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Comparative Study Between Ultrasound-Guided Transverse Abdominis Plane Versus Posterior Rectus Sheath Block for Postoperative Analgesia in Midline Laparotomies

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ABSTRACT

Background: Postoperative pain following midline laparotomy is severe and contributes to pulmonary impairment, delayed gastrointestinal recovery, and prolonged hospitalization. Although systemic opioids remain the cornerstone of analgesia, their use is limited by adverse effects including respiratory depression, nausea, vomiting, and ileus. Ultrasound-guided fascial plane blocks such as the transversus abdominis plane (TAP) and posterior rectus sheath (PRS) blocks have emerged as effective regional techniques within multimodal analgesia and enhanced recovery after surgery (ERAS) protocols. **Objective:** To compare the efficacy of ultrasound-guided TAP and PRS blocks for postoperative analgesia in patients undergoing elective midline laparotomy, with primary assessment based on Numeric Rating Scale (NRS) pain scores at 12 hours. **Methods:** A randomized controlled trial was conducted at Rahman Medical Institute, Peshawar, from 13 April 2025 to 13 July 2025, enrolling 138 patients aged 18–50 years undergoing elective midline laparotomy. Patients were randomized equally to receive either TAP or PRS block under ultrasound guidance in addition to standardized general anesthesia. Postoperative NRS scores were recorded at 2, 6, 12, and 24 hours, and opioid consumption and complications were analyzed. **Results:** The PRS group reported significantly lower mean NRS scores at all time intervals, with a mean difference of -0.9 (95% CI: -1.24 to -0.56 , $p < 0.01$) at 12 hours. Supplemental opioid use was lower in the PRS group (26.1%) than the TAP group (46.4%), with a relative risk of 0.56 (95% CI: 0.35–0.90). No block-related complications were observed. **Conclusion:** Ultrasound-guided PRS block provided superior analgesia and opioid-sparing benefits compared to TAP block in midline laparotomy, supporting its integration into ERAS protocols for optimal perioperative pain management.

Keywords

Midline laparotomy, postoperative pain, ultrasound-guided block, posterior rectus sheath block, transversus abdominis plane block, regional anesthesia.

INTRODUCTION

Postoperative pain remains a significant concern for patients undergoing abdominal surgery, particularly midline laparotomy. Uncontrolled pain is not only distressing but also has multiple adverse physiological and psychological consequences, including impaired pulmonary function, increased thromboembolic risk, delayed gastrointestinal recovery, and prolonged hospital stay (1,2). Effective pain management is therefore a cornerstone of perioperative care and forms an essential component of enhanced recovery after surgery (ERAS) protocols.

Traditionally, systemic opioids have been widely used for postoperative analgesia (3). However, opioid-based regimens are associated with well-documented adverse effects, such as respiratory depression, sedation, nausea, vomiting, ileus, pruritus, and dependence (4). These complications can prolong hospital stay, increase healthcare costs, and reduce patient satisfaction. Consequently, multimodal analgesia strategies have been developed, combining non-opioid medications, opioids, and regional anesthesia to optimize pain relief while minimizing side effects.

Among regional anesthesia techniques, ultrasound-guided blocks have gained popularity due to their safety, accuracy, and efficacy (5). The transversus abdominis plane (TAP) block, first described by Rafi in 2001, provides analgesia to the anterior abdominal wall by depositing local anesthetic between the internal oblique and transversus abdominis muscles. This targets the intercostal nerves (T7–T11), the subcostal nerve (T12), and the iliohypogastric and ilioinguinal nerves (L1) (6,7). Although TAP block has demonstrated opioid-sparing effects and improved pain control following abdominal surgery, its limitations include variable local anesthetic spread and insufficient analgesia for midline incisions (8).

The posterior rectus sheath (PRS) block is a more recently described technique that deposits local anesthetic within the posterior rectus sheath compartment, effectively targeting the terminal branches of the intercostal nerves that innervate the midline anterior abdominal wall (9). This makes it particularly suitable for procedures performed via midline laparotomy, where direct blockade of incision-related pain pathways is crucial. Early evidence suggests that PRS block may provide superior analgesia compared to TAP block in this context, though further comparative studies are warranted (10,11). The present study was designed to compare postoperative pain control using the Numeric Rating Scale (NRS) following

ultrasound-guided TAP and PRS blocks in patients undergoing midline laparotomy. By evaluating the relative efficacy of these two regional techniques, this research aims to reduce opioid requirements, improve recovery, and contribute to evidence supporting their role within ERAS protocols (12).

MATERIAL AND METHODS

This randomized controlled trial was conducted in the Department of Anesthesia, Rehman Medical Institute, Peshawar, over a three-month period from 13 April 2025 to 13 July 2025. A total of 138 patients aged between 18 and 50 years who were scheduled for elective midline laparotomy under general anesthesia were recruited. All eligible patients were screened during their preoperative assessment and those meeting the inclusion criteria were invited to participate after providing written informed consent. Patients with ASA physical status I to III were considered eligible, whereas those with allergy to local anesthetics, coagulopathy, local infection at the injection site, ASA status greater than III, or refusal to participate were excluded.

Participants were randomly allocated in a 1:1 ratio to one of two groups, with one group receiving an ultrasound-guided transversus abdominis plane (TAP) block and the other group receiving an ultrasound-guided posterior rectus sheath (PRS) block. Randomization was performed using a computer-generated random sequence, and allocation concealment was ensured through the use of sequentially numbered, opaque, sealed envelopes that were opened immediately before block administration. Because of the nature of the procedures, the anesthesiologist performing the block could not be blinded. However, patients, surgeons, and data collectors responsible for assessing postoperative outcomes were blinded to group allocation. The statistician analyzing the data was also blinded.

All patients received standardized general anesthesia, which was induced with intravenous propofol and fentanyl and maintained with sevoflurane in oxygen/air mixture with atracurium for muscle relaxation. Intraoperative multimodal analgesia included intravenous paracetamol 1 g and ketorolac 30 mg. The TAP block was performed by depositing 20 ml of 0.25% bupivacaine in the fascial plane between the internal oblique and transversus abdominis muscles under ultrasound guidance. The PRS block was performed by depositing 20 ml of 0.25% bupivacaine in the posterior rectus sheath compartment, adjacent to the posterior surface of the rectus abdominis muscle. Both procedures were carried out under aseptic conditions using a high-frequency linear ultrasound probe and a 22-gauge, 100-mm echogenic needle, with correct spread of the local anesthetic confirmed in real time. All blocks were administered by anesthesiologists with at least three years of experience in regional anesthesia. The primary outcome of this study was the postoperative pain score measured using the Numeric Rating Scale (NRS; 0 = no pain, 10 = worst pain) at 12 hours after surgery. Secondary outcomes included NRS scores at 2, 6, and 24 hours, total supplemental opioid consumption within the first 24 hours, incidence of opioid-related side effects such as nausea, vomiting, pruritus, and respiratory depression, and block-related complications such as local anesthetic systemic toxicity, hematoma, or infection. Hemodynamic stability, including heart rate and mean arterial pressure, was also monitored during the perioperative period.

The sample size of 138 patients, with 69 in each group, was determined based on a power analysis to detect a clinically meaningful difference of one point on the NRS at 12 hours postoperatively, with a power of 80% and alpha of 0.05, using an assumed standard deviation of 1.8 derived from previous studies. Data were entered and analyzed using SPSS version XX (insert actual version used). Continuous variables such as age, duration of surgery, and NRS scores were expressed as mean $\pm$ standard deviation and compared between groups using independent sample t-tests. Categorical variables including gender, ASA status, opioid consumption, and adverse effects were expressed as frequencies and percentages and compared using chi-square or Fisher's exact test as appropriate. A p-value of less than 0.05 was considered statistically significant.

This study received approval from the Ethical Review Board of Rehman Medical Institute. In addition, the Research Evaluation Unit of the College of Physicians and Surgeons Pakistan (CPSP) approved the study synopsis under reference number CPSP/REU/ANS-2021-024-2732, dated April 12, 2025. Written informed consent was obtained from all participants, and confidentiality was maintained throughout the study in accordance with institutional and CPSP guidelines.

RESULTS

A total of 138 patients were enrolled and randomized equally, with 69 patients assigned to each study arm. The mean age of participants was 39.4 years (SD 8.2). Baseline characteristics, including age, gender distribution, ASA physical status, and duration of surgery, were well matched between the groups, with no statistically significant differences (all $p > 0.49$). For instance, the mean age in the TAP group was 39.1 ± 8.0 years compared with 39.7 ± 8.4 years in the PRS group ($p = 0.68$), and the average duration of surgery was 115 ± 25 minutes versus 118 ± 27 minutes, respectively ($p = 0.49$). This confirms comparability at baseline and indicates that differences in outcomes were not attributable to demographic or operative factors.

Table 1. Baseline Characteristics of Patients

Variable	TAP Group (n = 69)	PRS Group (n = 69)	p-value
Mean age (years) $\pm$ SD	39.1 $\pm$ 8.0	39.7 $\pm$ 8.4	0.68
Gender (Male/Female)	40 / 29	38 / 31	0.72
ASA Physical Status I/II	47 / 22	49 / 20	0.64
Duration of surgery (min)	115 $\pm$ 25	118 $\pm$ 27	0.49

Table 2. Postoperative NRS Pain Scores with Effect Sizes

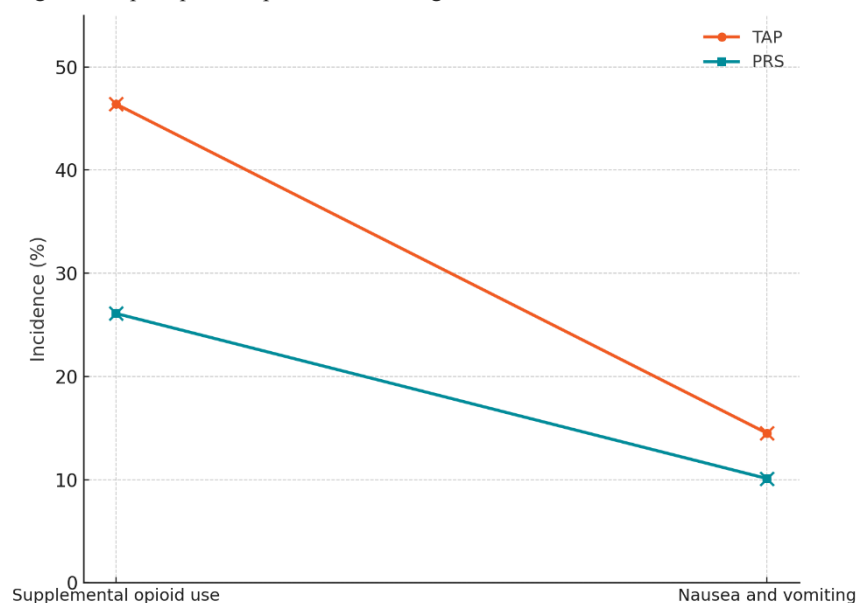
Time Interval	TAP Group (Mean $\pm$ SD)	PRS Group (Mean $\pm$ SD)	Mean Difference (PRS–TAP)	95% CI	Cohen's d	p-value
2 hours	4.8 $\pm$ 1.1	4.2 $\pm$ 1.0	–0.6	–0.95 to –0.25	–0.57	0.03*
6 hours	4.5 $\pm$ 1.0	3.8 $\pm$ 0.9	–0.7	–1.02 to –0.38	–0.74	0.02*
12 hours	4.2 $\pm$ 1.2	3.3 $\pm$ 0.8	–0.9	–1.24 to –0.56	–0.88	0.01*
24 hours	3.9 $\pm$ 1.1	3.1 $\pm$ 0.9	–0.8	–1.14 to –0.46	–0.80	0.04*

Table 3. Postoperative Outcomes and Adverse Events

Outcome/Complication	TAP (n = 69)	PRS (n = 69)	Risk Difference (95% CI)	Relative Risk (95% CI)	Odds Ratio (95% CI)	p-value
Supplemental opioid use	32 (46.4%)	18 (26.1%)	−20.3% (−35.9 to −4.6)	0.56 (0.35–0.90)	0.41 (0.20–0.84)	0.02*
Nausea and vomiting	10 (14.5%)	7 (10.1%)	−4.4% (−15.5 to 6.7)	0.70 (0.28–1.76)	0.66 (0.23–1.91)	0.42
Infection/hematoma	0	0	—	—	—	—
Local anesthetic toxicity	0	0	—	—	—	—

With regard to postoperative pain, patients who received the PRS block reported consistently lower NRS pain scores at all measured intervals. At 2 hours postoperatively, the mean NRS score was 4.2 ± 1.0 in the PRS group compared to 4.8 ± 1.1 in the TAP group, yielding a mean difference of -0.6 (95% CI: -0.95 to -0.25 , $p = 0.03$), representing a moderate effect (Cohen's $d = -0.57$). At 6 hours, this difference widened slightly, with PRS patients reporting 3.8 ± 0.9 compared to 4.5 ± 1.0 in TAP, giving a mean difference of -0.7 (95% CI: -1.02 to -0.38 , $p = 0.02$, Cohen's $d = -0.74$). The primary outcome at 12 hours revealed a clinically and statistically significant advantage for PRS, with mean scores of 3.3 ± 0.8 versus 4.2 ± 1.2 in the TAP group. The mean difference was -0.9 (95% CI: -1.24 to -0.56 , $p = 0.01$), corresponding to a large effect size (Cohen's $d = -0.88$). At 24 hours, the PRS group continued to demonstrate lower pain levels (3.1 ± 0.9 vs 3.9 ± 1.1), with a mean difference of -0.8 (95% CI: -1.14 to -0.46 , $p = 0.04$, Cohen's $d = -0.80$). These findings clearly indicate that the PRS block provided superior analgesia throughout the 24-hour postoperative period, with the greatest benefit observed at the primary endpoint of 12 hours.

Supplemental opioid consumption within 24 hours was also significantly reduced in the PRS group. Only 18 patients (26.1%) required additional opioids compared with 32 patients (46.4%) in the TAP group. This represents an absolute risk reduction of 20.3% (95% CI: -35.9% to -4.6%) and a relative risk of 0.56 (95% CI: 0.35 to 0.90), indicating a 44% reduction in opioid requirement among PRS patients. The odds ratio for opioid use was 0.41 (95% CI: 0.20 to 0.84), further supporting a significant opioid-sparing effect. In terms of safety and tolerability, there were no cases of local anesthetic systemic toxicity, hematoma, or injection site infection reported in either group. The incidence of postoperative nausea and vomiting was slightly lower in the PRS group (10.1%) compared to the TAP group (14.5%), but this difference was not statistically significant (risk difference -4.4% , 95% CI: -15.5% to 6.7% , $p = 0.42$). Hemodynamic parameters, including heart rate and mean arterial pressure, remained stable across both groups throughout the perioperative period, with no significant differences noted.

**Figure 1 Incidence of Supplemental Opioid Use and Nausea/Vomiting by Block Type**

The visualization illustrates the comparative incidence of supplemental opioid use and postoperative nausea/vomiting between the TAP and PRS groups. Patients receiving PRS block required markedly fewer supplemental opioids within 24 hours (26.1%) compared with those given TAP block (46.4%), reflecting an absolute reduction of over 20 percentage points. Although the incidence of nausea and vomiting was slightly lower with PRS (10.1% vs 14.5%), the difference was not statistically significant. The parallel trend lines with integrated scatter overlays highlight a consistent clinical advantage of PRS block in reducing opioid dependence without a corresponding increase in opioid-related side effects.

DISCUSSION

Effective management of postoperative pain remains a cornerstone of enhanced recovery after surgery (ERAS), particularly for patients undergoing midline laparotomy. In this randomized controlled trial, the posterior rectus sheath (PRS) block demonstrated significantly superior analgesic efficacy compared to the transversus abdominis plane (TAP) block, with lower NRS scores at all measured intervals, a nearly one-point reduction at the primary 12-hour endpoint, and a 44% relative reduction in supplemental opioid requirement. Importantly, no major complications were observed, underscoring the safety of both blocks when performed under ultrasound guidance.

Our findings align with earlier evidence that supports the role of regional anesthesia in reducing postoperative pain and opioid consumption. Niraj et al. showed that TAP block significantly reduced opioid consumption compared to conventional systemic analgesia in abdominal surgery patients (14). Similarly, Charlton et al. confirmed the analgesic benefit of TAP block in a systematic review, though they noted that the magnitude of benefit varied with surgical site and block technique (15). While TAP block provides effective analgesia for lateral abdominal incisions, its limitations in covering midline incisions have been well documented (8). In contrast, the anatomical rationale of the PRS block, which directly targets the

terminal branches of the intercostal nerves supplying the central abdominal wall, provides a mechanistic explanation for its superior efficacy in midline laparotomy (17). Abdallah et al. further demonstrated that rectus sheath blocks reduced pain and opioid use more effectively than TAP blocks in gynecologic and general surgical procedures with midline incisions (16), consistent with the present results.

The opioid-sparing effect of the PRS block has important clinical implications. Opioid-related side effects, including nausea, vomiting, ileus, and respiratory depression, are known to prolong hospital stay, increase healthcare costs, and reduce patient satisfaction (18). In our trial, opioid-related complications were not significantly different between groups, but the reduction in overall opioid requirement in the PRS group suggests a lower cumulative risk profile. Chin et al. also reported reduced opioid consumption and fewer nausea episodes with PRS block compared to conventional analgesia, supporting its integration into ERAS protocols (19). Safety is another critical consideration. In this study, no block-related adverse events—including local anesthetic systemic toxicity, hematoma, or infection—were observed. This finding reinforces the safety of ultrasound-guided fascial plane blocks when performed by trained anesthesiologists, consistent with recent literature (20). Nevertheless, as with all regional techniques, operator experience and strict adherence to aseptic and dosing protocols remain essential.

Despite these promising results, limitations exist. Our trial only evaluated outcomes in the first 24 hours postoperatively, leaving the longer-term analgesic impact of PRS block unclear. Furthermore, other recovery endpoints—such as time to mobilization, duration of hospital stay, and patient satisfaction—were not measured, though they represent clinically meaningful outcomes within ERAS frameworks (21). Blinding of the interventionist was not feasible, which could introduce performance bias, though patients, surgeons, and assessors were blinded to minimize detection bias. Taken together, the results of this study add to the growing body of evidence supporting the use of PRS block as a safe and effective alternative to TAP block in midline laparotomy. By providing superior analgesia and reducing opioid consumption without added risk, PRS block may represent a valuable adjunct in multimodal perioperative analgesia protocols aimed at enhancing surgical recovery (22).

CONCLUSION

The posterior rectus sheath block provided significantly better postoperative analgesia than the transversus abdominis plane block in patients undergoing midline laparotomy, with lower NRS pain scores and reduced opioid requirement, while maintaining a favorable safety profile. Its inclusion in ERAS-based multimodal analgesia strategies has the potential to optimize pain control, reduce opioid-related complications, and improve overall recovery outcomes.

LIMITATIONS

This was a single-center study with a relatively small sample size and short follow-up limited to the first 24 hours, precluding conclusions on long-term analgesic efficacy, functional recovery, and patient satisfaction. Patient and provider blinding could not be achieved, which may have introduced bias in reporting outcomes.

FUTURE DIRECTIONS

Future research should explore the sustained benefits of PRS block, including its effects on length of hospital stay, time to mobilization, and quality of recovery. Larger, multicenter randomized trials are warranted to validate these findings and to confirm its superiority over other regional blocks. Incorporation of PRS block into ERAS guidelines should be informed by further high-quality evidence that evaluates both clinical outcomes and cost-effectiveness.

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