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Original Research Article

Comparative evaluation of ultrasound-guided erector spinae block and quadratus lumborum block for post-operative analgesia in abdominal surgeries

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Abstract

Background: Midline abdominal surgeries are associated with significant postoperative pain. The introduction of ultrasound-guided techniques has expanded the repertoire of musculo-fascial plane blocks for effective perioperative and postoperative analgesia. This study aimed to compare the analgesic efficacy of ultrasound-guided Quadratus Lumborum Block (QLB) and Erector Spinae Plane Block (ESPB), combined with patient-controlled analgesia (PCA), for pain management following abdominal surgeries with midline incisions.

Materials and Methods: In this randomized prospective study, 70 patients were divided into two groups: Group Q (n = 35) received bilateral QLB with 20 mL of 0.375% Ropivacaine, while Group E (n = 35) received bilateral ESPB with the same dosage. Fentanyl PCA was used as analgesic supplement and rescue analgesia was given if NRS ≥4. The time of first demand for analgesia, total rescue analgesia consumed over 24 hours and adverse effects were noted.

Results: Significant differences in pain scores and analgesic requirements were observed between the two groups. At 0 hours post-surgery, Group Q demonstrated significantly lower mean NRS scores compared to Group E, both for dynamic pain (1.11 vs. 1.54, p = 0.002) and static pain (0.26 vs. 0.94, p < 0.001). Similar trends were observed at 4 hours, where Group Q had lower mean dynamic NRS scores (1.97 vs. 2.43, p = 0.004) and static NRS scores (1.11 vs. 1.51, p = 0.011). Opioid consumption over 24 hours was notably less in Group Q compared to Group E (206.29 µg vs. 270.6 µg, p = 0.034). Similarly, the total rescue analgesic requirement (diclofenac) was significantly lower in Group Q (95.00 mg vs. 136.36 mg, p = 0.006). There were no statistically significant differences in the incidence of adverse effects between the two groups, indicating a comparable safety profile.

Conclusion: Quadratus Lumborum Block (QLB), when used in conjunction with patient-controlled analgesia (PCA), provides superior pain relief compared to Erector Spinae Plane Block (ESPB), particularly in the immediate postoperative period.

Keywords: Analgesia, Ultrasound guided block, Erector Spinae Plane Block, Quadratus lumborum block, Patient-controlled analgesia.

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1. Introduction

Midline abdominal surgeries account for severe post-operative pain.[1] Effective post-operative pain management is crucial since severe pain is linked to difficult sleeping, limited mobility, and atelectasis, all of which will increase healthcare expenditures through delayed hospital discharge and decreased patient satisfaction.[2]

For post-operative pain control and to decrease the total opioid requirement, many interfacial plane blocks have been introduced e.g. Quadratus lumborum block (QLB), Erector spinae plane block (ESPB), transversus abdominis plane block (TAP) and para-vertebral block. Less complications result from the direct visualization of the needle, nerves, and surrounding anatomy provided by ultrasound (USG) guided methods.[3]

Quadratus lumborum block 3 includes application of local anaesthetic between Quadratus Lumborum Muscle (QLM) and psoas major muscle (PMM), in front of QLM where it attaches to the transverse process of L4 vertebra,[4] A local anaesthetic is injected in a plane between the erector spinae muscl and transverse process during an ESPB. Based on cadaveric and contrast studies, it is presumed to act at the origin of spinal nerves.[5]

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They are one of the safest and most effective methods to control pain from surgery and can be given as a single injection peripheral nerve block (sPNB), or as a continuous catheter infusion peripheral nerve block (cPNB). With Ultrasound guided (USG) techniques there is a direct visualization of needle, nerves, and adjacent anatomy, so risk of complication is lower.[6]

The present study was designed with the primary objective to evaluate analgesic efficacy using the NRS pain score in QLB and ESPB group in abdominal surgeries with midline incision. The secondary objective was to compare total postoperative analgesic consumption.

2. Materials and Methods

This was a single blinded, prospective experimental study which took place at a tertiary care hospital after proper approval from the institutional ethical board (SRHU/HIMS/ETHICS/2021/140) and Clinical Trial Registry India (CTRI/2022/02/040346). Study was conducted over a time period of 1 year. Written informed consent was taken from all the patients, they were also explained about NRS and usage of PCA pump (PCA- B. Braun Melgusen AG pump) during pre-operative visit.

The anaesthesiologist in charge for randomization employed opaque envelopes to position random numbers incepted through a computer, for that we used Random Allocation Software version 2.0 (Informer Technologies, Inc.) using simple randomization with 1:1 allocation. Patients in Group E were given Bilateral USG guided ESP block while Group Q patients received an ultrasound-guided Bilateral QL3 block after completion of surgery. All the patients and anaesthesiologist were blinded to group allocation. Anaesthetic technique was standardized for all the patients.

The sample size for this study was determined using the numerical rating scale (NRS) as the primary outcome measure to assess analgesic efficacy between the two groups. Based on previous research by Ökmen et al.[7] and Kwak et al.,[8] we considered a difference of 2 points on the NRS to be clinically significant. This threshold aligns with the findings of Farrar et al., who established that a 2-point reduction on an 11-point NRS represents a clinically important difference in pain intensity.[9]

The sample size formula used was: $n= (Z_{\alpha/2})^2\ p\ (1-p)/d^2$

Where,

$Z_{\alpha/2} = 1.96$ at 5% level of significance,

p = prevalence: 50% (or p=0.5, prevalence assumption),

1-p=1-0.5=0.5,

d=absolute precision: d=12%=0.12

Substituting these values, the calculated sample size was 67 patients. To simplify data handling and ensure balanced group sizes, the total sample size was rounded up to 70 patients, resulting in two equal groups of 35 participants each.

A total of 70 patients aged 18 to 65 years, of either sex, classified as ASA I or II, undergoing midline abdominal surgeries under general anaesthesia, were enrolled in the study. Patients were excluded if they refused to participate, had a history of allergy to study medications, bleeding disorders, dyselectrolytemias, severe cardiovascular, respiratory, liver, or kidney disease, recent use of anticoagulants or chronic pain relief medications, ASA physical status III or higher, local infection at the block site, inability to give informed consent or operate the PCA pump, or any psychiatric disorder. The patients were randomized into two groups: Group E, which received ultrasound-guided bilateral Erector Spinae Plane Block (ESPB), and Group Q, which received ultrasound-guided bilateral Quadratus Lumborum Block (QLB). Both groups received 20 mL of 0.375% Ropivacaine for each block following the completion of surgery (**Figure 1**).

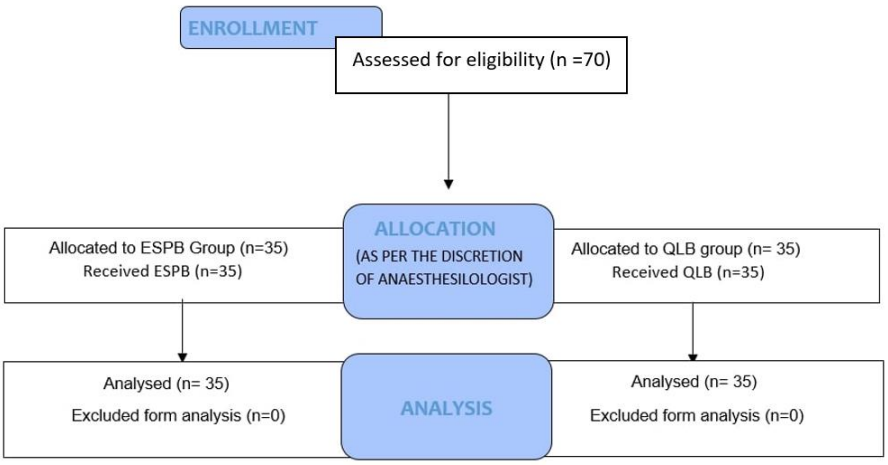

Figure 1: Consort flow diagram

Eligible patients were kept nil per oral for six hours for solids and two hours for clear fluids before surgery. Premedication included tablet Ranitidine 150 mg and tablet Alprazolam 0.25 mg, administered the night before and two hours prior to the procedure. In the preoperative area, patients were informed about the procedure, including Rapid Sequence Intubation (RSI) if required and the block application. After establishing intravenous access, baseline monitoring of ECG, non-invasive blood pressure (NIBP), SpO2, temperature, and end-tidal CO2 (EtCO2) was performed and recorded. Patients were premedicated with intravenous fentanyl 2 µg/kg, and general anaesthesia was induced using propofol 2 mg/kg and succinylcholine 1.5 mg/kg. RSI was performed with cricoid pressure applied, and the trachea was intubated with a Portex Polyvinyl Chloride (PVC) tube (size 7.5 for females and size 8.5 for males). Anaesthesia was maintained with a mixture of oxygen (50%) and air (50%) and sevoflurane (1–2% with MAC 1–1.2). Muscle relaxation was sustained with atracurium (loading dose 0.5 mg/kg followed by maintenance doses of 0.2 mg/kg).

Following surgery, and before extubation, blocks were administered by trained anaesthesiologists with over one year of experience in ultrasound-guided techniques. In Group E, ESPB was performed at the T9 level using a 13–6 MHz linear ultrasound probe. The transverse process of T9 was identified using the inferior angle of the scapula (T7) as a landmark. A 100 mm Sonoplex Ultra 360 block needle was advanced in-plane to the ultrasound probe until it reached the transverse process. After hydrodissection with 1 mL of saline to confirm needle tip placement, 20 mL of 0.375% Ropivacaine was injected bilaterally.

For Group Q, QLB was performed with patients in the lateral decubitus position. A 2–5 MHz curvilinear ultrasound probe was placed transversely along the anterior axillary line to identify the characteristic triple-layered abdominal muscles. The probe was moved posteriorly to visualize the "shamrock sign," with the L4 transverse process as the stem and the Erector Spinae, Quadratus Lumborum, and Psoas Major muscles as the leaves. A 100 mm Sonoplex Ultra 360 block needle was advanced in-plane towards the anterior aspect of the Quadratus Lumborum muscle. Needle placement was confirmed by hydrodissection with 1 mL of saline, followed by injection of 20 mL of 0.375% Ropivacaine bilaterally.

All patients received ondansetron 0.1 mg/kg and paracetamol 15 mg/kg intravenously 30 minutes before extubation. Post-extubation, patients were transferred to the Post-Anaesthesia Care Unit (PACU), where the time of transfer was recorded as the 0th hour. Vital parameters, including heart rate, blood pressure, and SpO2, were recorded every 30 minutes for the first hour and then every four hours.

Pain severity was assessed using the Numeric Rating Scale (NRS) at 0, 30 minutes, 1, 4, 8, 12, 16, 20, and 24 hours postoperatively. A fentanyl PCA pump was set to deliver a 20 µg bolus with a 20-minute lockout interval and a maximum dose of 200 µg over four hours. No baseline infusion was administered. Each patient also received paracetamol 15 mg/kg intravenously every eight hours. Rescue analgesia in the form of diclofenac sodium 75 mg IV was provided if the NRS score was ≥4, and the time to the first analgesic requirement and total fentanyl consumption within the first 24 hours were recorded.

The primary outcome of the study was the Numeric Rating Scale (NRS) score, assessed both during movement and at rest. The secondary outcome included evaluating motor block at specific time points—0, 30 minutes, 1, 4, 8, 12, 16, 20, and 24 hours after recovery from anaesthesia—using the modified Bromage Score.[10] Adverse effects or complications, such as pruritus, hypotension, and nausea/vomiting, were also documented. These parameters were assessed by an attending anaesthesiologist who was blinded to the group allocation.

Data analysis was performed using SPSS version 28.0 (SPSS, Chicago, Illinois). Continuous variables with normal distribution were analysed using the unpaired t-test, while the Mann-Whitney U test was applied for non-normally distributed variables. Categorical variables were assessed using Fisher's Exact Test or the Chi-Square Test, as appropriate. A p-value of <0.05 was considered statistically significant.

3. Results

A total of 70 patients meeting the eligibility criteria were included in the study. The demographic characteristics, including age, weight, height, BMI, and ASA grade distribution, were comparable between the two groups **(Table 1).**

The static and dynamic NRS scores were measured at various time intervals postoperatively. Significant differences were observed in pain perception between the two groups at 0 hours and 4 hours. For static NRS, the mean scores were significantly lower in Group Q compared to Group E at 0 hours ($p < 0.001$) and at 4 hours ($p = 0.011$). Similarly, for dynamic NRS, Group Q showed significantly lower scores at 0 hours ($p = 0.002$) and at 4 hours ($p = 0.004$). However, there were no significant differences in pain scores at 8, 12, 16, 20, and 24 hours postoperatively (**Table 2**, **Table 3** and **Figure 2**, **Figure 3**).

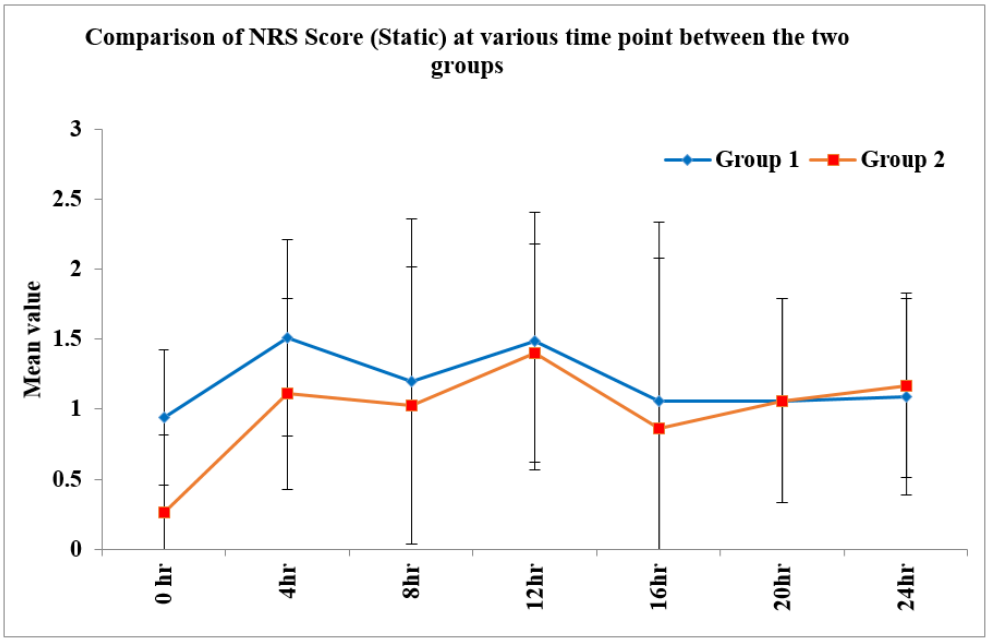

Figure 2: NRS (Static) at different time intervals for ESPB and QLB group (Group 1- ESPB, Group 2- QLB)

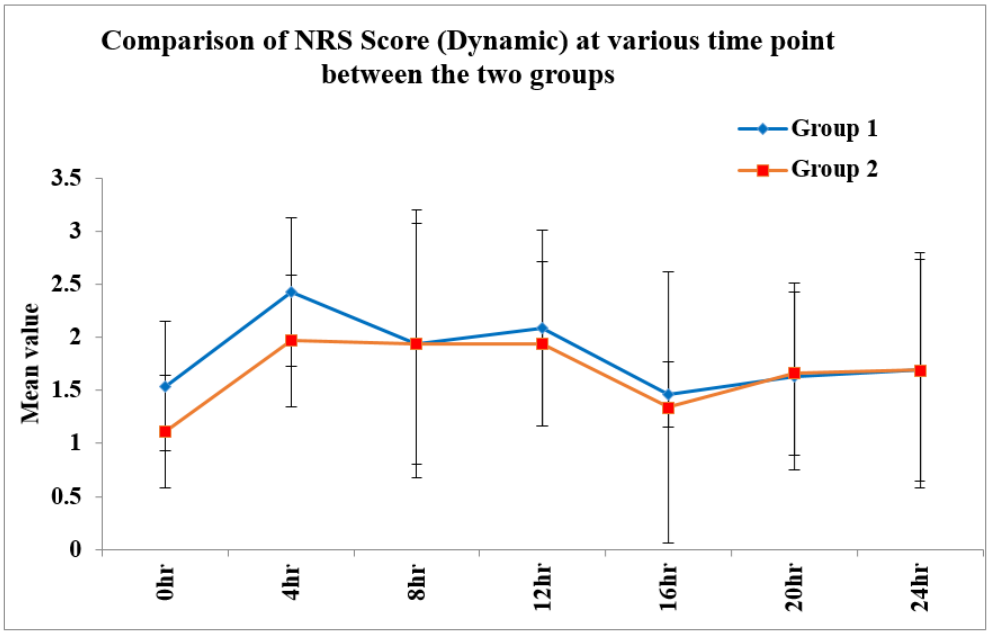

Figure 3: NRS (Dynamic) at different time intervals for ESPB and QLB group (Group 1- ESPB, Group 2- QLB)

Table 1: Demographic profile of patients in the two groups

	Group E (n=35)	Group Q (n=35)	p value
	Mean ± SD	Mean ± SD	
Age (years)	43.2 ± 11.99	44.77 ± 12.76	0.597
Weight (Kg)	55.74 ± 5.63	56.31 ± 6.11	0.685
Height (cm)	165.09 ± 5.76	163.37 ± 5.61	0.211
BMI (kg/cm^2)	20.45 ± 1.79	21.08 ± 1.93	0.164
ASA Grade I:II	13:22	10:25	0.445

SD- Standard deviation, BMI- *Body mass index, ASA- American Society of Anesthesiologists*

Table 2: Static numerical rating score at different time intervals for ESPB and QLB group

NRS Score (Static)	Group E (n=35)			Group Q (n=35)			p value*
	Mean ± SD	Min - Max	Median (IQR)	Mean ± SD	Min – Max	Median (IQR)	
0hr	0.94 ± 0.482	0 – 2	1 (1 - 1)	0.26 ± 0.56	0 – 2	0 (0 - 0)	<0.001
4hr	1.51 ± 0.70	0 – 2	2 (1 - 2)	1.11 ± 0.68	0 – 2	1 (1 - 2)	0.011
8hr	1.2 ± 1.16	0 – 4	0 (1 - 1)	1.03 ± 0.99	0 – 3	0 (1 - 1)	0.608
12hr	1.49 ± 0.92	0 – 4	1 (2 - 2)	1.4 ± 0.78	0 – 3	1 (1 - 2)	0.720
16hr	1.06 ± 1.28	0 – 3	0 (0 - 2)	0.86 ± 1.22	0 – 3	0 (0 - 2)	0.475
20hr	1.06 ± 0.73	0 – 2	1 (1 - 2)	1.06 ± 0.73	0 – 2	1 (1 - 2)	1.000
24hr	1.09 ± 0.7	0 – 2	1 (1 - 2)	1.17 ± 0.66	0 – 2	1 (1 - 2)	0.613

Data expressed as Median (IQR), *Man Whitney U test

Table 3: Dynamic numerical rating score at different timeintervals for ESPB and QLB group

NRS Score (Dynamic)	Group E (n=35)			Group Q (n=35)			p value*
	Mean± SD	Min-Max	Median (IQR)	Mean ± SD	Min-Max	Median (IQR)	
0hr	1.54 ± 0.61	0 -2	2 (1 - 2)	1.11 ± 0.53	0 - 2	1 (1 - 1)	0.002
4hr	2.43 ± 0.70	1 - 3	3 (2 - 3)	1.97 ± 0.62	1 - 3	2 (2 - 2)	0.004
8hr	1.94 ± 1.26	1 - 5	1 (2 - 2)	1.94 ± 1.14	1 - 5	2 (1 - 2)	0.845
12hr	2.09 ± 0.92	1 - 5	1 (2 - 3)	1.94 ± 0.77	1 - 3	2 (1 - 3)	0.604
16hr	1.46 ± 0.31	0 - 3	0 (1 - 3)	1.34 ± 1.28	0 - 3	1 (0 - 3)	0.711
20hr	1.63 ± 0.88	0 - 3	1 (2 - 2)	1.66 ± 0.77	0 - 3	2 (1 - 2)	0.850
24hr	1.69 ± 1.11	0 - 4	1 (1 - 2)	1.69 ± 1.05	0 - 4	1 (1 - 2)	0.949

Data expressed as Median (IQR), *Man Whitney U test

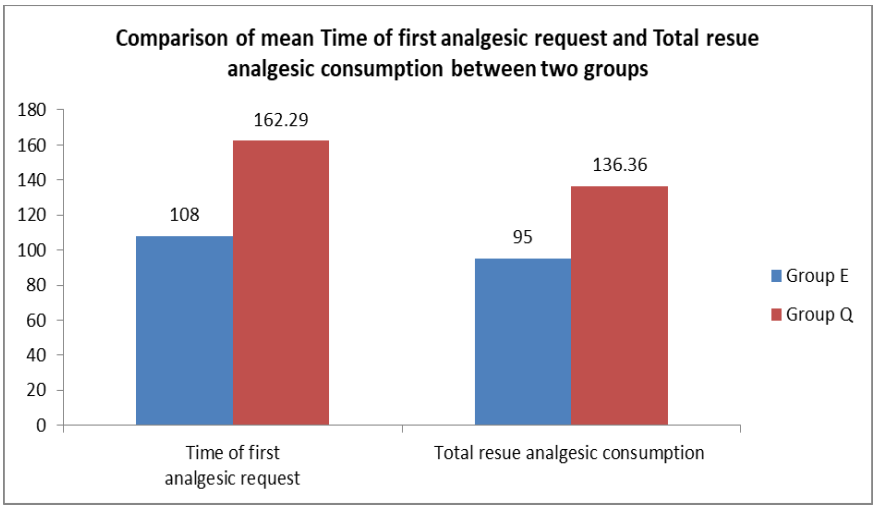

Figure 4: Comparison of mean time of first analgesia request and total rescue analgesia

The time to the first analgesic request was significantly longer in Group Q (162.29 ± 96.56 minutes) compared to Group E (108.00 ± 75.34 minutes), with a p-value of 0.013. Total fentanyl consumption over 24 hours was also significantly lower in Group Q (206.29 ± 106.69 µg) compared to Group E (270.86 ± 127.08 µg), with a p-value of 0.034 (**Table 4**).

Additionally, the number of PCA pump pushes and deliveries were significantly lower in Group Q compared to Group E. The mean number of PCA pump pushes in Group Q was 10.34 ± 8.16 (range: 3–47, median: 6 [IQR: 10–15]) compared to 15.37 ± 9.85 in Group E (range: 4–50, median: 10 [IQR: 12–21]), with a p-value of 0.037. Similarly, the mean number of PCA pump deliveries in Group Q was 10.31 ± 5.34 (range: 3–24, median: 6 [IQR: 10–15]) compared to 13.71 ± 6.34 in Group E (range: 4–24, median: 10 [IQR: 12–21]), with a p-value of 0.022 (**Table 4**).

The mean total consumption of rescue analgesic (Inj. Diclofenac) was significantly lower in Group Q (95.00 ± 34.33 mg) compared to Group E (136.36 ± 30.34 mg) (**Figure 4**).

Table 4: Comparison of first demand of opioid and total opioid consumption

	Group E (n=35)			Group Q (n=35)			p value
	Mean ± SD	Min-Max	Median (IQR)	Mean ± SD	Min-Max	Median (IQR)	
Time of first analgesic request	108.00±75.34	30-300	120 (30-150)	162.29 ± 6.56	30-420	150 (90-210)	0.013
Total fentanyl consumption over 24 hours (in µg)	270.86 ± 27.08	80-480	240 (200-420)	206.29 ±106.69	60-480	200 (120-300)	0.034
PCA Pump: No. of Pushes	15.37 ± 9.85	4-50	10 (12-21)	10.34 ± 8.16	3-47	6 (10-15)	0.037
No. of deliveries	13.71 ± 6.34	4-24	10 (12-21)	10.31 ± 5.34	3-24	6 (10-15)	0.022

SD: Standard deviation, IQR: The interquartile range, µg-microgram

Adverse events, including pruritus, hypotension, and nausea/vomiting, were documented. In Group E, 5.7% of patients experienced pruritus, and 8.6% had nausea/vomiting. In Group Q, 2.9% of patients experienced hypotension, and 5.7% had nausea/vomiting. There was no statistically significant difference in the incidence of complications between the two groups.

4. Discussion

This prospective randomised study aimed to evaluate the analgesic efficacy of Quadratus Lumborum Block (QLB) compared to Erector Spinae Plane Block (ESPB) in adult patients undergoing midline abdominal surgeries, a topic with limited prior research. The patients were randomized into two groups: Group E, which received ultrasound-guided bilateral Erector Spinae Plane Block (ESPB), and Group Q, which received ultrasound-guided bilateral Quadratus Lumborum Block (QLB). The findings demonstrated that QLB offered superior postoperative analgesia compared to ESPB, particularly in the immediate postoperative period.

In Group Q, the time until the first analgesic requirement was significantly longer (162.29 ± 96.56 minutes) than in Group E (108.00 ± 75.34 minutes). On average, patients in Group E required their first dose of opioid analgesia approximately 54 minutes earlier than those in Group Q, indicating a prolonged analgesic effect with QLB, especially in the early postoperative hours. This was consistent with higher NRS scores observed in Group E during this period, leading to a significantly higher number of PCA pump activations (mean 13.71 ± 6.34 in Group E vs. 10.31 ± 5.34 in Group Q; p = 0.022). Total fentanyl consumption over 24 hours was also significantly lower in Group Q (206.29 ± 106.69 µg) compared to Group E (270.86 ± 127.08 µg; p = 0.034).

These findings align with previous studies by Blanco et al. and Murouchi et al., which reported broader dermatomal coverage and longer analgesic duration with QLB compared to other blocks like TAP.[11,12] QLB provides an analgesic effect comparable to opioids, as supported by prior studies, and was also observed in our study, where QLB demonstrated faster onset and longer-lasting pain relief than ESPB.[13,14]

To maximize the spread of local anaesthetic (LA), the Erector Spinae Plane Block (ESPB) was administered beneath the erector spinae muscle in a deeper plane, as demonstrated in a cadaveric study by Forero et al.[15] In our study, the block was performed at the T9 level to achieve analgesic coverage from T5 to L2. This choice of injection site was supported by evidence from Abdella et al.[16] who found that LA typically spreads at least four vertebral levels caudally and three levels cranially from the site of injection, providing sufficient analgesic coverage for midline abdominal surgeries.

While ultrasound-guided ESPB requires block administration at two levels to adequately cover surgical incisions above and below the umbilicus, Quadratus Lumborum Block (QLB) achieves comprehensive dermatome coverage from L2 caudally to T4 cranially with a single injection. This broader coverage is attributed to the anticipated cranial migration of the local anaesthetic into higher paravertebral spaces. Kadam et al. reported that when contrast is injected during QLB, it initially covers the lateral border of the quadratus lumborum (QL) muscle, followed by the anterior QL surface and the psoas major muscle, in a posterior-cranial direction, eventually depositing in the paravertebral space. They observed contrast enhancement extending from T4 to L2.[17] Similarly, Dam M et al., using a cadaveric model, administered QL3 block at the L4 and L2 levels and observed paravertebral spread reaching the T9-T10 levels. Their findings also documented the involvement of somatic nerves and the thoracic sympathetic trunk, further highlighting QLB's extensive coverage.[18]

In contrast to ESPB in QLB, the structural and histological features of the thoracolumbar fascia (TLF) provide an alternative mode of action for local anaesthetics. The TLF's superficial layer contains a dense network of sympathetic neurons, along with high-threshold and low-threshold mechanoreceptors and nociceptive receptors. These receptors are responsive to the effects of local anaesthetics

and play a role in both acute and chronic pain modulation. Blockade of these receptors by local anaesthetics is believed to contribute significantly to the analgesic efficacy of QLB.[19,20] LB provides early and rapid pain relief in a high percentage of patients and allows early ambulation, which is one of the most important measures in the prevention of deep vein thrombosis and thromboembolic complications.[12]

The effectiveness of the interfacial plane block at various LA concentration levels has not yet been studied much. Larger amounts may be used, according to certain recommendations, for better paravertebral space dispersion and increased dermatomal coverage. When carried out at the thoracic level, lower LA volume consumption leads to an insufficient spread of LA. In the study by Altiparmak B et al., it was demonstrated that using a higher bupivacaine concentration (0.37%) in a volume of 20 mL significantly improved postoperative pain control compared to 0.25% bupivacaine at the same volume.[21] This highlights the importance of optimizing both concentration and volume for effective analgesia.

Our findings further validated the hypothesis that QLB provides better analgesic coverage compared to ESPB. This was evident from the significantly reduced consumption of rescue analgesics (Inj Diclofenac) in the QLB group. The mean total diclofenac consumption in Group Q was 95.00 ± 34.33 mg, compared to 136.36 ± 30.34 mg in Group E during the first 24 hours post-surgery ($p = 0.006$). These results emphasize the superior pain relief offered by QLB in the immediate postoperative period.

Abdominal wall blocks, including QLB and ESPB, are generally associated with minimal complications. Although motor weakness due to lumbar plexus involvement has been reported with QLB, our study did not observe any significant motor weakness among participants.[22] This highlights the safety and efficacy of these blocks in managing postoperative pain while minimizing potential side effects.

Our study faced several limitations, primarily due to conduct in single centre, our sample size was small. Conducting future studies with a larger sample would enhance the statistical power and reliability of our findings. Additionally, we did not evaluate long term pain outcomes or duration of hospital stay, which are important factors in assessing the overall impact of QL and ESPB blocks. The plasma level of ropivacaine was not measured and block was given under general anaesthesia, so success of block was not checked by dermatomal spread Moreover, the absence of a control group for comparison to standard care limits our ability to fully contextualize the relative benefits of QLB and ESPB. Addressing these aspects in future research could provide a more comprehensive understanding of their clinical benefits.

5. Conclusion

Quadratus Lumborum Block (QLB) provides a better analgesic profile compared to Erector Spinae Plane Block (ESPB) in midline abdominal surgeries, particularly in the initial postoperative hours. Decreased total opioid and rescue analgesic consumption in the QLB group further highlights its effectiveness.

6. Declaration of Patient Consent

The authors hereby certify that they have obtained appropriate patient consent forms. In the form the patient has given his/her consent for clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity.

7. Financial Support and Sponsorship

Nil.

8. Conflicts of Interest

There are no conflicts of interest.

9. Acknowledgements

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