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*Original Article*

# Comparison of the analgesic efficacy of ultrasound-guided retrolaminar block with serratus anterior plane block in patients undergoing radical mastectomy

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**Abstract:** Objectives: The newly introduced retrolaminar block (RLB) offers anesthesiologists an alternative regional anesthetic technique for radical mastectomy. However, few clinical studies have compared the efficacy of RLB with that of serratus anterior plane block (SAPB). This study aimed to investigate the postoperative analgesia efficacy between ultrasound-guided RLB and SAPB in patients undergoing radical mastectomy. Methods: Seventy patients were included in this prospective, randomized controlled trial. Patients were assigned to receive either ultrasound-guided RLB or SAPB. The primary outcome was the visual analogue scale (VAS) score during coughing at 6 hours postoperatively. The secondary indicators included dermatomal spread of sensory block (from T2 to T6 at the medial and lateral nipple lines assessed by acupuncture), intraoperative hemodynamic changes, and analgesia-related adverse reactions. Results: The median VAS scores during coughing at 6 hours postoperatively were 2 (IQ1-IQ3: 1-3; P = 0.39) in both groups, indicating no significant difference. Similar analgesic effects were observed at other time points within 48 hours post-surgery. RLB provided broader sensory coverage on the medial side of the nipple compared to SAPB (median [IQR]: 3 (3-4) and 2 (1-2)) (P = 0.006). No significant differences in mean arterial pressure (MAP) or heart rate (HR) were observed immediately or 5 minutes after skin incision. The incidence of adverse events did not differ significantly between the two groups. Conclusions: Retrolaminar block and Serratus anterior plane block provide comparable postoperative analgesia following radical mastectomy. However, RLB offers a broader sensory block range, particularly over the medial chest wall.

**Keywords:** Postoperative pain, nerve block, retrolaminar block, serratus anterior plane block, radical mastectomy

## Introduction

Breast cancer is a malignant solid tumor typically characterized by breast lumps, nipple discharge, and axillary lymphadenopathy. It has become one of the most prevalent cancers among women, with its incidence increasing year by year. Due to rising socioeconomic status and unique reproductive patterns of the population, China's contribution to global breast cancer burden is rapidly growing [1]. Currently, comprehensive treatment based on surgery remains the primary approach for treating breast cancer [2]. However, a substantial proportion of patients experience severe postoperative pain. Inadequate pain control results in increased opioid consumption and a higher incidence of complications such as nausea and vomiting [3]. Prolonged pain may develop into chronic neuropathic pain, significantly impairing

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recovery and quality of life [4]. Regional nerve block combined with general anesthesia is a multimodal analgesic method that can effectively alleviate intraoperative and postoperative pain, significantly reduce the use of anesthetics and opioids, and promote faster recovery [5, 6]. As a result, this technique has gained wide application in perioperative analgesia management.

Retrolaminar block (RLB) is a modified form of paravertebral block (PVB) [7]. While PVB is increasingly used for chest and abdominal surgeries due to its precise analgesic effects, it carries a risk of serious complications, including pneumothorax, hypotension, or nerve damage [8, 9]. Even with ultrasound guidance, performing a traditional PVB remains technically challenging, with its success heavily reliant on the operator's expertise. RLB, as an improved alternative to PVB, has received growing attention in recent years. It involves the ultrasound-guided injection of local anesthetic between the lamina of the thoracic vertebra and the erector spinal muscle [10]. Compared to PVB, RLB is easier to perform, associated with fewer complications such as pneumothorax, intrathecal injection, or vascular damage. However, the spread of anesthetic in RLB appears highly variable and is dose-dependent [11, 12].

The serratus anterior plane block (SAPB) targets the fascial plane between the lateral border of the pectoralis major and the serratus anterior muscle. Due to its myofascial space, SAPB typically requires only a single injection. It has been widely utilized for anesthesia in operations such as mastectomy, thoracotomy, thoracoscopic surgery, and rib fracture repair [13, 14]. Additionally, injecting the local anesthetic deep into the serratus anterior muscle has been found to simplify the procedure while maintaining comparable analgesic efficacy [15]. However, SAPB has certain limitations. Local anesthetic may diffuse extensively within the myofascial plane, potentially infiltrating the surgical field, which could interfere with the procedure and theoretically increase the risk of cancer cell dissemination.

Previous clinical studies have demonstrated that both RLB and SAPB can provide effective postoperative analgesia following breast surgery [16, 17], offering multiple options for regional anesthesia in thoracic procedures.

Although the precise mechanism of RLB remains unclear, cadaveric studies suggest that local anesthetic may diffuse into the paravertebral space via anatomical apertures, thereby blocking spinal nerves, while SAPB is thought to act by blocking the lateral cutaneous branches of the intercostal nerves [11, 12, 18]. Therefore, we hypothesized that RLB may offer superior analgesic coverage and efficacy compared to SAPB in the context of breast surgery. The aim of this study was to compare the analgesic efficacy, dermatomal coverage, and effects on surgical stress between RLB and SAPB in patients undergoing radical mastectomy.

## Materials and methods

This prospective, randomized, controlled trial adhered to the ethical guidelines of the 1975 Declaration of Helsinki and was approved by the Ethics Committee of Zhejiang Cancer Hospital (Chairperson: Ji Zhu) on August 25, 2023 (Approval Number: IRB-2023-744). The study was registered before patient enrollment at the Chinese Clinical Trial Registry (Registration No. ChiCTR2300075980). It was conducted at Zhejiang Cancer Hospital between August 2023 and March 2024. The study design was a prospective, randomized clinical trial with non-blinded intervention. Written informed consent was obtained from all participants prior to the study. All necessary precautions were taken to ensure patient privacy.

A total of 70 female patients scheduled for a modified radical mastectomy under general anesthesia were enrolled (**Figure 1**). Inclusion criteria: (1) Female patients aged 25-65 years; (2) American Society of Anesthesiologists (ASA) physical status I or II; (3) Body mass index (BMI) between 18 and 28 kg/m$^2$; (4) No known allergy to medications used in the study; and (5) Scheduled for modified radical mastectomy or radical mastectomy for breast cancer. Exclusion criteria: (1) Patients with hepatic or renal dysfunction, severe hypertension, diabetes, coagulation disorders, cardiovascular diseases, or other critical illnesses; (2) Contraindications to regional nerve block, such as anatomical abnormalities of spine or thorax, or puncture site infection; (3) Allergy to narcotic drugs; (4) Pregnancy; (5) Chronic pain; (6) Chronic opioid use, substance abuse, or alcoholism; (7) Motion sickness; or (8) Communication disorder or

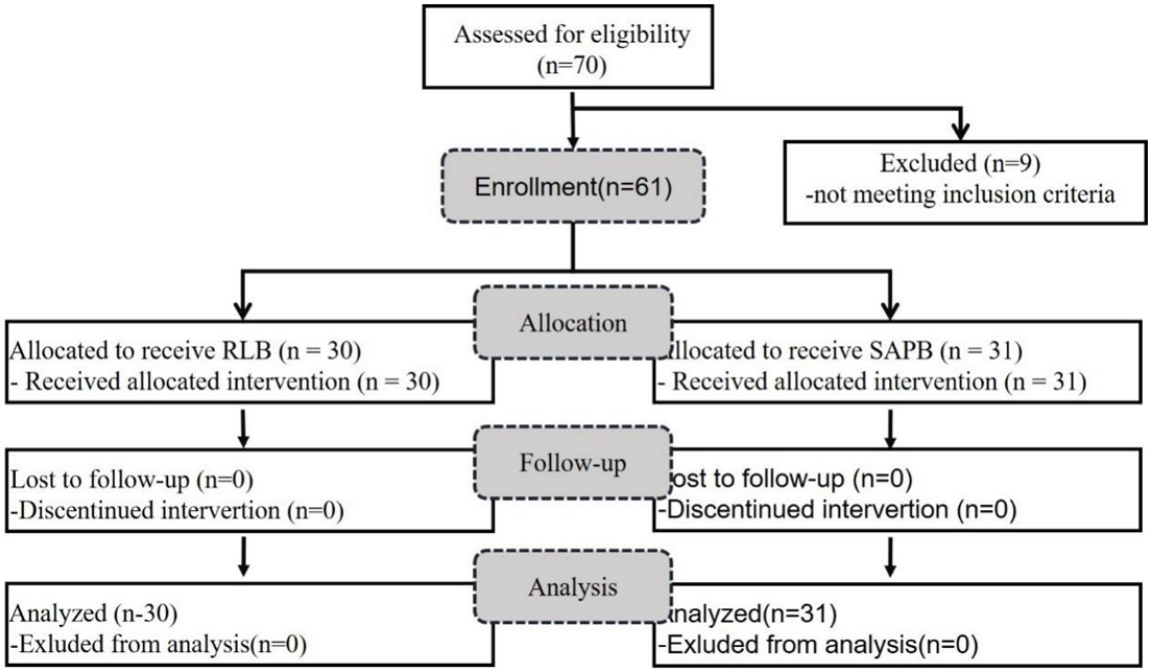


**Figure 1.** Study flow chart. RLB, retrolaminar block; SAPB, serratus anterior plane block.

inability to comprehend the visual analogue scale (VAS) scoring system.

Patients were randomly assigned to either the RLB group or the SAPB group in a ratio of 1:1. Random numbers from 1 to 70 were generated using EXCEL with the first 35 numbers assigned to the RLB group and the remaining 35 to the SAPB group.

Due to the distinct analgesic techniques used in each group, blinding was not possible for patients, anesthesiologists, or surgeons. However, data collection and postoperative evaluations were performed by a separate physician who was blinded to group allocation.

All patients fasted for 8 hours prior to surgery and were allowed to consume clear fluids for up to 2 hours before surgery. No premedication was administered. Standard monitoring was applied throughout the perioperative period, including electrocardiography, non-invasive blood pressure, pulse oximetry, and end-tidal carbon dioxide measurement. Both RLB and SAPB procedures were completed by experienced anesthesiologists specialized in regional anesthesia. For SAPB, patients were placed in a lateral position with the operative side facing upward and the arm abducted. After disinfection of the skin with 5% povidone-iodine solution, an ultrasound system (Wisonic Labat®, 2-5 MHz, China) was used to identify the serratus anterior muscle between the third and fourth ribs along the posterior axillary line [15]. Using a low-frequency ultrasound probe in the sagittal orientation with a sterile cover, the anterior serratus plane was visualized. A total of 20 mL of local anesthetic, comprising 10 mL of 0.375% ropivacaine (AstraZeneca AB, 3G0081C70) and 10 mL of 1% lidocaine (Chaohui, F2309250), was injected into the anterior serratus plane (**Figure 2A**). For RLB, the ultrasound probe was placed in a sagittal orientation on the lateral side of the posterior median line to identify the lamina, erector spine muscle, and transvers spinalis muscles at the target thoracic segment (**Figure 2B**) [12]. A 20G puncture needle was inserted using an intraplane technique in a cephalocaudal direction. Once the needle contacted the lamina and aspiration revealed with no blood, gas, or cerebrospinal fluid, 20 mL of local anesthetic solution, comprising 10 mL of 0.375% ropivacaine and 10 mL of 1% lidocaine, was administered between the transvers spinalis muscle and lamina.

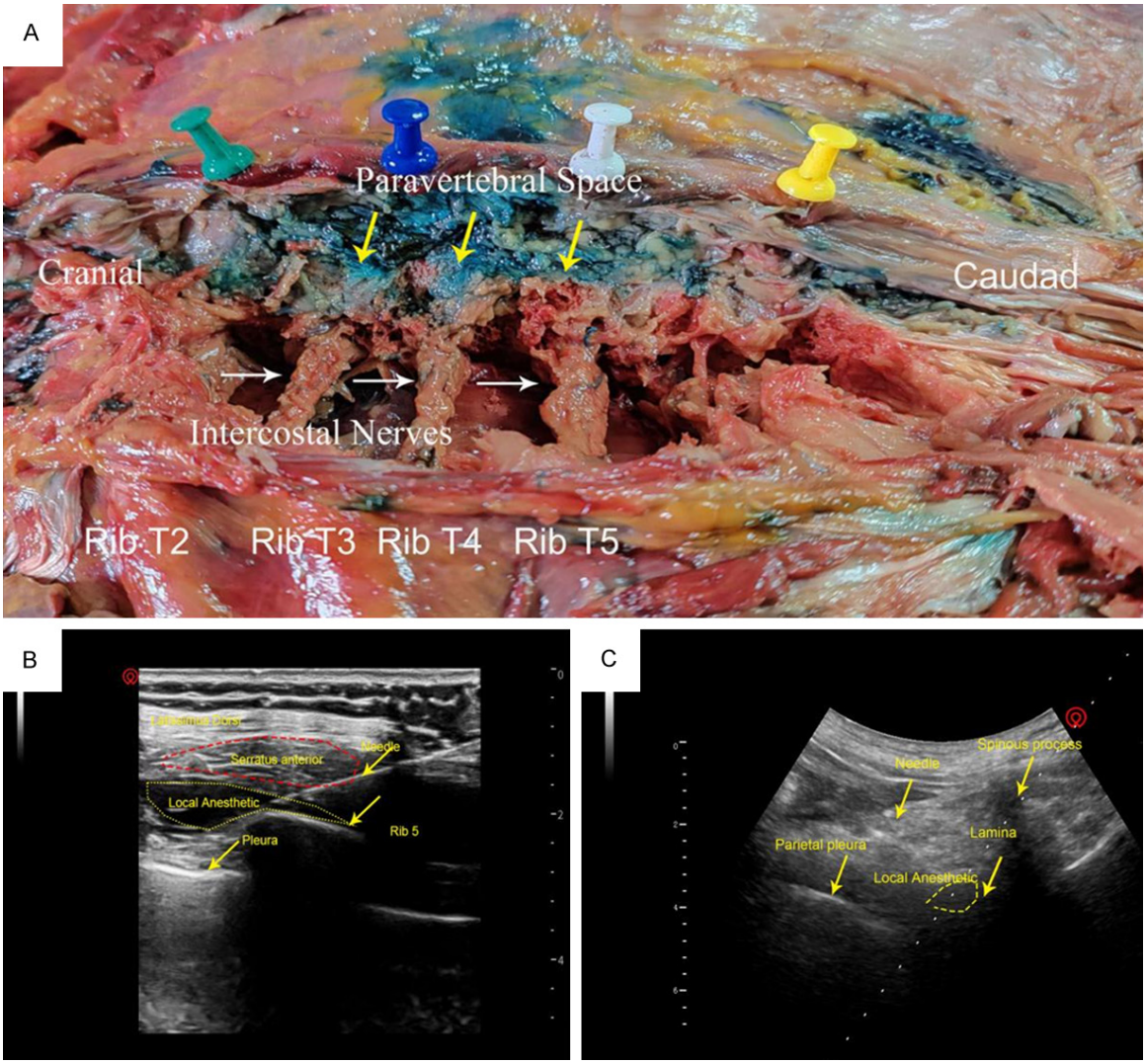


**Figure 2.** Anatomical and ultrasound image of RLB and SAPB. A. Cadaveric dissection showing the spread of blue dye injected into the retrolaminar spaces, with staining of the T3 and T5 spinal nerves within the paravertebral space. B. Ultrasound image illustrating the serratus anterior plane block. C. Ultrasound image of retrolaminar block. The yellow dotted line indicates the spread of local anesthetics, while the red dotted area outlines the serratus anterior muscle.

Five minutes after nerve block, anesthesiologists assessed the block plane by acupuncture at the medial and lateral nipple lines from T2 to T6. The anesthesiologists performing the blocks also monitored block-related complications, including pneumothorax, hypotension, and vascular injury. All patients received a standardized general anesthetic regimen, consisting of midazolam (Enhua, TMS23F08) 0.04 mg/kg, propofol (Corden Pharma S.P.A, X22098B) 1.5 mg/kg, sufentanil (Renfu, 31A091211) 4 ug/kg, and rocuronium (Tonghui, 23091903) 0.9 mg/kg for induction. Anesthesia was maintained with a continuous infusion of propofol at 5-6 mg/kg/h and remifentanil (Renfu, 30A07441) at 6-20 μg/kg/h. Intermittent positive pressure ventilation was applied following tracheal intubation, with a tidal volume of 6-8 mL/kg, respiratory frequency of 10-12 times/min, inspiratory-to-expiratory ratio of 1:2, and positive end-expiratory pressure (PEEP) of 3-5 $cmH_2O$. The bispectral index (BIS) was maintained between 40 and 60. Rocuronium was intermittently administered to maintain muscle relaxation, with train-of-four monitoring kept at 0-1. Dexamethasone (Runhong, 52305051) 5 mg and ondansetron (Tianheng, 220904A02) 8 mg were given for the prevention of postoperative nausea and vomiting (PONV).

**Table 1.** Comparison of baseline characteristics between the RLB and SAPB groups

| | Group R (n = 30) | Group S (n = 31) | *P*-Value |
|---|---|---|---|
| Age (y) | 52.8 ± 8.8 | 52.3 ± 9.08 | 0.825[a] |
| ASA Classification (I/II) | 8/22 | 12/19 | 0.320[b] |
| Height (cm) | 158.6 ± 4.62 | 158.9 ± 5.37 | 0.834[a] |
| Weight (kg) | 57.7 ± 7.39 | 58.7 ± 7.7 | 0.609[a] |
| BMI | 22 ± 2.99 | 23.2 ± 2.43 | 0.717[a] |

Note: [a]Independent t-test; [b]$\chi^2$ Test. RLB: retrolaminar block; SAPB: serratus anterior plane block; ASA: American Society of Anesthesiologists; BMI: body mass index; Data are presented as mean-standard deviation or absolute numbers.

**Table 2.** Comparison of dermatomal diffusion range between the RLB and SAPB groups

| Spread range | Group R (n = 28) | Group S (n = 29) | *P*-Value |
|---|---|---|---|
| Internal papillae | 3 (3-4) | 2 (1-2) | 0.006[a] |
| Lateral papillae | 3.5 (3-4) | 3 (2-4) | 0.236[a] |
| Contralateral, n (%) | 3 (10.7) | 1 (3.4) | 0.280[b] |
| Fail, n (%) | 4 (13.3) | 6 (19.4) | 0.530[b] |

Note: [a]Kruskal-Wallis test; [b]Fisher's Exact test; RLB: retrolaminar block; SAPB: serratus anterior plane block; Data are expressed as median [IQR: 1-3].

In addition, pilot cadaveric studies were conducted to evaluate the diffusion range of the retrolaminar block, using 20 mL of methylene blue solution (**Figure 2C**).

Pain was assessed using the Visual Analogue Scale (VAS), ranging from 0 to 10 (0 = no pain, 10 = the most severe pain) [19]. The primary outcome was the VAS scores during coughing at 6 hours after surgery. In addition, VAS scores at rest, during activity, and during coughing were recorded at 1, 6, 12, 24 and 48 hours after the operation. If the postoperative resting VAS score exceeded 4, patients received 50 mL of intravenous acetaminophen (Renfu, 230608DM) as rescue analgesia. Secondary outcomes included the extent of sensory block (T2 to T6 at the medial and lateral nipple lines) assessed by pin-prick testing, intraoperative hemodynamic changes, and analgesia-related adverse reactions, such as PONV, respiratory depression, and pulmonary atelectasis [20, 21]. Follow-up was completed after recording the VAS score and postoperative complications at 24 hours.

*Statistical analysis*

Our preliminary study demonstrated a VAS score of 0.74 ± 0.46 and 1.38 ± 1.19 in the RLB group and SAPB groups, respectively. Based on this, the minimum sample size was calculated to be 32 patients per group using PASS software 2021 (NCSS LLC, Kaysville, UT, USA). Considering a 10% dropout rate, 35 patients were enrolled in each group. IBM SPSS Statistics 26.0 (IBM Corp, Armonk, NY) was used for statistical analysis. Variables were expressed as mean ± standard deviation (SD), interquartile range [IQR]), or number (proportion), as appropriate. The Kolmogorov-Smirnov test was used to assess normality. Continuous variables were analyzed using the independent samples t-test or the Mann-Whitney U test, as appropriate. Ranked data were analyzed using the Kruskal-Wallis test. Categorical variables were analyzed using the $\chi^2$ test or Fisher's exact test. The non-inferiority of the primary outcome was evaluated using the two-sided 95% confidence interval (CI) of the mean difference. All statistical tests were two-tailed, and statistical significance was defined as $P < 0.05$.

## Results

Patient recruitment and study flow are illustrated in the CONSORT diagram (**Figure 1**). A total of 70 patients were screened for eligibility. Among them, 9 patients were excluded for not meeting the inclusion criteria. Ultimately, 61 patients were enrolled and randomly assigned to either the RLB group (n = 30) or the SAPB group (n = 31).

*Patient characteristics*

The demographic and clinical characteristics of the two groups are shown in **Table 1**. There were no significant differences between the two groups in terms of ASA, age, height, weight, or BMI. In addition, no adverse events occurred during the performance of either nerve block.

*Nerve block spread*

There was no significant difference in dermatomal spread at the lateral nipple line between the two groups (P = 0.392). However, the RLB group exhibited significantly greater and more consistent spread at the medial nipple line compared to the SAPB group (P = 0.006, **Table 2**).

**Table 3.** Comparison of intraoperative change in mean arterial blood pressure and heart rate between the RLB and SAPB groups

| Time point | MAP (mmHg) | | | HR (beats/min) | | |
|---|---|---|---|---|---|---|
| | Group R (n = 30) | Group S (n = 31) | *P*-Value | Group R (n = 30) | Group S (n = 31) | *P*-Value |
| Baseline | 88.2 ± 11.2 | 82.8 ± 8.3 | 0.034 | 67.8 ± 8.5 | 65.1 ± 8.8 | 0.227 |
| After skin incision | 91 ± 10.8 | 87.2 ± 10.1 | 0.155 | 66.9 ± 8.1 | 65.5 ± 9.2 | 0.518 |
| 5 minutes after skin incision | 93.4 ± 14.3 | 88.6 ± 10 | 0.133 | 65.1 ± 7.6 | 65 ± 9.1 | 0.987 |

Note: RLB: retrolaminar block; SAPB: serratus anterior plane block; Independent t-test; Data are presented as mean-standard deviation.

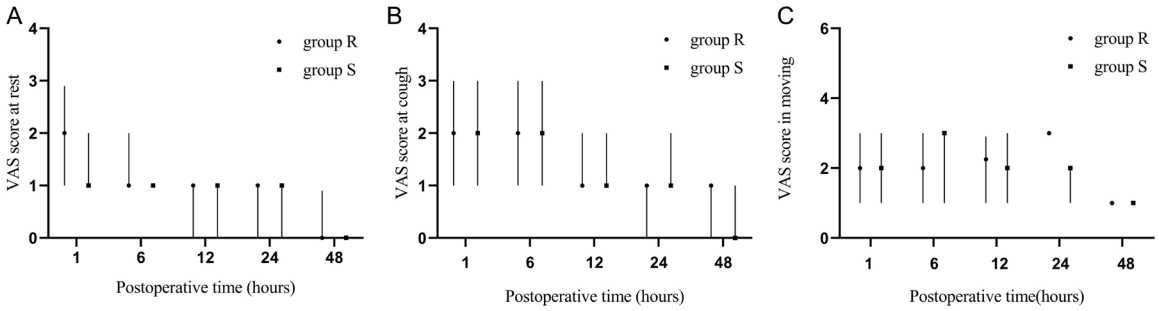


**Figure 3.** Postoperative VAS scores at rest, during coughing and movement. A. Postoperative VAS scores at rest; B. Postoperative VAS scores during coughing; C. Postoperative VAS scores during movement. VAS: Visual Analogue Scale.

*Hemodynamic changes*

The mean arterial pressure (MAP) and heart rate (HR) of the two groups at the time of skin incision and 5 minutes thereafter were slightly higher than the baseline values. However, there was no significant difference between the two groups in MAP and HR at skin incision (MAP: P = 0.57; HR: P = 0.34) and 5 minutes after surgery (MAP: P = 0.80; HR: P = 0.10) (**Table 3**).

*Postoperative analgesia and safety*

There was no significant difference in VAS scores during coughing at 6 hours postoperatively between the two groups (IQR: 1-3; P = 0.39, **Figure 3**). Additionally, there was no significant difference in VAS scores at resting, during coughing, or during movement at any other time point within 48 hours postoperatively (**Figure 3**). Some patients experienced postoperative complications, including PONV (P = 1), dizziness (P = 0.29), and respiratory depression (P = 0.31). The incidence of these adverse events did not differ significantly between the two groups (**Table 4**).

## Discussion

In this prospective, randomized, controlled clinical trial, we aimed to compare the analgesic effects of retrolaminar block (RLB) and serratus anterior plane block (SAPB) in patients undergoing breast mastectomy. Our results demonstrated that RLB provided analgesic efficacy comparable to that of SAPB, as reflected by similar VAS scores during coughing at 6 hours postoperatively. Both blocks utilized a mixture of 10 mL of 0.375% ropivacaine and 10 mL of 1% lidocaine, administered at the level of the fourth thoracic vertebra. While both techniques achieved similar sensory block ranges at the lateral nipple line, RLB resulted in significantly greater dermatomal spread toward the medial nipple line compared to SAPB. Intraoperative hemodynamic variables, including blood pressure and heart rate, remained stable and showed no significant differences between the two groups. These findings suggest that both RLB and SABP are effective regional anesthesia techniques for postoperative analgesia in breast surgery, providing satisfactory pain relief with comparable safety profiles. More-

**Table 4.** Comparison of postoperative outcomes between the RLB and SAPB groups

| | Group R (n = 30) | Group S (n = 31) | *P*-Value |
|---|---|---|---|
| PONV, n (%) | 3 (10) | 3 (9.7) | 1.000 |
| Dizziness, n (%) | 3 (10) | 1 (3.2) | 0.290 |
| Respiratory depression, n (%) | 1 (3.3) | 0 | 0.310 |
| Pulmonary atelectasis, n (%) | 0 | 0 | - |

Note: Fisher's Exact test; PONV, postoperative nausea and vomiting; RLB: retrolaminar block; SAPB: serratus anterior plane block; Data are expressed as the absolute numbers (with the percentage of the whole).

over, the incidence of postoperative complications, such as nausea, dizziness, and respiratory depression, did not differ significantly between the groups.

Both RLB and SABP are technically straightforward to perform, with reliable anatomical landmarks provided by adjacent bony structures, contributing to high success rates [12, 22]. Previous studies on dye diffusion suggest that injection volume significantly influences the extent of anesthetic spread and the effectiveness of nerve blockade. However, there remains controversy regarding the precise anatomical mechanisms and diffusion patterns of anesthetic agents following RLB in cadaver studies. Some dye diffusion studies have shown that an injection volume of 10 mL does not reach the paravertebral space (PVS), whereas 20 mL can spread across 1 to 3 vertebral levels within the PVS, though not into the epidural space. Conversely, other studies have reported that 20 mL of dye may extend into the intervertebral foramen and even the epidural space via the RLB pathway [23]. Additional cadaveric experiments using 30 mL of methylene blue in the retrolaminar space revealed diffusion across approximately 3 paravertebral levels and an average of 5 retrolaminar levels in both human and porcine models [10]. In comparison, cadaveric experiment of SABP demonstrated that 20 mL methylene blue could stain the intercostal nerves from the 3rd to the 6th thoracic level [22, 24]. Therefore, we performed pilot experiments on the extent of RLB in cadavers with 20 mL methylene blue diluent, which demonstrated that RLB can block the posterior rami and intercostal nerves (**Figure 2A**). Considering trial safety and referencing previous clinical studies, we selected 20 mL as the injection volume for anesthetic administration. To achieve both rapid onset and prolonged analgesic effects, we used a combination of 1% lidocaine and 0.375% ropivacaine.

Previous studies have suggested that RLB offers superior analgesia during the first 4-6 h after surgery [25]. Additionally, multiple reports have indicated that RLB results in lower VAS scores at 6 hours postoperatively compared with the control group, especially during coughing [26]. Therefore, the VAS score during coughing at 6 hours postoperatively was selected as the primary endpoint for evaluating the analgesic efficacy of the nerve block.

Pain perception is inherently dynamic and influenced by multiple factors over time. Resting pain scores offer only a baseline measure of postoperative pain. However, effective coughing and expectoration are essential for clearing respiratory secretions and preventing pulmonary complications following surgery. Similarly, regular upper limb functional exercises are necessary to reduce the risk of postoperative axillary lymphedema and dysfunction. Notably, movement-induced friction at the surgical site often exacerbates pain compared to rest. Therefore, to capture the multifaceted and evolving nature of postoperative pain, this trial incorporated assessments under three conditions (rest, coughing, and rehabilitation exercises) at multiple time points.

Our results showed reduced pin-prick sensation across 3-4 intercostal spaces near the injection site, although the extent of spread varied among patients. This distribution is consistent with the dye diffusion patterns observed in cadaver studies, suggesting that 20 mL dose of local anesthetic can exert analgesic effects in thoracic surgery by blocking the anterior branches of the spinal nerves [27]. For SAPB, previous studies have reported a sensory block range covering approximately five intercostal spaces at the midaxillary line. However, the range of deep anterior serratus block in the posterior axillary plane remains unverified [28]. In our study, the sensory block ranges of RLB and SAPB were evaluated and compared. Results indicated that most sensory block ranges spread across 3 to 4 segments, with

the SAPB group predominantly displaying a two-segment block range in the medial papilla. This disparity might be due to insufficient diffusion time during pin-prick testing. Moreover, the conservative use of 20 mL of local anesthetic might have limited the observable difference in diffusion range between RLB and SAPB. Future investigations employing larger injection volumes, such as 30 mL, may provide a clearer comparison of the analgesic coverage offered by these two techniques.

Huang et al. reported that the intraoperative remifentanil consumption was reduced following a single administration of RLB in patients undergoing breast surgery [16]. In our surgery, we evaluated surgical stress by monitoring changes in blood pressure and heart rate during skin incision, as previously described [23, 29]. Both groups exhibited minimal hemodynamic fluctuations, indicating limited stress responses. This suggests that total intravenous anesthesia combined with local anesthesia offers effective analgesia. However, these parameters were insufficient to distinguish between the two nerve block techniques.

Mayes et al. reported that a single-injection RLB provided adequate postoperative pain relief for about 4 hours [22]. Similarly, Onishi et al. found significantly lower pain scores in the RLB group compared to the control group within the first 2 hours after surgery [30]. Based on these findings, we evaluated the VAS score over a 48-hours period, with the primary outcome defined as the VAS score during coughing at 6 hours postoperatively. In our study, ultrasound-guided RLB effectively reduced postoperative pain, although it did not demonstrate a significant advantage over SAPB. Previous trials have indicated that RLB offers improved analgesic efficacy compared to erector spinae blocks, but is generally less effective than paravertebral nerve blocks [31, 32]. Our findings indicate that RLB provides reliable postoperative analgesic effect, with a high success rate and short procedure time. These characteristics make RLB a practical and efficient alternative for regional anesthesia in breast cancer surgery.

## Limitations of the study

Several limitations of this study should be acknowledged. First, administering RLB and SAPB while patients were awake may have caused discomfort during assessment of the sensory block range. Second, we did not record the surgical duration, which could impact postoperative analgesia outcomes. Third, our evaluation of intraoperative stress relied solely on blood pressure and heart rate measurements, which may not fully capture the physiological stress response throughout the entire procedure. Lastly, some physicians reported that SAPB occasionally interfered with the clinical assessment of tissue edema in the surgical field.

## Conclusions

Ultrasound-guided RLB and SAPB provides comparable analgesic efficacy in patients undergoing radical mastectomy. However, RLB exhibits a more consistent and extensive spread of local anesthetic. Based on these findings, RLB may be considered a preferable regional anesthesia technique for postoperative analgesia in breast cancer surgery.

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## Disclosure of conflict of interest

None.

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