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ORIGINAL RESEARCH

# A Prospective Randomized Controlled Study of Ultrasound-Guided Rectus Sheath Block for Pain Management in Laparoscopic Umbilical Hernia Repair with Intraperitoneal Onlay Mesh

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**Objective:** To evaluate the clinical efficacy and safety of ultrasound-guided rectus sheath block (RSB) in laparoscopic umbilical hernia repair with intraperitoneal onlay mesh (IPOM).

**Methods:** A total of 139 patients scheduled for laparoscopic umbilical hernia repair with IPOM were selected and randomly assigned to either the group receiving general anesthesia combined with bilateral rectus sheath block (Group GR, 71 patients) or the group receiving general anesthesia alone (Group G, 68 patients). We monitored the patients' heart rate (HR) and mean arterial pressure (MAP) at four time points: before anesthesia induction (T1), at the start of surgery (T2), during mesh fixation (T3), and upon removal of the laryngeal mask (T4). Postoperative pain levels were evaluated using the Visual Analogue Scale (VAS) at 1 hour (T5), 6 hours (T6), and 12 hours (T7) after surgery while resting, as well as at 24 hours (T8) during activity. We also compared the number of times the patient-controlled intravenous analgesia (PCIA) pump was pressed and the use of additional analgesics within 24 hours post-surgery, along with recording any adverse reactions and complications associated with RSB.

**Results:** At time points T2 and T3, the HR and MAP in Group GR were significantly lower than those in Group G ($P < 0.05$). Additionally, VAS scores at various postoperative intervals were lower in Group GR, with significant differences noted at T5, T7, and T8 ($P < 0.05$). Group GR also had significantly fewer presses on the analgesia pump within 24 hours post-surgery compared to Group G, while the incidence of adverse events was similar between the two groups.

**Conclusion:** Ultrasound-guided RSB is a straightforward and safe technique for laparoscopic umbilical hernia repair with IPOM. It offers clear analgesic benefits and significantly reduces early postoperative pain.

**Keywords:** analgesia, IPOM, rectus sheath block, ultrasound-guided, umbilical hernia

## Introduction

Umbilical hernias account for approximately 6–14% of adult abdominal wall hernias.[1] These hernias are typically acquired and are mainly caused by increased abdominal pressure. Umbilical hernias do not heal on their own and usually require surgical intervention. Treatment options include open repair and laparoscopic repair, with the latter using intraperitoneal onlay mesh (IPOM), a minimally invasive technique widely used in clinical practice.[2] Compared to traditional open suture surgery, laparoscopic IPOM offers advantages such as less trauma, faster recovery, and lower infection rates.[3]

Laparoscopic IPOM, performed under general anesthesia, often leads to both acute and chronic postoperative pain, mainly due to the use of sutures and staples.[4,5] Studies have shown that the transversus abdominis plane block (TAPB) provides effective analgesia during the IPOM procedure for abdominal wall hernias.[6,7] Unlike other hernia surgeries, the

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trauma in laparoscopic IPOM for umbilical hernias primarily stems from the abdominal wall rather than internal organs. This trauma is concentrated around the umbilicus and affects the bilateral rectus abdominis and its medial aspects due to the creation of observation ports, suspension of the mesh through the abdominal wall puncture device, and fixation using a stapler, resulting in mainly localized abdominal wall pain. Evidence indicates that the rectus sheath block (RSB) can effectively block sensory inputs from both sides of the abdominal wall, providing significant analgesia for midline abdominal surgeries.[8] We hypothesize that RSB can also offer effective pain relief when combined with general anesthesia in laparoscopic umbilical hernia repairs using IPOM.

Moreover, the ultrasound-guided RSB is a straightforward procedure with fewer contraindications than spinal anesthesia. For patients who cannot undergo spinal anesthesia or have difficulties with TAPB, the ultrasound-guided RSB is an excellent alternative. Thus, we used RSB alongside general anesthesia for laparoscopic umbilical hernia repair with IPOM to assess its safety and analgesic effectiveness, particularly its impact on early postoperative pain relief.

# Materials and Methods

## General Information

We selected 139 patients who underwent scheduled laparoscopic umbilical hernia repair with IPOM under general anesthesia at our hospital from October 2022 to February 2024. The patients ranged in age from 26 to 75 years and weighed between 49 and 85 kg. They were classified as ASA (American Society of Anesthesiologists) Class I–III. Exclusion criteria for the study: a history of drug abuse; severe coagulopathy; unplanned postoperative transfers to the surgical intensive care unit; skin breakdown or infection at the nerve block site; severe cardiac, pulmonary, hepatic, or renal dysfunction; neurological or psychiatric disorders; and emergency admissions for incarcerated umbilical hernias. The study was approved by the hospital's ethics committee. Before surgery, patients and their families provided informed consent and were randomly assigned to either the general anesthesia combined with RSB group (Group GR) or the general anesthesia alone group (Group G) according to a random number table. The study flow is illustrated in Figure 1.

## General Anesthesia

Upon entering the operating room, all patients were arranged in a supine position and underwent routine monitoring, including electrocardiogram (ECG), oxygen saturation, and non-invasive blood pressure. Baseline heart rate (HR) and mean arterial pressure (MAP) were recorded at rest, and intravenous access was established. Preoperative medications included slow IV administration of midazolam 1 mg and atropine 0.005 mg/kg. Patients in Group GR received general anesthesia combined with RSB, while those in Group G received only general anesthesia. During the surgery, muscle relaxation and bispectral index (BIS) were monitored. Anesthesia induction involved pre-oxygenation via a mask, followed by IV administration of etomidate 0.3 mg/kg, sufentanil 0.5 μg/kg, and rocuronium 0.6 mg/kg.

Once the patient was unconscious, oxygen was administered under pressure via a mask, and a laryngeal mask airway (LMA) was inserted after jaw relaxation. Mechanical ventilation settings included a tidal volume (Vt) of 6–8 mL/kg, a respiratory rate (RR) of 14–16 per minute, end-tidal CO2 partial pressure (PETCO2) maintained between 35–45 mmHg, and SPO2 between 98%-100%. The BIS value was kept between 40–60, and train-of-four (TOF) was maintained with at least T3 and T4 absent. Anesthesia was maintained with target-controlled infusion (TCI) of propofol and remifentanil at 4.0–5.0 μg/L. Rocuronium was supplemented based on TOF results. If HR or MAP increased more than 20% above baseline, IV propofol 20 mg or remifentanil 20 μg was administered based on BIS values. If systolic pressure fell below 100 mmHg or MAP below 60 mmHg, IV ephedrine 3–6 mg was administered, and the infusion rates of propofol or remifentanil were adjusted accordingly.

At the end of surgery, patients were connected to a patient-controlled intravenous analgesia (PCIA) pump and transferred to the recovery room. The PCIA regimen included sufentanil 150 μg, ondansetron 12 mg, and dexamethasone 10 mg diluted to 150 mL in saline; with a background dose of 3 mL/h, a self-controlled dose of 2 mL per activation, and a lockout time of 15 minutes. During the preoperative visit, patients and their families were educated and trained on the use of the PCA pump.

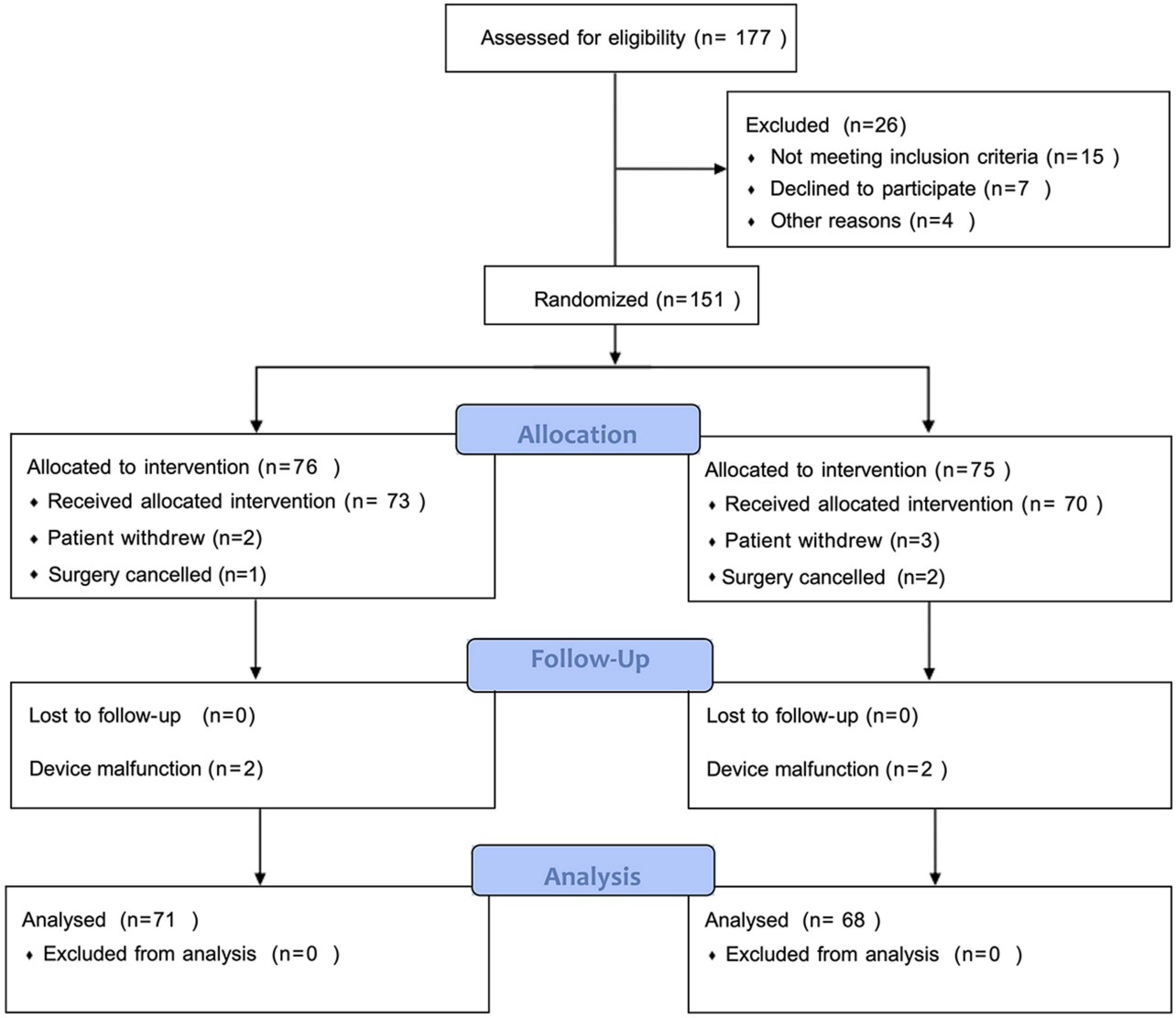


**Figure 1** Flowchart.

## Regional Block

In the GR group, following the intravenous administration of midazolam 1 mg, the RSB procedure was performed using a Mindray TE7 ultrasound machine equipped with a linear array probe. The probe was positioned transversely lateral to the umbilicus (as shown in Figure 2A), allowing visualization of the intact rectus abdominis and the posterior sheath of the rectus abdominis while avoiding the arteries of the abdominal wall (as depicted in Figure 2B). Under sterile conditions, a Pajunk nerve stimulation needle, either 22 G, 50 mm or 21 G, 100 mm depending on the thickness of the abdominal wall, was advanced in-plane from the inner to the outer direction. It traversed through the skin, subcutaneous tissue, anterior sheath of the rectus abdominis, and rectus abdominis muscle. Upon reaching the shallow part of the posterior sheath of the rectus abdominis, the needle tip was slightly retracted; if no blood or gas was aspirated, 1–2 mL of saline was injected to confirm the needle tip's placement. Once confirmed, local anesthetic was injected. Successful blockade was confirmed via ultrasound imaging, which showed depression of the peritoneum and a spindle-shaped diffusion of the drug between the rectus abdominis and its posterior sheath (as illustrated in Figure 2C), following which the remaining local anesthetic was injected. The block was performed after entering the operating room but before the induction of general anesthesia.


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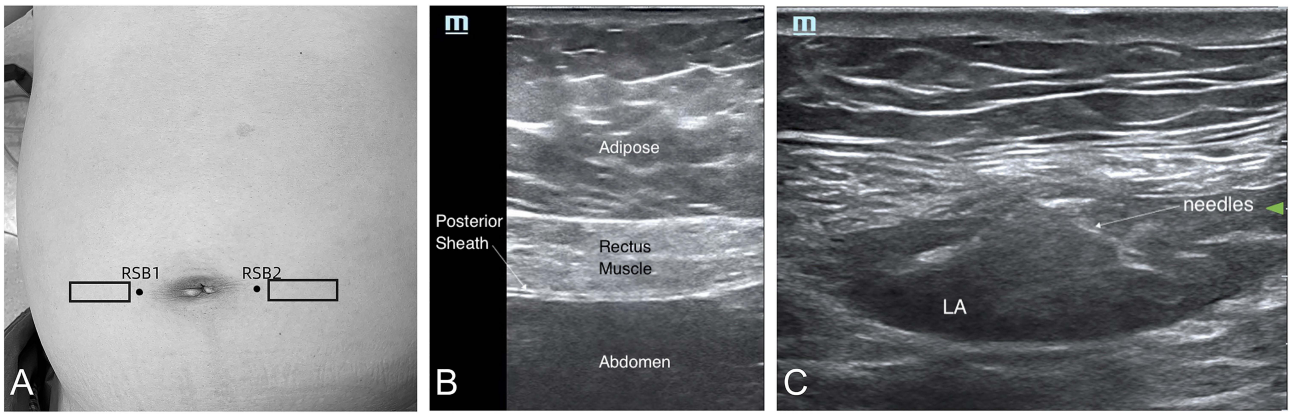


**Figure 2** Diagram of Bilateral Rectus Sheath Block with Ultrasound Guidance. (**A**) Positioning of Ultrasound Probe and Needle Insertion Site; (**B**) Ultrasound Visualization of Unilateral Rectus Abdominis Anatomy; (**C**) Dissemination of Drug within the Posterior Sheath of the Rectus Abdominis.
**Abbreviation**: LA, Local Anesthetic.

The same procedure was repeated on the opposite side. Each side received an injection of 0.25% ropivacaine hydrochloride solution (Naropin 0.1 g/10 mL, manufactured by AstraZeneca, Sweden, batch number: NBNZ) and epinephrine hydrochloride 0.1 mg (1:200,000), totaling 20 mL.[9] The success of the block was assessed subjectively by the patient, with the block considered successful if pain around the puncture site had decreased. An experienced anesthesiologist performed the nerve block, while postoperative pain assessment and observation were conducted by a physician not involved in anesthesia administration.

## Observation Indices

The HR and MAP of patients in both groups were monitored at the following time intervals: before anesthesia induction while at rest (T1), at the beginning of the surgery (T2), during the staple gun fixation of the patch (T3), and upon removal of the laryngeal mask (T4).

In the GR group, patients were assessed for signs of peritoneal bleeding around the umbilical hernia. This involved the surgeon conducting a laparoscopic examination promptly after establishing pneumoperitoneum, aiding in the observation and identification of any peritoneal injury around the umbilical hernia.

The Visual Analogue Scale (VAS) scores were assessed 1 hour after the operation (T5), 6 hours after the operation (T6), and 12 hours after the operation (T7) during rest, as well as 24 hours after the operation (T8) during mobilization.

The count of presses on the patient-controlled intravenous analgesia pump, which represents the number of additional analgesic supplements administered, was monitored within the first 24 hours after the operation.

We monitored for occurrences of local anesthetic toxicity, postoperative nausea and vomiting (PONV), and other adverse reactions and associated complications. Any occurrence of nausea or vomiting after the operation was documented as a case of PONV.

The primary outcome measures were evaluated by examining postoperative VAS scores, counts of analgesia pump presses, and intraoperative HR and MAP levels to assess pain intensity. Secondary outcome measures included incidences of puncture injuries associated with the RSB, local anesthetic toxicity, and the occurrence of PONV in both groups.

## Statistical Analysis

Statistical analysis was performed using SPSS 25.0 software.

The sample size was calculated using the formula: $n=[(Z_{\alpha/2}+Z_{\beta})^2\times 2\sigma^2)]/(\mu 1-\mu 2)^2$, in which significance level ($\alpha$) = 0.05, statistical power ($1-\beta$) = 0.80, effect Size ($\mu 1-\mu 2$) = 50.5, population standard deviation ($\sigma$) = 1. The required sample size (n) for each group is approximately 63 participants.

Normally distributed quantitative data were presented as mean ± standard deviation ($\bar{x} \pm s$), and comparisons between groups were conducted using the independent samples *t*-test. Non-normally distributed quantitative data were expressed as medians (interquartile range), and group comparisons were made using the Mann–Whitney *U*-test. Count data were presented as absolute numbers or percentages, and group comparisons were performed using the $\chi^2$ test. A *P*-value of less than 0.05 was considered statistically significant.

# Results

## General Patient Characteristics

There were 71 patients (male 41, female 31) in the GR group and 68 (male 29, female 39) in the G group. There were no significant discrepancies between the GR and G groups concerning body mass index (27.20±6.630 vs 26.33±6.210, $P = 0.462$), age (50.10±15.595 vs 53.10±16.522, $P = 0.265$), and duration of surgery (70.14±12.416 vs 68.61±15.617, $P = 0.323$).

## HR and MAP at Different Time Points During Surgery

At T1 and T4, there were no noteworthy variations in HR and MAP between the GR and G groups ($P > 0.05$). Nonetheless, at T2 and T3, HR and MAP were notably elevated in the G group compared to the GR group ($P < 0.05$) (Table 1).

## Postoperative Analgesic Effect

The VAS scores at different time points were notably lower in the GR group in comparison to the G group, with significant discrepancies observed at T5, T7, and T8 ($P < 0.05$) (Table 1).

Throughout the patient-controlled intravenous analgesia period, the analgesic supplement count, as per the records from the electronic analgesia pump, was notably lower in the GR group when compared with the G group ($P < 0.05$) (Table 2).

## Adverse Reactions and Complications

In the GR group, there were no instances of local anesthetic toxicity, and laparoscopic examination did not reveal any peritoneal oozing. Moreover, there was no notable distinction in the occurrence of PONV between the GR and G groups [12/71 (17.6%) vs 19/68 (26.7%), $P = 0.103$).

# Discussion

IPOM is a widely-used minimally invasive approach for umbilical hernia repair. However, due to the utilization of mesh suspension and stapling devices, along with increased intra-abdominal pressure, patients often experience considerable postoperative pain. Effective postoperative pain management is crucial for facilitating early mobilization and swift recovery in individuals with umbilical hernias. Presently, patient-controlled intravenous analgesia utilizing opioid analgesics is the predominant method of postoperative pain relief in laparoscopic surgery.[10] While opioids are potent analgesics, their efficacy varies among patients, and higher doses can lead to adverse effects such as respiratory depression, nausea, vomiting, pruritus, and slowed gastrointestinal motility.[11]

Given that patients with umbilical hernia are often obese, the use of opioids increases the risk of postoperative adverse reactions.[12] Researchers have conducted studies that emphasized the importance of reducing opioid use as a crucial component of enhanced recovery after surgery (ERAS) protocols.[13,14] Multimodal analgesia, which integrates medications with different mechanisms of action and diverse analgesic techniques is currently favored for acute pain management. This approach targets various aspects and sites of postoperative pain, aiming to achieve balanced analgesia, thereby promoting internal stability and enhancing postoperative recovery.[15]

Among multimodal analgesic strategies, combining general anesthesia with nerve blocks is commonly practiced. Nerve blocks offer localized pain relief, reducing the reliance on opioid analgesics.[16] Given that the primary source of pain in laparoscopic umbilical hernia repair with IPOM is the abdominal wall around the umbilicus rather than the

**Table 1** HR, MAP, and VAS at Different Time Points Between the Two Study Groups

| Group | n | HR (Times/Minute, $\bar{x} \pm s$) | | | | MAP (mmHg, $\bar{x} \pm s$) | | | | VAS (Points, $\bar{x} \pm s$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ | $T_6$ | $T_7$ | $T_8$ |
| GR Group | 71 | 63.35±1.73 | 62.61±1.39 | 58.06±1.31 | 70.33±1.20 | 75.10±1.60 | 78.34±1.39 | 77.22±2.39 | 81.22±2.43 | 0.89±0.708 | 1.70±0.744 | 2.18±0.732 | 1.77±0.701 |
| G Group | 68 | 64.01±1.88 | 76.33±1.45 | 67.77±1.09 | 73.80±0.857 | 76.59±1.52 | 89.22±2.01 | 90.35±1.28 | 83.92±1.80 | 1.29±0.734 | 2.04±0.742 | 2.56±0.632 | 3.25±0.731 |
| *P*-value | | 0.545 | 0.007 | 0.011 | 0.302 | 0.551 | 0.019 | 0.021 | 0.490 | 0.038 | 0.089 | 0.045 | 0.032 |


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**Table 2** Comparison of Additional Medication Supplementation During the 24-Hour Postoperative Period with Patient-Controlled Intravenous Analgesia Between the Two Study Groups (Cases)

| Group | Additional 0 Times | Additional 1 Time | Additional 2 Times | Additional 3 Times | Additional 4 Times |
|---|---|---|---|---|---|
| GR Group | 17 | 20 | 24 | 10 | 0 |
| G Group | 3 | 21 | 26 | 13 | 5 |
| *P*-value | | | | | 0.035 |

visceral organs, it aligns perfectly with the indications for an RSB. Hence, this study adopts RSB to optimize both intraoperative and postoperative analgesia.

In the study, RSB was administered prior to the initiation of surgery, preemptively disrupting the transmission of surgical nociceptive stimuli. This proactive approach helps in averting the development of hyperalgesia and sensory abnormalities.[17] The rectus abdominis muscle lies bilaterally along the midline of the abdomen, enclosed within the rectus sheath, and primarily innervated by the thoracolumbar nerves $T_7$-$T_{12}$.[18,19] During the RSB procedure, local anesthetics are confined within the posterior sheath of the rectus abdominis, resulting in a localized blockade. The RSB specifically targets the anterior branches of the thoracolumbar nerves, particularly $T_9$-$T_{11}$, making it particularly suitable for surgeries involving midline abdominal incisions and rectus abdominis manipulations.[8,20] Hence, the RSB is well-suited for laparoscopic umbilical hernia repair with IPOM.

Clinical observations suggest that incising the skin at the beginning of surgery, establishing pneumoperitoneum, and utilizing a staple gun for patch fixation are procedures that elicit significant stimulation, leading to fluctuations in circulatory parameters among patients. In the study, HR and MAP of patients in the GR group at these critical junctures were notably lower compared to those in the G group, indicating the remarkable analgesic efficacy of the RSB in laparoscopic umbilical hernia repair with IPOM. This is particularly advantageous for elderly patients with umbilical hernia, especially those with cardiovascular conditions.

Following laparoscopic umbilical hernia repair with IPOM, all patients in the study utilized patient-controlled intravenous analgesia due to the significant postoperative pain. While VAS scores at various postoperative time points were generally low for both groups, those in the GR group were notably lower than those in the G group at 1 hour and 12 hours postoperatively during rest, as well as during physical activity 24 hours postoperatively. Furthermore, data from the electronic analgesia pump records revealed that within the 24-hour postoperative period with patient-controlled intravenous analgesia, the count of self-administered medication supplements in the GR group was significantly lower compared to the G group, considering the background dose. This underscores the considerable efficacy of RSB in providing pain relief in the early postoperative phase and during patient activity, facilitating early mobilization post-surgery. Given that the rectus abdominis muscle is part of the core muscle group and plays a role in coughing actions, the effective analgesia provided by the RSB is particularly advantageous for elderly patients who need to actively cough to clear secretions after undergoing general anesthesia.

In the study, the duration of analgesia achieved through RSB exceeded the action time of ropivacaine.[21] This prolonged duration can be attributed to the relatively enclosed nature of the posterior sheath of the rectus abdominis, allowing the local anesthetic to effectively block the nerve endings distributed within, thereby enhancing its efficacy. Additionally, the IPOM technique employed in the study did not compromise the integrity of the rectus sheath, which has sparse vascular distribution, leading to slower absorption of local anesthetics. Moreover, the utilization of a long-acting local anesthetic in combination with a low concentration of epinephrine further delayed the rate of anesthetic absorption.[16] Our findings are consistent with those reported by Yin et al.[22]

However, despite the implementation of RSB in the GR group, some patients still required additional analgesics during the patient-controlled intravenous analgesia period, indicating that perfect analgesia cannot be guaranteed even with RSB. This could be attributed to insufficient volume of local anesthetic to achieve adequate diffusion, or it might be related to the presence of intercostal nerves that do not run between the rectus abdominis and the posterior sheath

but rather between the rectus abdominis and the anterior sheath.[23] In certain populations, the anterior cutaneous nerves do not enter the rectus sheath, instead traveling directly through the lateral sheath to the surface and innervating the abdominal wall.[24,25] Consequently, during RSB, these nerves may not be effectively blocked, resulting in sustained pain sensation in the areas they innervate. Nevertheless, RSB still conferred a distinct and effective analgesic effect in laparoscopic umbilical hernia repair with IPOM surgeries. From the perspective of nerve block techniques, enhancing the proficiency of ultrasound-guided block procedures and using lower concentrations of local anesthetics to increase the drug volume may help extend the blockade's coverage. Additionally, RSB should not be relied upon as the sole analgesic method. It should be combined with other pain management strategies to improve patient comfort.

Under ultrasound guidance, the RSB procedure is relatively straightforward. In the ultrasound image, the anterior and posterior sheaths of the rectus abdominis are depicted as bright hyperechoic lines, which are easily discernible even in obese patients. The in-plane puncture technique enhances the intuitiveness of the procedure, and the positioning of the nerve block needle is straightforward. Intraoperative laparoscopic observations of the abdominal wall revealed no instances of peritoneal oozing around the umbilical hernia in the GR group, indicating the absence of incidents where the nerve block needle penetrated the posterior sheath of the rectus abdominis during RSB. Furthermore, there were no occurrences of local anesthetic toxicity in the GR group, underscoring the safety and relative ease of the ultrasound-guided RSB procedure.

Although the statistical analysis did not reveal a significant difference in the incidence of PONV between the two groups, the GR group experienced fewer occurrences of PONV compared to the G group. Initially, we anticipated that the early postoperative analgesic effect of the RSB would reduce the actual need for opioid analgesics in the GR group. However, the formulation of patient-controlled intravenous analgesia was not individually tailored to lower dosages, leading to a relatively high utilization of opioid analgesics. Higher opioid usage should have theoretically increased the incidence of PONV in the GR group compared to the G group. The unexpected results may be attributed to a higher proportion of female patients in the G group, which could have influenced the incidence of PONV.

This study has several limitations. Firstly, the dosage of local anesthetic for the RSB was not personalized. Individualizing the dosage of local anesthetic in the RSB and optimizing the formulation for patient-controlled intravenous analgesia might improve anesthesia and postoperative analgesic outcomes. Secondly, the study did not evaluate the usage of general anesthetic drugs during surgery. Monitoring and comparing the consumption of general anesthetic drugs in both groups throughout the surgical procedure could provide further insights into the advantages of combining general anesthesia with the RSB.

In summary, ultrasound-guided rectus sheath block emerges as a safe and feasible approach, delivering effective analgesia during and immediately following laparoscopic umbilical hernia repair with IPOM. Its clinical utility presents substantial value in perioperative pain management.

## Abbreviations

RSB, rectus sheath block; HR, heart rate; MAP, mean arterial pressure; VAS, visual analogue scale; IPOM, intraperitoneal onlay mesh; TAPB, transversus abdominis plane block; PCIA, Patient Controlled Intravenous Analgesia; TOF, Train Of Four; SICU, Surgical intensive care unit; PONV, postoperative nausea and vomiting; BIS, Bispectral Index; ASA, American Society of Anesthesiologists; PETCO2, End Tidal Carbon Dioxide partial pressure.

## Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki (as was revised in 2013). The study was approved by Ethics Committee of the Beijing Chao-Yang Hospital, Capital Medical University (No.KYLL-2017-039). The written, informed consent was obtained from the participant for the publication.

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## Disclosure

The authors declare no conflict of interest.

## References

1. Shankar DA, Itani KMF, O'Brien WJ, Sanchez VM. Factors associated with long-term outcomes of umbilical hernia repair. *JAMA Surg*. 2017;152(5):461–466. doi:10.1001/jamasurg.2016.5052
2. Chinese Society of Hernia and Abdominal Wall Surgery. Chinese expert consensus on intra-abdominal patch repair (2022 edition). *Chin J Pract Surg*. 2022;(7):042.
3. Sharma A, Mehrotra M, Khullar R, Soni V, Baijal M, Chowbey PK. Laparoscopic ventral/incisional hernia repair: a single centre experience of 1242 patients over a period of 13 years. *Hernia*. 2011;15(2):131–139. doi:10.1007/s10029-010-0747-z
4. Chelala E, Baraké H, Estievenart J, Dessily M, Charara F, Allé JL. Long-term outcomes of 1326 laparoscopic incisional and ventral hernia repair with the routine suturing concept: a single institution experience. *Hernia*. 2016;20(1):101–110. doi:10.1007/s10029-015-1397-y
5. Nguyen SQ, Divino CM, Buch KE, et al. Postoperative pain after laparoscopic ventral hernia repair: a prospective comparison of sutures versus tacks. *JSLS*. 2008;12(2):113–116.
6. Chesov I, Belîi A. Postoperative analgesic efficiency of transversus abdominis plane block after ventral hernia repair: a prospective, randomized, controlled clinical trial. *Rom J Anaesth Intensive Care*. 2017;24(2):125–132. doi:10.21454/rjaic.7518.242.chv
7. Paasch C, Aljedani N, Ortiz P, et al. The transversus abdominis plane block may reduce early postoperative pain after laparoscopic ventral hernia repair a matched pair analysis. *Ann Med Surg*. 2020;55:294–299. doi:10.1016/j.amsu.2020.05.044
8. Bashandy GM, Elkholy AH. Reducing postoperative opioid consumption by adding an ultrasound-guided rectus sheath block to multimodal analgesia for abdominal cancer surgery with midline incision. *Anesth Pain Med*. 2014;4(3):e18263. doi:10.5812/aapm.18263
9. Tamura T, Kaneko K, Yokota S, et al. Comparison between rectus sheath block with 0.25% ropivacaine and local anesthetic infiltration with 0.5% ropivacaine for laparoscopic inguinal hernia repair in children. *Nagoya J Med Sci*. 2019;81(3):341–349. doi:10.18999/nagjms.81.3.341
10. Xu JG, Wu XM, Luo AL, et al. Expert consensus on postoperative pain management in adults. *J Clin Anesthesiol*. 2010.
11. Wild J, Yamada T, Arjona Ferreira JC, Hale M. Onset of action of naldemedine in the treatment of opioid-induced constipation in patients with chronic noncancer pain: results from 2 randomized, placebo-controlled, Phase 3 trials. *Pain*. 2019;160(10):2358–2364. doi:10.1097/j.pain.0000000000001629
12. Hilling DE, Koppert LB, Keijzer R, Stassen LP, Oei IH. Laparoscopic correction of umbilical hernias using a transabdominal preperitoneal approach: results of a pilot study. *Surg Endosc*. 2009;23(8):1740–1744. doi:10.1007/s00464-008-0177-5
13. Zwicker JD, Zhang Y, Ren J, et al. Glial TLR4 signaling does not contribute to opioid-induced depression of respiration. *J Appl Physiol*. 2014;117(8):857–868. doi:10.1152/japplphysiol.00534.2014
14. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. *Ann Surg*. 2008;248(2):189–198. doi:10.1097/SLA.0b013e31817f2c1a
15. Weston E, Noel M, Douglas K, et al. The impact of an enhanced recovery after minimally invasive surgery program on opioid use in gynecologic oncology patients undergoing hysterectomy. *Gynecol Oncol*. 2020;157(2):469–475. doi:10.1016/j.ygyno.2020.01.041
16. Hamid HKS, Ahmed AY, Alhamo MA, Davis GN. Efficacy and Safety Profile of Rectus Sheath Block in Adult Laparoscopic Surgery: a Meta-analysis. *J Surg Res*. 2021;261:10–17. doi:10.1016/j.jss.2020.12.003
17. Kong M, Li X, Shen J, Ye M, Xiang H, Ma D. The effectiveness of preemptive analgesia for relieving postoperative pain after video-assisted thoracoscopic surgery (VATS): a prospective, non-randomized controlled trial. *J Thorac Dis*. 2020;12(9):4930–4940. doi:10.21037/jtd-20-2500
18. Seidel R, Wree A, Schulze M. Does the approach influence the success rate for ultrasound-guided rectus sheath blocks? An anatomical case series. *Local Reg Anesth*. 2017;10:61–65. doi:10.2147/LRA.S133500
19. Rozen WM, Tran TM, Ashton MW, Barrington MJ, Ivanusic JJ, Taylor GI. Refining the course of the thoracolumbar nerves: a new understanding of the innervation of the anterior abdominal wall. *Clin Anat*. 2008;21(4):325–333. doi:10.1002/ca.20621
20. Finnerty O, Carney J, McDonnell JG. Trunk blocks for abdominal surgery. *Anaesthesia*. 2010;65(Suppl 1):76–83. doi:10.1111/j.1365-2044.2009.06203.x
21. Winnie L, Kao YH, Liao CC, Tamura T, Chang ML, Hsieh KY. Comparative analgesic efficacies of ropivacaine and bupivacaine for postoperative rectus sheath block in paediatric abdominal surgery: a meta-analysis of randomized controlled trial and retrospective cohort studies. *Pain Res Manag*. 2021;2021:5535730. doi:10.1155/2021/5535730
22. Cao Y, Hu YW, Li SF, et al. Application of transversus abdominis plane block combined with rectus sheath block in the repair of direct inguinal hernia in the elderly. *J Clin Anesthesiol*. 2019;35(11):4.
23. Courreges P, Poddevin F, Lecoutre D. Para-umbilical block: a new concept for regional anaesthesia in children. *Paediatr Anaesth*. 1997;7(3):211–214. doi:10.1046/j.1460-9592.1997.d01-79.x
24. Skinner AV, Lauder GR. Rectus sheath block: successful use in the chronic pain management of pediatric abdominal wall pain. *Paediatr Anaesth*. 2007;17(12):1203–1211. doi:10.1111/j.1460-9592.2007.02345.x
25. Simpson DM, Tyrrell J, De Ruiter J, Campbell FA. Use of ultrasound-guided subcostal transversus abdominis plane blocks in a pediatric patient with chronic abdominal wall pain. *Paediatr Anaesth*. 2011;21(1):88–90. doi:10.1111/j.1460-9592.2010.03471.x