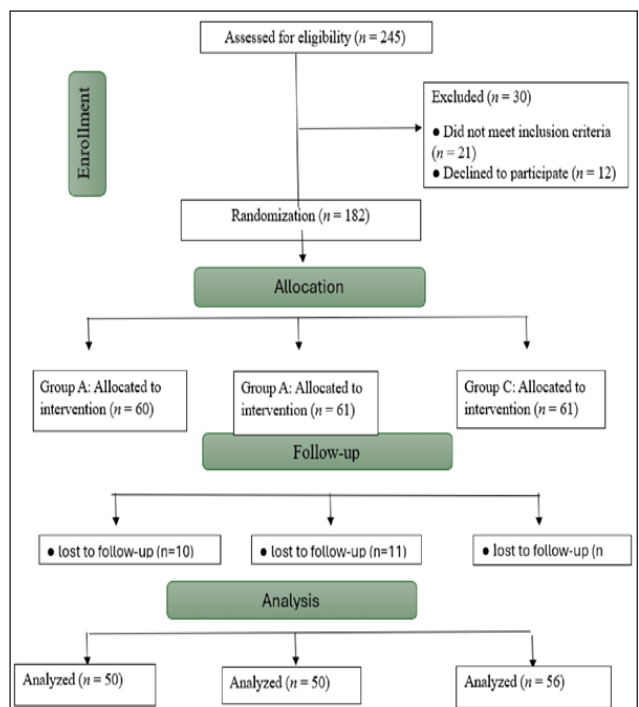


Fig. 1: CONSORT diagram for patient assignment throughout the study.

Table 1: Demographic and clinical data of studied groups:

	ESPB group (n= 50)	QLB group (n= 50)	Control (n= 56)	P-value	P1	P2	P3
Session							
1 st	40(80%)	40(80%)	40(71.4%)	0.476 ^{Chi}	1.000 ^{Chi}	0.306 ^{Chi}	0.306 ^{Chi}
2 nd	10(20%)	10(20%)	16(28.6%)				
Sex							
Male	30(60%)	28(56%)	34(60.7%)	0.872 ^{Chi}	0.685 ^{Chi}	0.940 ^{Chi}	0.623 ^{Chi}
Female	20(40%)	22(44%)	22(39.3%)				
Age							
Median (Q1-Q3)	39(28.75-45.75)	38(26.75-48)	39(28-48.5)	0.780 ^H			
Weight							
Median (Q1-Q3)	80(76-92.25)	86(73.75-90)	86.5(76-89.75)	0.426 ^H			
Stone size (ml)							
Median (Q1-Q3)	19(14.75-20)	18(16.75-18.25)	17(15.25-20)	0.992 ^H			
Side							
RT	24(48%)	32(64%)	30(53.6%)	0.263 ^{Chi}	0.107 ^{Chi}	0.567 ^{Chi}	0.277 ^{Chi}
LT	26(52%)	18(36%)	26(46.4%)				
HFU							
Median (Q1-Q3)	1230(937.5-1300)	1100(950-1225)	1150(850-1300)	0.522 ^H			
jj stent							
No	36(72%)	34(68%)	38(67.9%)	0.876 ^{Chi}	0.663 ^{Chi}	0.643 ^{Chi}	0.987 ^{Chi}
Yes	14(28%)	16(32%)	18(32.1%)				
Hydronephrosis							
No	32(64%)	32(64%)	38(67.9%)	0.889 ^{Chi}	1.000 ^{Chi}	0.676 ^{Chi}	0.676 ^{Chi}
Mild	18(36%)	18(36%)	18(32.1%)				
Localization							
Fluoroscopy	34(68%)	34(68%)	38(67.9%)	0.937 ^{Chi}	0.761 ^{Chi}	0.987 ^{Chi}	0.743 ^{Chi}
us	16(32%)	14(28%)	18(32.1%)				
ASA							
Median(Q1-Q3)	1(1-1)	2(1-2)	1(1-1)	<0.001 ^{**H}	<0.001 ^{**Bon}	1.000 ^{Bon}	<0.001 ^{**Bon}

The data were presented as the mean±SD for parametric data or median and Interquartile range [Median (IQ)] for non-parametric data and for categorical data were presented as number (percentage). Abbreviations: P value: Comparison between all studied groups using Kruskal–Wallis H “H” for nonparametric continuous data and the significance values have been adjusted by the Bonferroni correction “Bon” for multiple tests. Abbreviations: P value: Comparison between categorical data were used:

- If <20% of expected cell counts is <5, we report the p-value of the Chi Square test “Chi”.
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 - If 2X2 (each variable has only 2 categories), we use Fisher’s exact test “FE”.
 - If more than 2X2, use the Exact test “E”.

P-value >0.05 considered statistically not significant; *: P-value <0.05 considered statistically significant; **: P-value <0.01 considered highly statistically significant; P-value: Comparison between all studied groups; P1: Comparison between ESPB group versus QLB group; P2: Comparison between ESPB group versus Control group; P3: Comparison between QLB group versus Control group.

Table 2: VAS score follow-up distribution among studied groups:

VAS score	ESPB group (n= 50)	QLB group (n= 50)	Control (n= 56)	P-value	P1	P2	P3
Preoperative							
Median (Q1-Q3)	0(0-0)	0(0-0)	0(0-0)	1.000 ^H			
After 5 min							
Median (Q1-Q3)	0(0-0)	0(0-0)	0(0-2)	<0.001** ^H	1.000 ^{Bon}	<0.001** ^{Bon}	0.001** ^{Bon}
After 10 min							
Median (Q1-Q3)	0(0-0)	0(0-1.25)	3(2-4.75)	<0.001** ^H	0.204 ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
After 15 min							
Median (Q1-Q3)	0(0-1)	1(0-4)	4(3.25-5)	<0.001** ^H	0.001** ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
After 20 min							
Median (Q1-Q3)	1(0-2)	2(1-5)	5(4-5)	<0.001** ^H	0.009** ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
After 25 min							
Median (Q1-Q3)	2(1-4)	3(1.75-5)	5(5-6)	<0.001** ^H	0.445 ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
After 30 min							
Median (Q1-Q3)	4(1.75-5.25)	5(2-5)	5(5-5.75)	<0.001** ^H	0.668 ^{Bon}	<0.001** ^{Bon}	0.020* ^{Bon}
P-value2	<0.001** ^{Fri}	<0.001** ^{Fri}	<0.001** ^{Fri}				

The data were presented as the mean±SD for parametric data or median and Interquartile range [Median (IQ)] for non-parametric data; Abbreviations: *P* value: Comparison between all studied groups using Kruskal–Wallis H “H” for nonparametric continuous data and the significance values have been adjusted by the Bonferroni correction “Bon” for multiple tests. For compare between more than two intervals follow-up times in related samples among each group was used Friedman's Two-Way Analysis of Variance by Ranks test “Fri”. *P*-value >0.05 considered statistically not significant; *: *P*-value <0.05 considered statistically significant; **: *P*-value <0.01 considered highly statistically significant; *P*-value: Comparison between all studied groups; *P*1: Comparison between ESPB group versus QLB group; *P*2: Comparison between ESPB group versus Control group; *P*3: Comparison between QLB group versus Control group; *P*-value2: Comparison between all intervals follow-up times among each group.

Table 3: Analgesic requirement, patient satisfaction and complications among studied groups:

	ESPB group (n= 50)	QLB group (n= 50)	Control (n= 56)	P-value	P1	P2	P3
1 st analgesic (min)							
Median(Q1-Q3)	25(20-30)	15(10-25)	12.5(10-15)	<0.001** ^H	<0.001** ^{Bon}	<0.001** ^{Bon}	0.022* ^{Bon}
Total fentanyl (mic)							
Median(Q1-Q3)	50(25-50)	50(50-75)	125(100-175)	<0.001** ^H	0.168 ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
Regional block time (min)							
Median(Q1-Q3)	10(9-13.5)	8(5.75-10)		<0.001** ^H			
Patients' satisfaction							
Median(Q1-Q3)	5(4-5)	4(4-5)	3(2-4)	<0.001** ^H	1.000 ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
Complications							
Hematuria	30(60%)	28(56%)	20(35.7%)	0.026* ^{Chi}	0.685 ^{Chi}	0.012* ^{Chi}	0.036* ^{Chi}
Hematoma	3(6%)	4(8%)	0(0%)	0.146 ^E	1.000 ^E	0.102 ^E	0.046* ^E
Fever	14(28%)	20(40%)	12(21.4%)	0.184 ^{Chi}	0.205 ^{Chi}	0.432 ^{Chi}	0.038* ^{Chi}
Nausea	4(8%)	3(6)	6(10.7%)	0.718 ^E	1.000 ^E	0.746 ^E	0.495 ^E
Vomiting	3(6%)	1(2%)	4(7.1)	0.539 ^E	0.617 ^E	1.000 ^E	0.367 ^E
Dizziness	2(4%)	2(4%)	2(3.57%)	1.000 ^E	1.000 ^E	1.000 ^E	1.000 ^E
Respiratory distress	1(2%)	0(0%)	4(7.1%)	0.130 ^E	1.000 ^E	0.367 ^E	0.120 ^E

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P-value >0.05 considered statistically not significant; *: *P*-value <0.05 considered statistically significant; **: *P*-value <0.01 considered highly statistically significant; *P*-value: Comparison between all studied groups; *P*1: Comparison between ESPB group versus QLB group; *P*2: Comparison between ESPB group versus Control group; *P*3: Comparison between QLB group versus Control group.

Table 4: SWL outcomes among studied groups:

	ESPB group (<i>n</i> = 50)	QLB group (<i>n</i> = 50)	Control (<i>n</i> = 56)	<i>P</i> -value	<i>P</i> 1	<i>P</i> 2	<i>P</i> 3
Mean energy							
Median(Q1-Q3)	100 (95.75-105)	103 (96.75-107.25)	85(78-89.75)	0.021* ^H	0.350 ^{Bon}	0.010* ^{Bon}	0.010* ^{Bon}
Number of shock waves							
Median(Q1-Q3)	4000(3800-4241.5)	4000(3852-4285.75)	3500(3237.5-3787.5)	<0.001** ^H	0.030* ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
Number of sessions							
One	35(70%)	37(74%)	24(42.9%)				
Two	12(24%)	11(22%)	16(28.6%)	<0.001** ^{Chi}	0.891 ^E	0.004** ^{Chi}	<0.001** ^{Chi}
Need another	3(6%)	2 (4%)	16(28.6%)				
Stone clearance	47(94%)	48(96%)	42(75%)	<0.001** ^H	0.981 ^{Bon}	<0.001** ^{Bon}	<0.001** ^{Bon}
Next procedure							
No	47(94%)	48(96%)	48(85.7%)				
RIRS	3(6%)	2(4%)	4(7.1%)	0.083 ^E	1.000 ^E	0.197 ^E	0.135 ^E
URS	0(0%)	0(0%)	4(7.1%)				

The data were presented as the mean±SD for parametric data or median and Interquartile range [Median (IQ)] for non-parametric data and for categorical data were presented as number (percentage). Abbreviations: *P*. value: Comparison between all studied groups using Kruskal–Wallis H “H” for nonparametric continuous data and the significance values have been adjusted by the Bonferroni correction “Bon” for multiple tests. Abbreviations: *P*. value: Comparison between categorical data were used:

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 - If 2X2 (each variable has only 2 categories), we use Fisher’s exact test “FE”.
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P-value >0.05 considered statistically not significant; *: *P*-value <0.05 considered statistically significant; **: *P*-value <0.01 considered highly statistically significant; *P*-value: Comparison between all studied groups; *P*1: Comparison between ESPB group versus QLB group; *P*2: Comparison between ESPB group versus Control group; *P*3: Comparison between QLB group versus Control group.

DISCUSSION

The treatment of renal urolithiasis presents significant challenges, with many approaches leaning toward less invasive techniques such as PCNL, RIRS, SWL. Shock wave lithotripsy (SWL) is considered one of the least invasive options for managing renal stones; however, it faces difficulties due to its lower success rates compared to other techniques which may be due to limitations on the energy delivered during sessions, which can be impacted by pain severity and potential complications. In this randomized controlled clinical study, 156 patients presented to our clinics with renal stones fulfilling criteria for treatment of SWL. We compared the analgesic effects of both the erector spinae plane block (ESPB) and the quadratus lumborum block (QLB) before SWL in adult patients, and we monitored their impact on stone clearance. We hypothesized that utilizing local anesthesia techniques would allow us to deliver maximum energy for fragmenting stones, minimizing limitations imposed by patient pain and movement during the procedure due to shockwave discomfort.

Both the QLB and ESPB groups demonstrated statistically significant pain relief compared to the control group. Notably, the visual analog scale (VAS) scores

were lower in the ESPB group than in the QLB group at both 20 and 15 minutes, indicating superior pain control. Furthermore, both blocks resulted in reduced overall opioid consumption relative to the control group, with the ESPB group exhibiting the lowest usage. Additionally, the time to the first analgesic requirement was prolonged in both treatment groups compared to the control group, suggesting a longer duration of analgesia.

The mechanisms underlying the pain experienced during SWL are not fully understood but are believed to involve multiple factors^[15]. Two primary sources of pain are thought to be superficial cutaneous nociceptors and deeper visceral receptors, including those in the periosteum, pleura, peritoneum, and musculoskeletal structures. Moreover, various technical and physical factors—such as the type of lithotripter, stone size and location, position of the shockwave focus, cavitation phenomena, peak pressure of the shockwaves, focal zone dimensions, and the entry point of the shockwaves on the skin—significantly influence pain levels during the procedure^[16].

It is essential to keep the patient calm and cooperative during treatment to ensure accurate stone targeting and

effective fragmentation. However, pain management is often left to the discretion of urologists, primarily guided by personal experience, which can lead to inconsistent outcomes. Therefore, selecting an analgesic that provides effective relief with minimal side effects is crucial. Although several studies have assessed various analgesic approaches for SWL^[17-19], there remains no clear consensus on the optimal method that balances pain control, safety, and cost-effectiveness.

Various analgesics, including opioids like fentanyl and NSAIDs, have been used during shock wave lithotripsy (SWL). Fentanyl is favored for its quick onset and strong pain relief, but it can cause side effects such as respiratory depression and nausea, leading to longer hospital stays and increased costs. This highlights the need for alternative pain management strategies to reduce opioid use.

Our study demonstrated a significant reduction in fentanyl-related side effects, particularly respiratory distress, in both the QLB and ESPB groups compared to the control group. This decrease in adverse effects is primarily due to the reduced total consumption of fentanyl in both QLB and ESPB.

The ESPB technique has shown promise in providing regional analgesia for a wide range of surgical interventions involving the anterior, posterior, and lateral aspects of the thoracic and abdominal regions^[20,21]. Additionally, it has been effectively applied in managing both acute and chronic pain conditions^[8]. Its analgesic effect is thought to stem from the diffusion of local anesthetic agents into the paravertebral and intercostal spaces across multiple levels, blocking the dorsal and ventral rami along with associated sympathetic fibers. This leads to relief from both somatic and visceral pain^[22].

QLB has recently attracted growing attention for use in both adult and pediatric populations^[6,7,23-25]. Its primary mechanism of action is thought to involve the lateral arcuate ligament, which acts as a conduit between the thoracic and transversalis fasciae. This anatomical feature facilitates the spread of local anesthetics from the QLB site into the thoracic paravertebral space, resulting in effective relief of both somatic and visceral pain^[26-28].

Numerous studies have explored the roles of QLB and ESPB in various surgical procedures, both open and laparoscopic. However, only a few have examined the efficacy of these regional blocks in patients undergoing shock wave lithotripsy. For instance, Karaaslan M. assessed the analgesic effectiveness of ESPB compared to intramuscular diclofenac sodium in patients undergoing SWL^[29], finding significantly lower VAS scores in the ESPB group. Similarly, Mursel Ekinçi applied ESPB to

manage procedural pain in a 2-year-old pediatric patient undergoing SWL, reporting positive outcomes with the patient remaining calm and comfortable postoperatively^[30]. These findings align with the results of our own research on the same procedure.

Only a limited number of studies have investigated the role of QLB in SWL patients. Yayik A.M. and colleagues^[31] administered QLB to 15 patients to assess its impact on analgesia and stone fragmentation during SWL. They reported an average fentanyl consumption of 15.00 ± 15.08 mcg, with mean VAS scores recorded at 5-minute intervals ranging from 0.20 ± 0.41 to 2.73 ± 1.22 . Complete fragmentation was achieved in 9 out of the 15 patients, while 5 experienced partial fragmentation. The authors attributed the high success rate to the reduction of pain-induced movement facilitated by effective analgesia from QLB.

In our study, we examined the impact of our technique on increasing the stone-free rate, achieving overall success rates of 94% and 96% for renal stones in the ESPB and QLB groups, respectively, compared to 75% in the control group. Additionally, the number of SWL sessions needed significantly decreased in the regional analgesia groups, with a reduction to 30% for ESPB and 26% for QLB, compared to 58% for the control group. We attribute this high success rate to the increased energy delivered during each SWL session in the local anesthesia groups, along with reduced patient movement compared to the control group, resulting from lower pain experiences. However, we also found that the increased energy delivery was associated with a higher complication rate, including post-SWL hematuria and renal hematoma in some cases. This highlights the importance of pain experience, as it plays a valuable role in limiting serious complications related to the increased energy delivery during SWL.

LIMITATION OF STUDY

Further studies with larger patient populations are needed to strengthen the statistical results. This study focused exclusively on patients with renal pelvic stones; additional research should include patients with calyceal stones, particularly upper, middle, and lower calyceal stones, which generally have lower SWL success rates.

CONCLUSIONS

The use of local anesthesia for adults prior to SWL provides pain-free sessions, allowing for increased energy delivery to renal stones and, consequently, a higher stone-free rate. However, it is essential to consider the complications associated with higher energy levels. Both QLB and ESPB are effective analgesic options; however,

ESPB may offer certain advantages in terms of analgesic efficacy and ease of application. A review of the literature indicates that ESPB is generally simpler and safer to perform due to its more superficial location, distinct sono-anatomical landmarks, and reliance on a bony structure as the endpoint for injection. In contrast, QLB is technically more challenging and time-consuming, primarily because of its deeper target site, the difficulty in maintaining needle visualization with a convex probe, and the need for greater expertise to avoid complications such as renal injury, retroperitoneal hematoma, or lower limb weakness resulting from unintended lumbar plexus involvement. Considering these factors, it may be preferable for patients undergoing SWL to opt for ESPB, as it is a safer and easier technique compared to QLB.

AUTHORS' CONTRIBUTION

Study concept and design: Z. M. S., O. E. M. and A. A.; analysis and interpretation of data: O. M. and M. A. E. R.; drafting of the manuscript: M. G. A.; critical revision of the manuscript for important intellectual content: Z. M. S., O. E. M., and Z. M. S.

ETHICS APPROVAL STATEMENT

Ethical approval was obtained from the South Valley University Ethical Committee, and informed written consent was secured from all participants meeting the inclusion criteria. Ethical committee approval No. (SVU. MED.AIP029.4.23.590).

CONFLICT OF INTERESTS

There are no conflicts of interest.

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