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Original Article

Enhanced analgesic efficacy and reduced stress response with ropivacaine transversus abdominis plane block in laparoscopic myomectomy

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Abstract: Background: Managing postoperative pain and stress response was critical in laparoscopic myomectomy, a procedure for uterine fibroids. Ropivacaine transversus abdominis plane block (RTAPB) may offer enhanced analgesic efficacy and reduced stress responses compared to traditional analgesia. Methods: This retrospective analysis examined 217 patients undergoing laparoscopic myomectomy at Hankou Hospital of Wuhan from June 2020 to September 2023. Patients were divided into routine analgesia (CA, n = 105) and RTAPB (n = 112) groups. Pain levels were assessed using the Visual Analog Scale (VAS). Stress hormone levels (cortisol, norepinephrine, Interleukin-6), preoperative and postoperative recovery, sleep quality, hemodynamic stability, complications, and patient satisfaction were evaluated post-surgery. Results: The RTAPB group demonstrated significantly lower postoperative VAS pain scores at all measured intervals ($P < 0.05$). Stress hormones (postoperative cortisol, norepinephrine, and IL-6) were substantially lower in the RTAPB group compared to CA ($P < 0.05$), indicating reduced stress response. Intraoperative hemodynamic stability was improved with RTAPB, reflected in lower heart rate and mean arterial pressure ($P < 0.05$). Postoperative recovery and sleep quality were also better in the RTAPB group, as evidenced by higher QoR-40 and lower PSQI scores ($P < 0.01$). Although not statistically significant, RTAPB showed a trend toward fewer complications. Patient satisfaction, particularly with pain management, was significantly higher in the RTAPB group ($P < 0.001$). Conclusion: RTAPB significantly enhances analgesic efficacy and moderates the physiological stress response in laparoscopic myomectomy patients compared to routine analgesia.

Keywords: Ropivacaine, transversus abdominis plane block, analgesic efficacy, stress response, laparoscopic myomectomy

Introduction

The surgical management of uterine fibroids, particularly through laparoscopic myomectomy, presents unique challenges related to postoperative pain and stress response [1]. Uterine fibroids, or leiomyomas, are a prevalent form of benign tumors affecting women, often necessitating surgical intervention due to symptoms like heavy menstrual bleeding, pelvic pain, and reproductive complications [2]. Laparoscopic myomectomy has emerged as a minimally invasive alternative to traditional open surgery, offering benefits such as reduced blood loss, shorter hospital stays, and quicker return to daily activities [3]. However, the procedure also has postoperative complications, predominantly due to significant pain and the body's stress response, which can hinder recovery and affect patient satisfaction [4].

Pain management in laparoscopic surgeries is crucial, not only for patient comfort but also for reducing the physiological repercussions of pain-induced stress responses, such as endocrine disruptions and increased sympathetic nervous system activity [5]. Conventional analgesic approaches typically involve the use of systemic opioids and non-opioid analgesics, which, while effective, can cause adverse effects including nausea, vomiting, and respiratory depression, potentially complicating postoperative recovery [6].

The incorporation of regional anesthetic techniques, such as the transversus abdominis

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plane block (TAPB), provides a promising alternative by directly targeting the sensory nerve fibers of the anterior abdominal wall [7]. This technique effectively blocks nociceptive signal transmission, thereby offering potentially superior analgesic benefits [8]. Ropivacaine, a local anesthetic known for its favorable profile of prolonged analgesia with minimal motor blockade, enhances the TAPB technique, representing an advanced strategy for managing postoperative pain that reduces reliance on systemic analgesics and minimizes associated side effects [9].

Research indicates that the surgical stress response, characterized by the release of stress hormones such as cortisol and norepinephrine, presents significant implications for patient recovery [10]. These hormonal surges, triggered by activation of the HPA axis and sympathetic nervous system, can compromise immune function, promote inflammation, and alter hemodynamic stability [11]. Reducing this stress response is thought to improve surgical outcomes by stabilizing physiological parameters, thus enhancing patient recovery and reducing complications [12]. The integration of TAPB with ropivacaine in surgical practice could, therefore, represent a significant advancement not only in pain management but also in moderating the neuroendocrine response to surgical trauma [13].

The utilization of ropivacaine transversus abdominis plane block (RTAPB) represents an innovative approach to managing postoperative pain and mitigating stress response in patients undergoing laparoscopic myomectomy. This study seeks to fill a gap in the literature by systematically evaluating the effectiveness of RTAPB in improving patient outcomes, thereby providing a rationale for its adoption in clinical practice.

Materials and methods

Case selection

A retrospective analysis was conducted on 217 patients who underwent laparoscopic myomectomy at Hankou Hospital of Wuhan between June 2020 and September 2023. The study received approval from the Institutional Review Board and Ethics Committee of Hankou Hospital of Wuhan. Informed consent was waived, as the research used only de-identified patient data without impacting patient care or posing any potential harm. This waiver conformed to regulatory and ethical guidelines relevant to retrospective research and was sanctioned by the Institutional Review Board and Ethics Committee. The study procedures are shown in **Figure 1**.

Inclusion criteria: (1) Participants aged between 18 and 65 years; (2) Diagnosis of uterine fibroid-related diseases requiring surgical removal [14]; (3) Acceptance of laparoscopic surgery as the surgical method; (4) Classification as ASA I-II; (5) No prior history of abdominal surgery or chronic pain; (6) No known allergies to relevant anesthetics; (7) No skin damage or infection present at the puncture site.

Exclusion criteria: (1) Presence of other malignant tumors; (2) Use of drugs affecting neurological function prior to surgery; (3) Difficulty in undergoing the surgical procedure; (4) Significant organ diseases, including cardiac, renal, or hepatic conditions; (5) Existing neurological or psychiatric disorders; (6) Disorders of consciousness or cognitive function impairment impeding basic communication and task engagement; (7) Long-term use of opioid analgesics.

Data extraction

Patient data were extracted from electronic medical records using a standardized data extraction form. The form included demographic characteristics, pain scores at various time intervals, stress hormone levels (cortisol, norepinephrine (NE), Interleukin-6 (IL-6)), preoperative and postoperative recovery status, sleep quality, postoperative complications, and patient satisfaction.

Grouping criteria and treatment approach

All patients underwent laparoscopic myomectomy. Anesthesia induction was achieved through sequential intravenous administration of 0.4-0.6 μg/kg sufentanil (Yichang Renfu Pharmaceutical Co., Ltd., Approval No. H20054171), 1.50-2.00 mg/kg propofol (Sichuan Guorui Pharmaceutical Co., Ltd., Approval No. H20030114), and 0.15-0.20 mg/kg cisatracurium (Jiangsu Hengrui Pharmaceutical Co., Ltd., Approval No. H20060869). Following successful tracheal intubation, me-

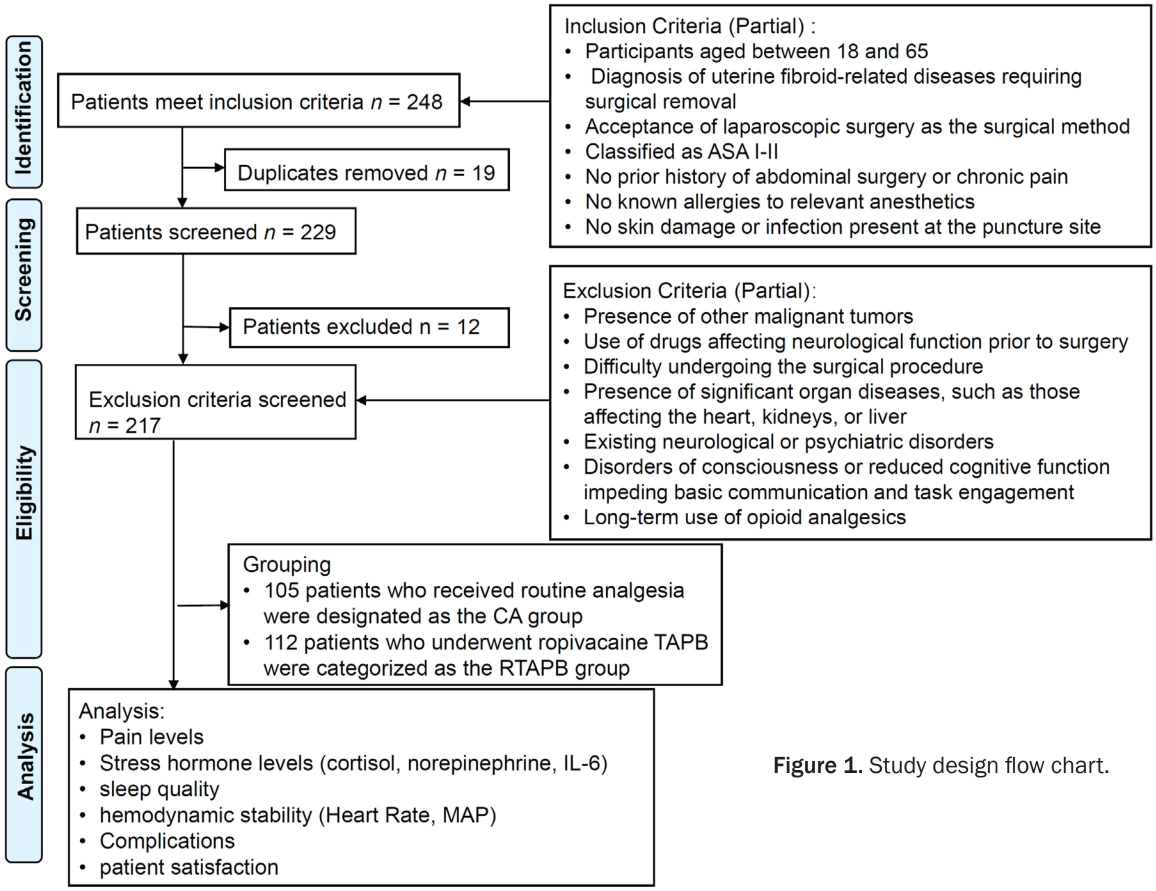

Figure 1. Study design flow chart.

chanical ventilation was applied with the following parameters: respiratory rate of 10-14 breaths per minute, tidal volume of 8 mL/kg, and an oxygen flow rate of 15 L/min. During the surgery, 2-5 mg of cisatracurium and 5-10 μg of sufentanil were intermittently administered. Sevoflurane inhalation was discontinued prior to skin suturing.

Treatment solutions were decided by the attending physicians based on clinical guidelines and standard practices. Patients were not involved in the decision-making process, and the allocation to either the routine analgesia group (CA) or RTAPB group was determined retrospectively based on the analgesic method used during their procedure. Based on the analgesic methods employed, 105 patients who received routine analgesia were designated as the CA group, while 112 patients who underwent ropivacaine TAPB were categorized as the RTAPB group. The CA group received conventional analgesia, which entailed an injection of 3 mg granisetron (Sichuan Taiji Pharmaceutical Co., Ltd., Taiji Group, Approval No. H20030161, 3 mL:3 mg) administered 30 minutes before the conclusion of the surgery to mitigate postoperative adverse reactions. In contrast, the RTAPB group underwent ropivacaine ultrasound-guided TAPB. Following the induction of anesthesia, patients were positioned supine, and a Mindray portable ultrasound device (Shenzhen Mindray Biomedical Electronics Co., Ltd., Model: UMT-400) with a 7.5 MHz high-frequency probe was utilized. The ultrasound probe was placed at the midline between the iliac crest and the lower edge of the rib. After routine disinfection, a 20 G puncture needle was inserted through the external oblique and internal oblique muscles to reach the transverse abdominis muscle plane. Upon confirmation of the needle tip position and absence of blood aspiration, 15 mL of 0.4% ropivacaine (AstraZeneca AB, registration certificate No. H20140764) was administered. The same procedure was repeated on the contralateral side. The successful diffusion of ropivacaine, indicated by a shuttle-shaped distribution between the muscle layers, confirmed the efficacy of the injection. Upon discontinuation of anesthesia medication, patients regained consciousness and respiration before extubation and transfer to the testing and treatment room. Observations were conducted 24 hours post-surgery.

Visual Analog Scale (VAS)

Pain was evaluated using the Visual Analog Scale (VAS). During the assessment, the side of the scale with numerical values was kept hidden from the patient. The patient was instructed to mark the appropriate position on the ruler that corresponded to their perceived pain level. The physician then determined the pain score based on the patient's mark. The scores range from 0 to 10, with higher numbers indicating greater pain. A score of 0-3 points indicates mild pain, 4-6 points indicates pain that affects rest, and 7-10 points signifies unbearable pain. The reliability of VAS, as measured by Cronbach's alpha, was 0.796 [15].

Detection of patients' stress hormone levels

A 5 mL fasting blood sample was collected from elbow vein. The sample was centrifuged (Hunan Xiangxi Scientific Instrument Factory, Model: TLD12A) at 3000 r/min for 10 minutes at a low-temperature (4°C) to obtain the supernatant, which was then stored in a -80°C freezer for subsequent testing. The levels of cortisol, norepinephrine, and IL-6 were measured using the enzyme-linked immunosorbent assay (ELISA) method. The ELISA reagent kit was supplied by Wuhan Eli Lilly Biotechnology Co., Ltd., and the assay was conducted using a Spectra Max Paradigm multifunctional ELISA reader (Molecular Devices, USA). Additionally, the patient's heart rate (60-100 beats/minute as normal) and mean arterial pressure (70-105 mmHg as normal for adults) were monitored. Mean arterial pressure was calculated using the formula: mean arterial pressure = (systolic pressure + 2 × diastolic pressure)/3, or alternatively, mean arterial pressure = diastolic pressure + 1/3 pulse pressure difference.

Detection of preoperative and postoperative recovery status and sleep quality of patients

The QoR-40 (Quality of Recovery-40) score was used as a comprehensive tool to evaluate the quality of postoperative recovery in patients across multiple dimensions. The score ranges from 40 to 200 points, representing recovery quality from very poor to excellent. It includes five clinically relevant dimensions: physical comfort (12 items), emotional state (9 items), self-care ability (5 items), psychological support (7 items), and pain (7 items), for a total of 40 items. Each item was scored up to 5 points, resulting in a maximum possible total score of 200 points. Higher scores correspond to better recovery quality. The reliability of this scale was confirmed with a Cronbach's alpha coefficient greater than 0.700 [16].

The Pittsburgh Sleep Quality Index (PSQI) was used to assess patients' sleep quality on the day before surgery and three days after surgery. The PSQI consists of 19 self-evaluative items and 5 additional evaluative items, although the 19th self-evaluative item and the 5 additional items were not included in the scoring. The scoring was based on the other 18 items, which were grouped into 7 components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. Each component is scored from 0 to 3, with the total PSQI score ranging from 0 to 21, derived from the sum of these components. Higher scores indicate poorer sleep quality. The PSQI has a Cronbach's alpha coefficient of 0.710, supporting its reliability [17].

Satisfaction

A questionnaire survey was conducted to evaluate both overall patient satisfaction and pain satisfaction in the two groups. The satisfaction score was derived from a questionnaire developed by the hospital, which primarily assessed the patients' satisfaction with surgical and anesthesia outcomes during their hospital stay. The total questionnaire score was 100 points, with satisfaction levels categorized as follows: 90-100 points for very satisfied, 60-89 points for relatively satisfied, and less than 50 points for dissatisfied. Higher scores indicate greater satisfaction among participants. Overall satisfaction was calculated using the formula: (number of very satisfied + number of somewhat satisfied)/total number of cases × 100%.

Observational indicators

The primary outcome measures: Pain scores: evaluated using the VAS at 1 hour, 6 hours, 12 hours, 24 hours, and on the day of discharge post-surgery; Stress hormone levels: measured using the ELISA method for cortisol, norepinephrine, and IL-6; Hemodynamic stability: evaluated by monitoring heart rate and MAP preoperatively, intraoperatively at 5 and 10 minutes, and postoperatively; Postoperative recovery and sleep quality: assessed using the QoR-40 score and the PSQI; Patient satisfaction: measured using a hospital-developed questionnaire assessing overall satisfaction and satisfaction with pain management.

Secondary outcome measures: Postoperative complications: incidences of nausea, vomiting, infection, hematoma, bladder retention, extended hospital stay, and fever.

Statistical analysis

Data analysis was conducted using SPSS 29.0 statistical software (SPSS Inc., Chicago, IL, USA). Categorical data were presented as frequencies and percentages [n (%)] and analyzed using the chi-square test. When the sample size was ≥ 40 and the theoretical frequency (T) was ≥ 5, the standard chi-square test was applied, with the statistic represented by χ^2. For cases where the sample size was ≥ 40 but the theoretical frequency was between $1 \leq T < 5$, the chi-square test was adjusted using a correction formula. In instances where the sample size was < 40 or the theoretical frequency was $T < 1$, Fisher's exact test was utilized for statistical analysis. Continuous variables were subjected to the Shapiro-Wilk test to assess normal distribution. Normally distributed data were expressed as mean ± standard deviation (X ± sd), while non-normally distributed data were analyzed using the Wilcoxon rank-sum test and presented as median (25% quantile, 75% quantile). For VAS scores, heart rate, and mean arterial pressure (MAP) across different time points, one-way ANOVA with repeated measures was used to determine the significance of changes over time and between groups. Pairwise comparisons were performed using Tukey's post-hoc test to identify specific time points where differences were significant. Correlation analysis was conducted using Pearson's correlation coefficient to evaluate the relationships between the intervention and key outcome measures. A *p*-value of less than 0.05 was considered statistically significant.

Results

Demographic and basic data

The mean age was 34.25 ± 5.08 years for the CA group and 33.78 ± 4.95 years for the RTAPB group (*P* = 0.493). The mean BMI was 24.56 ± 3.12 kg/m^2 in the CA group and 24.67 ± 2.98 kg/m^2 in the RTAPB group (*P* = 0.797) (**Table 1**). The distribution of ASA classification I/II was slightly higher in the CA group (74.29%) compared to the RTAPB group (71.43%, *P* = 0.636). Surgical time was similar between the two groups, with a mean of 85.67 ± 12.45 minutes in the CA group and 84.12 ± 11.78 minutes in the RTAPB group (*P* = 0.345). Employment and smoking status, previous surgical and chronic pain history, marital and educational status, duration of menstrual cycle, and history of hormonal therapy showed no significant differences between the two groups (all *P* > 0.05). These findings suggest that initial baseline characteristics of the two groups were well balanced, allowing for unbiased comparison of postoperative outcomes associated with the analgesic interventions evaluated.

Pain scores at different time intervals

At 1 hour post-operation, the RTAPB group reported lower VAS scores (3.75 ± 1.08) compared to the CA group (4.27 ± 1.23; *P* = 0.001) (**Figure 2**). This trend persisted at 6 hours post-op, with the RTAPB group scoring 4.88 ± 1.12 and the CA group 5.25 ± 1.35 (*P* = 0.028), and at 12 hours post-op with scores of 3.79 ± 0.92 for RTAPB and 4.16 ± 1.2 for CA (*P* = 0.013). Significant differences were also observed at 24 hours, where the RTAPB group had a mean score of 2.95 ± 0.76 compared to 3.25 ± 1.17 in the CA group (*P* = 0.025). On the day of discharge, pain scores further decreased in the RTAPB group (2.45 ± 0.55) compared to the CA group (2.79 ± 0.95; *P* = 0.001). These findings indicate the superior analgesic efficacy of the RTAPB technique across all measured time points.

Cortisol

Pre-operatively, cortisol levels were not significantly different between the two groups, with mean values of 18.26 ± 3.14 μg/L in the CA group and 17.37 ± 4.29 μg/L in the RTAPB group (*P* = 0.081) (**Figure 3**). Post-operative

Table 1. Comparison of demographic characteristics of participants between the two groups

Characteristic	CA Group (n = 105)	RTAPB Group (n = 112)	t/χ^2	P
Age (years)	34.25 ± 5.08	33.78 ± 4.95	0.687	0.493
BMI (kg/m^2)	24.56 ± 3.12	24.67 ± 2.98	0.258	0.797
ASA Classification I/II	78 (74.29%)	80 (71.43%)	0.223	0.636
Surgical Time (minutes)	85.67 ± 12.45	84.12 ± 11.78	0.947	0.345
Employment Status (Employed/Unemployed)	70 (66.67%)	72 (64.29%)	0.136	0.712
Smoking Status (Smoker/Non-smoker)	20 (19.05%)	18 (16.07%)	0.332	0.564
Chronic Pain History (Yes/No)	15 (14.29%)	12 (10.71%)	0.635	0.426
Previous Surgical History (Yes/No)	25 (23.81%)	30 (26.79%)	0.254	0.614
Marital Status (Single/Married/Divorced)	30 (28.57%)/60 (57.14%)/15 (14.29%)	32 (28.57%)/65 (58.04%)/15 (13.39%)	0.039	0.981
Educational Level (High School/College/Postgraduate)	40 (38.1%)/50 (47.62%)/15 (14.29%)	38 (33.93%)/60 (53.57%)/14 (12.5%)	0.77	0.681
Duration of Menstrual Cycle (days)	28.5 ± 2.3	28.1 ± 2.5	1.238	0.217
Hormonal Therapy History (Yes/No)	20 (19.05%)	18 (16.07%)	0.332	0.564

CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; BMI: Body Mass Index; ASA: American Society of Anesthesiologists.

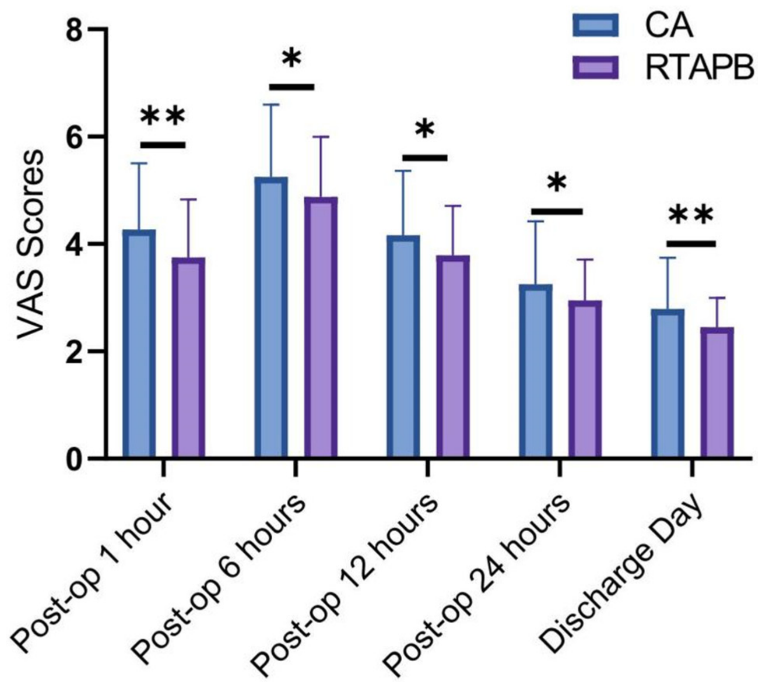

Figure 2. Comparison of VAS scores between the two groups at different time intervals. CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; VAS: Visual Analog Scale; *: P < 0.05; **: P < 0.01.

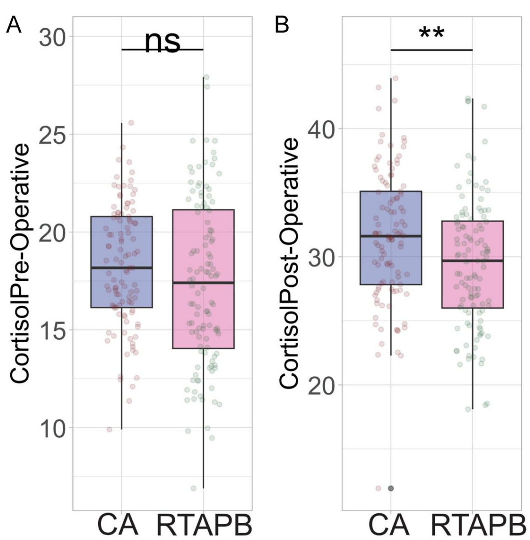

Figure 3. Comparison of stress hormone cortisol (μg/L) levels between the two groups. A: Pre-operative Cortisol; B: Post-operative Cortisol. CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; ns: no significant difference; **: P < 0.01.

cortisol levels, however, were notably lower in the RTAPB group, with a mean of 29.48 ± 5.12 μg/L, significantly lower compared to 31.55 ± 5.25 μg/L in the CA group (P = 0.004). This suggests that the RTAPB technique may effectively attenuate the stress response associated with laparoscopic myomectomy.

Norepinephrine (NE)

The analysis of NE levels, a marker of stress response, showed no significant difference pre-operatively between the CA group and the RTAPB group, with mean levels of 10.33 ± 2.62 mmol/L and 9.89 ± 2.65 mmol/L, respectively (P = 0.223) (**Figure 4**). However, post-operative NE levels were significantly lower in the RTAPB group, with a mean of 13.68 ± 3.26 mmol/L, compared to 15.13 ± 3.46 mmol/L in the CA group (P = 0.002). This reduction suggests that the RTAPB technique effectively mitigates the stress response following laparoscopic myomectomy.

Stress response indicators

Evaluation of interleukin-6 (IL-6) levels, a stress response indicator, revealed no significant pre-operative difference between the two groups, with mean levels of 18.35 ± 3.51 ng/L and 17.85 ± 3.49 ng/L, respectively (P = 0.297) (**Figure 5**). Post-operatively, IL-6 levels were significantly lower in the RTAPB group, with a mean of 31.49 ± 4.76 ng/L, as compared to 33.01 ± 5.22 ng/L in the CA group (P = 0.025). This suggests that the RTAPB technique was effective in reducing the inflammatory stress response following laparoscopic myomectomy.

Hemodynamic indicators

The evaluation of hemodynamic indicators, specifically heart rate, revealed no significant difference pre-operatively between the two groups, with mean heart rates of 72.26 ± 7.07 bpm and 73.52 ± 6.83 bpm, respectively (P = 0.184) (**Figure 6**). Intraoperatively, at 5 minutes, the RTAPB group exhibited a significantly lower heart rate of 65.49 ± 7.5 bpm, compared

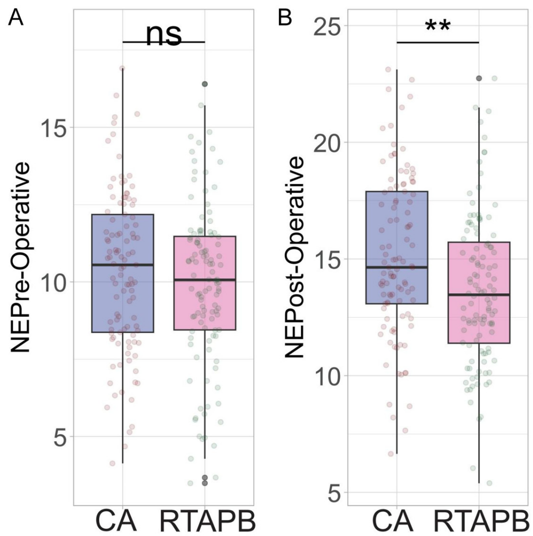

Figure 4. Comparison of stress hormone NE (mmol/L) levels between the two groups before and after the opeartion. A: Pre-operative NE; B: Post-operative NE. CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; NE: Norepinephrine; ns: no significant difference; **: P < 0.01.

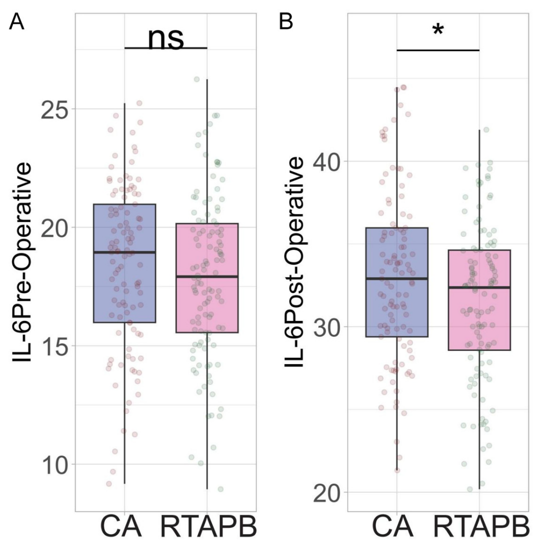

Figure 5. Comparison of stress response indicator IL-6 (ng/L) between the two groups before and after the operation. A: Pre-operative IL-6; B: Post-operative IL-6. CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; IL-6: Interleukin-6; ns: no significant difference; *: P < 0.05.

to 67.43 ± 6.62 bpm in the CA group (*P* = 0.045). This trend continued at 10 minutes intraoperatively, with heart rates of 65.36 ± 7.76 bpm in the RTAPB group and 67.61 ± 6.28 bpm in the CA group (*P* = 0.019). Post-operative heart rates showed no significant difference between the two groups, with the CA group at 70.62 ± 7.12 bpm and the RTAPB group at 68.82 ± 8.2 bpm (*P* = 0.087). These findings suggest that the RTAPB technique contributes to better intraoperative hemodynamic stability.

Analysis of mean arterial pressure (MAP) revealed no significant difference between the two groups pre-operatively, with mean values of 92.1 ± 9.65 mmHg and 92.25 ± 10.47 mmHg, respectively (*P* = 0.911) (**Figure 7**). However, intraoperative MAP at 5 minutes was significantly lower in the RTAPB group, with a mean of 89.62 ± 8.47 mmHg, compared to 93.25 ± 9.45 mmHg in the CA group (*P* = 0.003). Similarly, at 10 minutes intra-operatively, the RTAPB group maintained a lower MAP of 87.2 ± 11.36 mmHg versus 91.39 ± 12.76 mmHg in the CA group (*P* = 0.011). Post-operative MAP Values did not show a significant difference, with values of 92.66 ± 8.83 mmHg in the RTAPB group and 91.28 ± 6.58 mmHg in the CA group (*P* = 0.193). These findings suggest that the RTAPB technique effectively contributes to intraoperative hemodynamic stability in patients undergoing laparoscopic myomectomy.

Recovery status and sleep quality

Pre-operatively, QoR-40 scores were similar between the two groups, with the CA group scoring 101.25 ± 10.21 and the RTAPB group 100.51 ± 10.47 (*P* = 0.596) (**Figure 8**). However, by the third postoperative day, the RTAPB group showed significant improvement with a score of 180.25 ± 10.62 compared to 176.23 ± 10.12 in the CA group (*P* = 0.005). In terms of sleep quality, preoperative PSQI scores were comparable between the two groups, with 3.01 ± 0.29 in the CA group and 3.02 ± 0.26 in the RTAPB group (*P* = 0.722). Postoperatively, the RTAPB group reported significantly better sleep quality, scoring 1.97 ± 0.29 compared to 2.11 ± 0.34 in the CA group (*P* = 0.002). These results indicate that the RTAPB may enhance postoperative recovery and sleep quality in patients undergoing laparoscopic myomectomy.

Post-operative complications

Incidences of nausea and vomiting were observed at a higher rate in the CA group com-

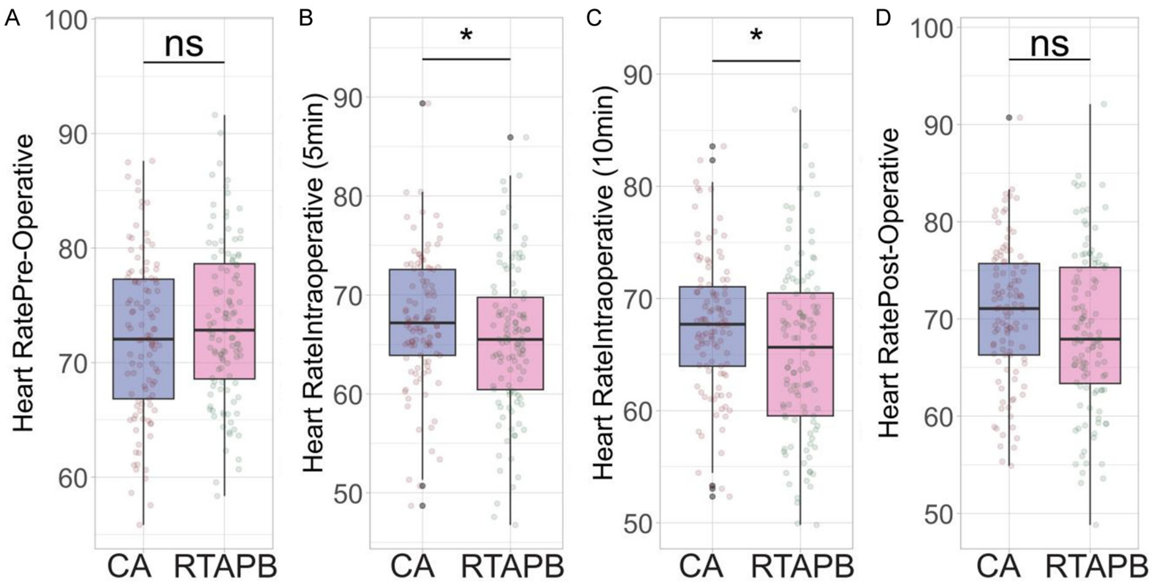

Figure 6. Comparison of heart rate (bpm) between the two groups at various time points. A: Pre-operative heart rate; B: Intraoperative heart rate at 5 min; C: Intraoperative heart rate at 10 min; D: Post-operative heart rate. CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; ns: no significant difference; *: P < 0.05.

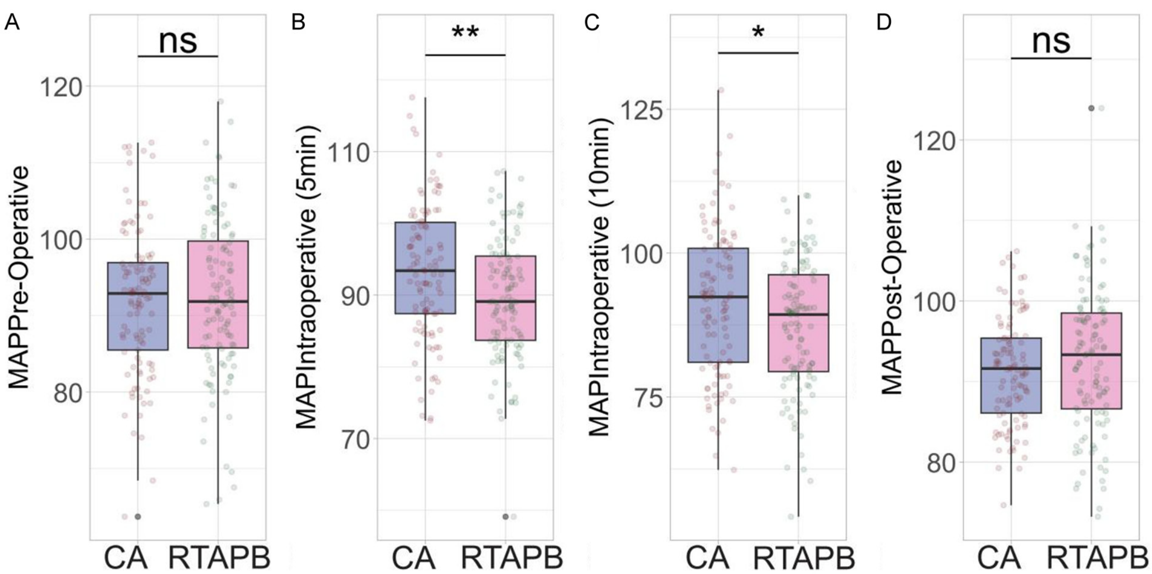

Figure 7. Comparison of MAP (mmHg) between the two groups at various time points. A: Pre-operative MAP; B: Intraoperative MAP at 5 min; C: Intraoperative MAP at 10 min; D: Post-operative MAP. CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; MAP: Mean Arterial Pressure; ns: no significant difference; *: P < 0.05; **: P < 0.01.

pared to the RTAPB group, though differences were not statistically significant (10.48% vs. 4.46%, P = 0.09) (**Table 2**). The rates of infection were 1.9% in the CA group and 0.89% in the RTAPB group (P = 0.955), while hematoma was noted in 2.86% of the CA group and in none of the RTAPB group (P = 0.223). Bladder retention was 6.67% in the CA group and 0.89% in the RTAPB group (P = 0.058). Extended hospital stay occurred in 7.62% of the CA group and 1.79% of the RTAPB group (P = 0.085). The incidence of fever was 3.81% in the CA group

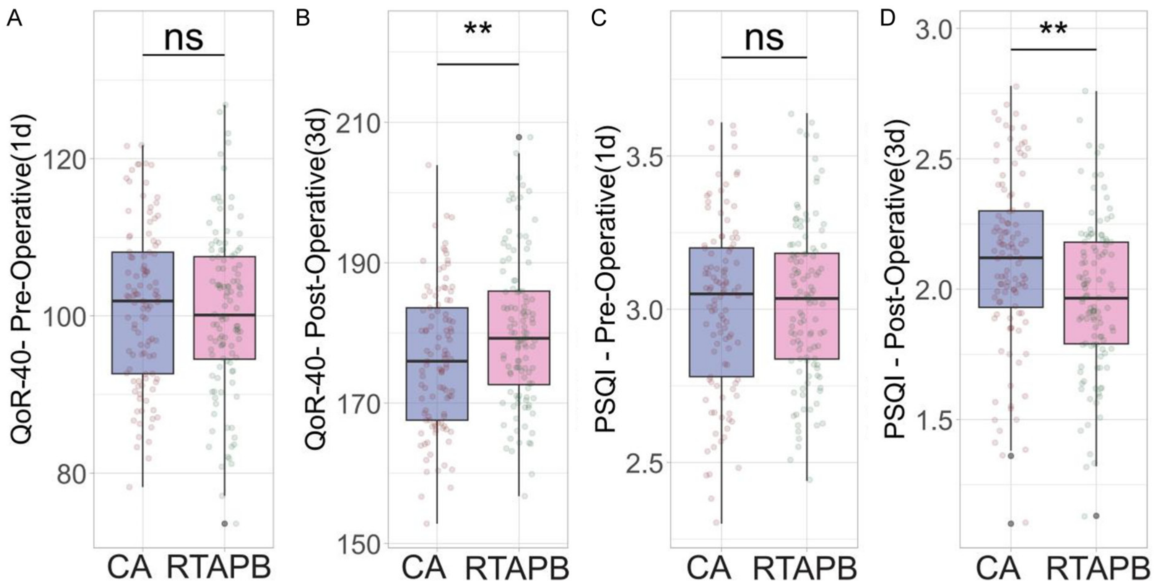

Figure 8. Comparison of preoperative and postoperative recovery status and sleep quality between the two groups. A: Pre-operative QoR-40 score (1 d); B: Post-operative QoR-40 score (3 d); C: Pre-operative PSQI score (1 d); D: Post-operative PSQI score (3 d). CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group; QoR-40: Quality of Recovery-40; PSQI: Pittsburgh Sleep Quality Index; ns: no significant difference; **: P < 0.01.

Table 2. Comparison of post-operative complications between the two groups

Complication	CA Group (n = 105)	RTAPB Group (n = 112)	χ^2	P
Nausea/Vomiting	11 (10.48%)	5 (4.46%)	2.868	0.09
Infection	2 (1.9%)	1 (0.89%)	0.003	0.955
Hematoma	3 (2.86%)	0 (0%)	1.488	0.223
Bladder Retention	7 (6.67%)	1 (0.89%)	3.592	0.058
Extended Hospital Stay	8 (7.62%)	2 (1.79%)	2.973	0.085
Fever	4 (3.81%)	2 (1.79%)	0.244	0.621

CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group.

Table 3. Comparison of patient satisfaction scores between the two groups

Parameter	CA Group (n = 105)	RTAPB Group (n = 112)	t	P
Overall Satisfaction	6.65 ± 1.26	7.86 ± 0.89	8.079	< 0.001
Satisfaction with Pain	5.48 ± 1.14	7.14 ± 0.71	12.861	< 0.001

CA Group: Conventional Analgesia Group; RTAPB Group: Ropivacaine Transversus Abdominis Plane Block Group.

compared to 1.79% in the RTAPB group (*P* = 0.621). While not statistically significant, the RTAPB group demonstrated lower rates of complications, suggesting a potential trend towards improved postoperative outcomes.

Patient satisfaction scores

Overall satisfaction scores were higher in the RTAPB group, with a mean of 7.86 ± 0.89, compared to 6.65 ± 1.26 in the CA group (*P* < 0.001) (**Table 3**). Additionally, satisfaction with pain management was markedly better in the RTAPB group, scoring an average of 7.14 ± 0.71 versus 5.48 ± 1.14 in the CA group (*P* < 0.001). These findings suggest enhanced patient satisfaction with both general experience and pain control when utilizing the RTAPB technique in laparoscopic myomectomy procedures.

Table 4. Correlation analysis between intervention and key outcome measures

Parameter	rho	*P* value
Post-operative 1 hour	-0.229	P < 0.001
Post-operative 6 hours	-0.136	0.045
Post-operative 12 hours	-0.161	0.018
Post-operative 24 hours	-0.168	0.013
Discharge day	-0.200	0.003
Cortisol post-operation	-0.196	0.004
NE post-operation	-0.195	0.004
IL-6 post-operation	-0.141	0.038
Intraoperative heart Rate at 5 min	-0.137	0.044
Intraoperative heart Rate at 10 min	-0.145	0.033
Intraoperative MAP at 5 min	-0.193	0.004
Intraoperative MAP at 10 min	-0.141	0.038
QoR-40 post-operation (3 d)	0.172	0.011
PSQI post-operation (3 d)	-0.222	P < 0.001
Overall satisfaction	0.493	P < 0.001
Satisfaction with pain	0.690	P < 0.001

NE: Norepinephrine; IL-6: Interleukin-6; MAP: Mean Arterial Pressure; QoR-40: Quality of Recovery-40; PSQI: Pittsburgh Sleep Quality Index.

Correlation analysis between intervention and key outcome measures

The correlation analysis between the intervention and key outcome measures revealed several significant associations **Table 4**. Post-op cortisol levels (r = -0.196, $P = 0.004$), NE post-op levels (r = -0.195, $P = 0.004$), and IL post-op levels (r = -0.141, $P = 0.038$) showed a significant negative correlation with the intervention. Intraoperative heart rate at 5 min (r = -0.137, $P = 0.044$) and 10 min (r = -0.145, $P = 0.033$) and intraoperative MAP at 5 min (r = -0.193, $P = 0.004$) and 10 min (r = -0.141, $P = 0.038$) also demonstrated significant negative correlations with the intervention. QoR-40 post-op scores at 3 d (r = 0.172, $P = 0.011$) showed a significant positive correlation, while PSQI post-op scores at 3 d (r = -0.222, $P < 0.001$) exhibited a significant negative correlation with the intervention. Overall satisfaction (r = 0.493, $P < 0.001$) and satisfaction with pain (r = 0.690, $P < 0.001$) were positively correlated with the intervention. The results indicate that the intervention was associated with improved patient satisfaction and better pain control, suggesting a beneficial impact on patient outcomes.

Discussion

The findings of this retrospective study highlight the significant impact of ropivacaine transversus abdominis plane block (RTAPB) on analgesic efficacy and physiological stress response in patients undergoing laparoscopic myomectomy. Initially, the reduced pain scores observed in the RTAPB group at varying postoperative intervals underscore the superior analgesic efficacy of this technique. The mechanism underlying this improvement can be attributed to the specific targeting of the transversus abdominis plane, which is rich in sensory nerve fibers supplying the anterior abdominal wall [18]. By administering local anesthetics like ropivacaine within this plane, RTAPB effectively blocks the neural transmission of nociceptive signals to the central nervous system, thereby mitigating pain perception [19]. This targeted blockade thus reduces the reliance on systemic analgesics, which are often associated with a myriad of side effects. Consequently, patients in the RTAPB group not only experience reduced pain but also benefit from a subsequent decrease in systemic analgesic consumption, thereby minimizing complications such as nausea, vomiting, and respiratory depression.

The attenuation of postoperative cortisol and norepinephrine levels in the RTAPB group further elucidates the role of this technique in modulating stress responses. Surgery stimulates the hypothalamic-pituitary-adrenal (HPA) axis and sympathetic nervous system, leading to increased secretion of stress hormones such as cortisol and norepinephrine [20]. These hormones not only reflect the physiological stress response but also influence immune function and inflammation, potentially affecting recovery and susceptibility to complications [21]. The reduction in these markers suggests a dampening of the surgical stress response. The local anesthetic properties of ropivacaine, by inhibiting the afferent conveyance of pain-related stimuli to the CNS, likely contribute to decreased HPA axis activation [22]. This physiological modulation can reduce the systemic inflammatory state often exacerbated by surgical trauma, fostering improved recovery outcomes.

In addition to analgesic effectiveness and stress response modulation, RTAPB demonstrated favorable impacts on hemodynamic stability. Intraoperative heart rate and mean arterial pressure were significantly lower in the RTAPB group. Such hemodynamic stability may be interpreted as a secondary outcome of effective analgesia, where dampened autonomic stress responses alleviate fluctuations in cardiovascular parameters [23]. This stability was particularly advantageous in maintaining organ perfusion and function during surgery, thereby potentially reducing perioperative morbidity [24].

Further supporting the advantageous outcome profile associated with RTAPB was the observed enhancement in postoperative recovery quality and sleep patterns. Patients in the RTAPB group reported significantly better quality of recovery and sleep scores. These improvements can be attributed to the combined benefits of effective pain management and physiological stress reduction, which collectively enhance overall patient comfort and well-being [25]. Effective analgesia not only minimizes discomfort but also reduces sleep disturbances, contributing to substantial improvements in postoperative recovery metrics [26]. Additionally, by attenuating the inflammatory response and enhancing hemodynamic control, RTAPB likely plays a role in optimizing the recovery milieu, evident in both subjective scoring and reduced complication rates [27].

The reduced incidence of certain postoperative complications in the RTAPB group was noteworthy, although not statistically significant for all measured categories. This trend towards decreased complications such as nausea, vomiting, and extended hospital stays reflects the holistic benefits of RTAPB in perioperative management. Enhanced analgesic control and stress modulation can foster a faster return to homeostasis, permitting more rapid convalescence and discharge readiness [28].

Patient satisfaction metrics firmly establish the perceived benefit of RTAPB from the recipient's standpoint. The stark increase in overall satisfaction and pain-specific satisfaction within the RTAPB cohort emphasizes the tangible improvements offered by this analgesic strategy. Enhanced satisfaction likely reflects a reduced symptom burden and an improved quality of the hospital experience, signaling an increasingly patient-centered approach to postoperative care [29]. As healthcare continues to orient towards value-based care models, such gains in satisfaction are of critical importance, potentially influencing institution-wide adoption of advanced analgesic techniques [30].

The findings from this study underscore the multifaceted role of RTAPB in optimizing surgical outcomes. Beyond pain relief, the modulation of the surgical stress response and hemodynamic parameters, together with enhanced recovery and satisfaction, promotes a more comprehensive enhancement of the perioperative experience. Nevertheless, further investigation should delve into the cost-effectiveness of widespread RTAPB adoption, considering the resource demands of ultrasound-guided regional anesthesia. Additionally, future studies should aim to delineate long-term outcomes associated with RTAPB, assessing whether the short-term benefits noted herein can translate into sustained enhancements in health-related quality of life.

This study, while demonstrating significant benefits of RTAPB in enhancing analgesic efficacy and modulating stress response, is not without its limitations. Firstly, the retrospective design inherently poses constraints on causality assessments, and potential selection biases may influence the findings. Additionally, the study lacks randomization and blindness, which could introduce confounding variables affecting the observed outcomes. The sample size, although adequate for detecting differences in primary endpoints, may limit generalizability to broader patient populations, and may not capture rare adverse events associated with the intervention. Lastly, long-term outcomes beyond the immediate postoperative period were not assessed, restricting the ability to evaluate sustained benefits of the analgesic strategy. Future prospective and randomized controlled trials would be valuable in addressing these limitations, enhancing the robustness and external validity of the conclusions drawn.

Conclusion

In summary, this study demonstrates that RTAPB offers significant advantages over routine analgesia in the management of patients undergoing laparoscopic myomectomy. The mechanistic insights elucidate that targeted analgesic delivery in RTAPB achieves superior pain control, while mitigating stress-induced endocrinological and hemodynamic disturbance. This, in turn, results in improved postoperative recovery, fewer side effects, and greater patient satisfaction. As surgical practices continue to evolve, rigorous assessment of such novel analgesic modalities remain paramount to optimizing patient outcomes, supporting a transition towards more effective and patient-centric perioperative care strategies.

Disclosure of conflict of interest

None.

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