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Effects of serratus posterior superior intercostal plane block on postoperative analgesia in patients undergoing breast cancer surgery: a randomized controlled trial

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Abstract

Background The serratus posterior superior intercostal plane block (SPSIPB) is a newly described truncal block. This study aimed to compare the effects of SPSIPB with conventional methods on postoperative opioid consumption and pain scores within 24 h postoperatively.

Methods This randomized controlled trial included 60 patients aged 18–65 years with an American Society of Anesthesiologists Physical Status of I–III. Patients were randomly assigned to either the SPSIPB or the control group. The primary outcome was cumulative opioid consumption within the first 24 h postoperatively. Secondary outcomes included resting and dynamic Numerical Rating Scale (NRS) pain scores, Quality of Recovery (QoR)-15 questionnaire scores, intraoperative remifentanil consumption, and the incidence of postoperative nausea and vomiting.

Results Total tramadol consumption was significantly lower in the SPSIPB group during the first 12 h and at the end of the 24th hour postoperatively compared with the control group ($p < 0.05$). The dynamic NRS score at 0 h postoperatively was lower in the SPSIPB group ($p = 0.001$), whereas no significant differences in NRS scores were observed at other time-points. The postoperative QoR-15 scores were significantly higher in the SPSIPB group compared with the control group. Furthermore, the SPSIPB group had significantly lower intraoperative remifentanil consumption ($p = 0.003$). Nausea and vomiting were more frequent at 12 and 24 h postoperatively in the control group compared with the SPSIPB group.

Conclusions Serratus posterior superior intercostal plane block significantly reduced opioid use, and improved recovery quality after oncoplastic breast surgery.

Trial registration NCT06225908, registered at ClinicalTrials.gov.

Keywords Serratus posterior superior intercostal plane block, Breast surgery, Postoperative pain management, Opioid consumption, Regional anesthesia

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Background

Cancer remains a leading cause of death globally and poses a significant obstacle to extending life expectancy. Among women, breast cancer has surpassed lung cancer as the most commonly diagnosed malignancy, with an estimated 2.3 million new cases annually [1]. The management of non-metastatic breast cancer typically involves a combination of preoperative and postoperative systemic therapies, such as chemotherapy, endocrine therapy, and immunotherapy using monoclonal antibodies targeting tumor receptors, alongside surgery and radiation therapy. Early postoperative complications, including wound infections, seroma formation, hematomas, and pain, are frequently observed during the initial recovery period [2].

Pain is a well-recognized postoperative complication of breast surgery, with substantial adverse effects on both recovery and quality of life [3]. Studies indicate that 60% of women experience chronic pain and 40% experience acute postoperative pain following breast cancer surgery [4, 5]. Poorly managed postoperative pain not only exacerbates stress, anxiety, and sleep disturbances but also leads to serious consequences, including prolonged hospital stays, elevated inflammatory cytokine levels, and activation of the sympathetic nervous system [6, 7].

Perioperative pain management for breast surgery involves a range of pharmacological and regional anesthetic techniques. These include paracetamol, nonsteroidal anti-inflammatory drugs, selective cyclooxygenase-2 inhibitors, ultrasound-guided paravertebral and pectoral nerve blocks, and local anesthetic infiltration at the wound site [4]. In 2023, Tulgar et al. [8] introduced the serratus posterior superior intercostal plane block (SPSIPB) as a novel technique in a case series involving cadavers and five patients. This approach provides almost complete sensory block in the back of the neck, shoulder, axilla, and hemithorax. It has shown promise for various surgical indications, including breast, shoulder, and thoracic procedures.

In this study, we aimed to investigate the effects of SPSIPB on the analgesic requirement in the first 24 h after oncoplastic breast surgery.

Methods

Study design

This prospective randomized controlled trial was conducted at Zonguldak Bülent Ecevit University Hospital between January and March 2024. Ethical approval was obtained from the Local Ethics Committee (protocol number: 2023-12-13/12; ClinicalTrials.gov identifier: NCT06225908). All patients received detailed information about the study, and both written and verbal informed consent were obtained. Participants were educated on the use of the Numerical Rating Scale (NRS), the Quality of Recovery (QoR)-15 questionnaire, and the Patient-Controlled Analgesia (PCA) device. The study was conducted in adherence to the Consolidated Standards of Reporting Trials guidelines.

Study population

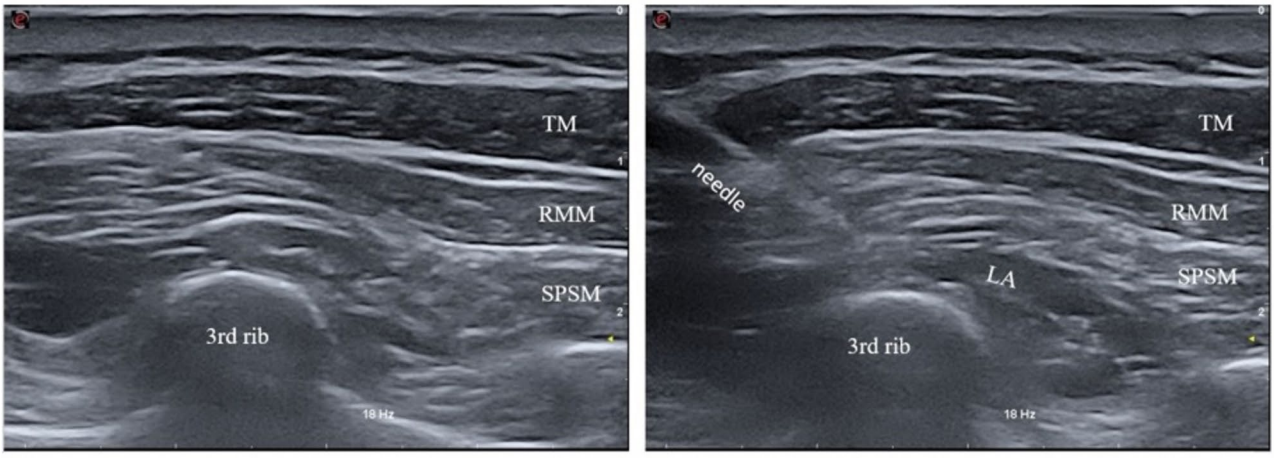
Sixty patients, aged 18–65 years, with an American Society of Anesthesiologists Physical Status (ASA PS) I-III, scheduled for elective unilateral oncoplastic breast surgery (modified radical mastectomy and axillary lymph node dissection) under general anesthesia, were included in the study. Exclusion criteria included patients who declined participation, had ASA PS IV–V, a known allergy to local anesthetics, coagulopathy, infection at the block site, those who will not undergo axillary dissection, chronic analgesic use, were uncooperative, or were undergoing bilateral surgery. Patients were randomized into two groups using a computer-assisted program and the sealed envelope method: SPSIPB group ($n = 30$) and control group ($n = 30$). Randomization and preparation of sealed envelopes were performed by different non-study staff.

Serratus posterior superior intercostal plane block

To ensure standardization of the study, all blocks were administered by the same anesthesiologist (ÇB), who had previously performed this block at least 50 times. Patients in the SPSIPB group were transferred to a block room before surgery. Following routine monitoring, 1 mg of midazolam was administered for sedation. Patients were positioned prone, and after ensuring proper sterilization, the SPSIPB procedure was performed using a linear ultrasound probe (3–13 mHz, MyLab X7; Esaote, Genoa, Italy). The probe was positioned along the medial border of the scapula at the level of the second and third ribs on the surgical side. Key anatomical structures, including the trapezius, rhomboid major muscle (RMM), and serratus posterior superior muscle (SPSM), as well as the second and third ribs, were identified. Using the in-plane technique, the needle was advanced into the fascial plane between the third rib and the SPSM. Proper placement was confirmed by injecting 1–2 mL of isotonic solution, followed by the administration of 20 mL of 0.25% bupivacaine after negative aspiration (Fig. 1). Twenty minutes after the block procedure, patients were transferred to the operating room.

General anesthesia

General anesthesia was administered to all patients, with routine monitoring supplemented by bispectral index monitoring. Intubation was performed following standard induction using intravenous lidocaine (1 mg/kg), propofol (2–3 mg/kg), fentanyl (1 μg/kg), and rocuronium (0.6 mg/kg). All surgeries were performed by



TM: Trapezius muscle, RMM: Rhomboid major muscle, SPSM: serratus posterior superior muscle, LA: Local anesthetic

Fig. 1 Ultrasound image of SPSIPB application

the same surgeon. During the procedure, bispectral index values were maintained between 40 and 60 using sevoflurane, and remifentanil was infused at a rate of 0.05–1 μg/kg/min, as needed. Hemodynamic data were recorded at specific intervals throughout the intraoperative period. Intravenous paracetamol (10 mg/kg), tramadol (1 mg/kg), and metoclopramide (10 mg) were administered 30 min before the end of the operation. Remifentanil infusion was discontinued with the final suture, and the total amount consumed was recorded. The time from the final suture to extubation was recorded and defined as the emergence time. At the conclusion of surgery, all patients were extubated using appropriate doses of neostigmine and atropine, and subsequently transferred to the post-anesthesia care unit (PACU). The durations of anesthesia and surgery were recorded.

Postoperative analgesia protocol

Patients were monitored in the PACU, where a PCA device containing tramadol was provided. The PCA settings included no basal infusion, a 10 mg bolus dose, and a 20-minute lockout interval. The time of arrival at the PACU was designated as hour 0. Resting and dynamic (coughing) NRS scores were assessed in the PACU. For patients with an NRS score of ≥ 4, 25 μg of intravenous fentanyl was administered as a rescue analgesic. Pain was reassessed 15 min later, and if the NRS score remained ≥ 4, an additional dose of fentanyl was given. The total amount of rescue analgesics administered before discharge from the PACU was recorded. Any complications, including nausea, vomiting, hypotension, bradycardia, respiratory depression, or pruritus, were documented during the PACU stay. Patients were transferred to the ward once a Modified Aldrete score of ≥ 9 was achieved.

In the ward, 10 mg/kg of paracetamol was administered every 8 h throughout the postoperative period. Resting and dynamic NRS scores were evaluated and recorded at 1, 2, 6, 12, and 24 h postoperatively. During these evaluations, the Ramsey Sedation Scale scores and any complications were also documented. For uncontrolled pain (NRS ≥ 4) despite the use of PCA and paracetamol, 75 mg of intramuscular diclofenac sodium was given as a rescue analgesic. If the pain persisted following intramuscular injection, 0.25 mg/kg of intravenous pethidine was administered. The amount of rescue analgesics administered postoperatively was recorded. Treatments for nausea and vomiting were documented over the first 24 h postoperatively. At the 24-hour mark, patients completed the QoR-15 questionnaire again. The PCA device was then terminated, and the total opioid consumption and the number of PCA requests over 24 h were recorded.

The primary outcome was the cumulative opioid consumption within the first 24 h postoperatively. Secondary outcomes included resting and dynamic NRS pain scores, QoR-15 questionnaire scores, intraoperative remifentanil consumption, and the incidence of postoperative nausea and vomiting.

Sample size

The sample size was estimated using the G*Power program (Heinrich Heine University, Düsseldorf, Germany) based on a pilot study conducted prior to the main study. For the pilot, 10 patients not included in the final analysis were enrolled in each group. The calculation was based on the total opioid consumption within

24 h postoperatively, using a 95% confidence interval, and a power of 90% (d = 0.9). The opioid consumption was recorded as 44 ± 35.96 mg in the SPSIPB group and 96.2 ± 73.22 mg in the control group. Based on these parameters, the minimum required sample size per group was determined to be 28. To account for potential dropouts, 32 patients were included in each group.

Statistical analysis

Statistical analyses were conducted using IBM SPSS software (version 20.0; IBM Corp., Armonk, NY, USA). The Kolmogorov–Smirnov test was applied to assess the normality of data distribution. Continuous data are presented as mean ± standard deviation. Categorical variables were analyzed using the chi-square test. For normally distributed data, the Student's t-test was employed, whereas the Mann–Whitney U test was used for data that did not follow a normal distribution. Statistical significance was set at $p < 0.05$. Bonferroni correction was used for the analysis of NRS. Statistical significance was adjusted to $p < 0.0083$ due to measurements from six time points.

Results

In this study, 64 patients were assessed for eligibility, of whom two declined to participate. Furthermore, one patient from the SPSIPB group and one from the control group were excluded owing to PCA-related issues during follow-up. Consequently, 60 patients were included in the statistical analyses (Fig. 2). No significant differences were observed in demographic or surgical data between the two groups. However, the SPSIPB group demonstrated significantly lower intraoperative remifentanil consumption compared with the control group ($p = 0.003$; Table 1).

In the PACU, fentanyl was administered to one patient in the SPSIPB group and three patients in the control group, with no significant difference between the groups ($p = 0.612$). Similarly, no significant differences were observed between the groups regarding complications encountered in the PACU. The resting and dynamic NRS scores are presented in Table 2. At 0 h post-surgery, the resting and dynamic NRS scores were significantly lower in the SPSIPB group compared with the control group ($p = 0.01$ and 0.001, respectively). Moreover, the dynamic NRS score at 1 h post-surgery was significantly lower in

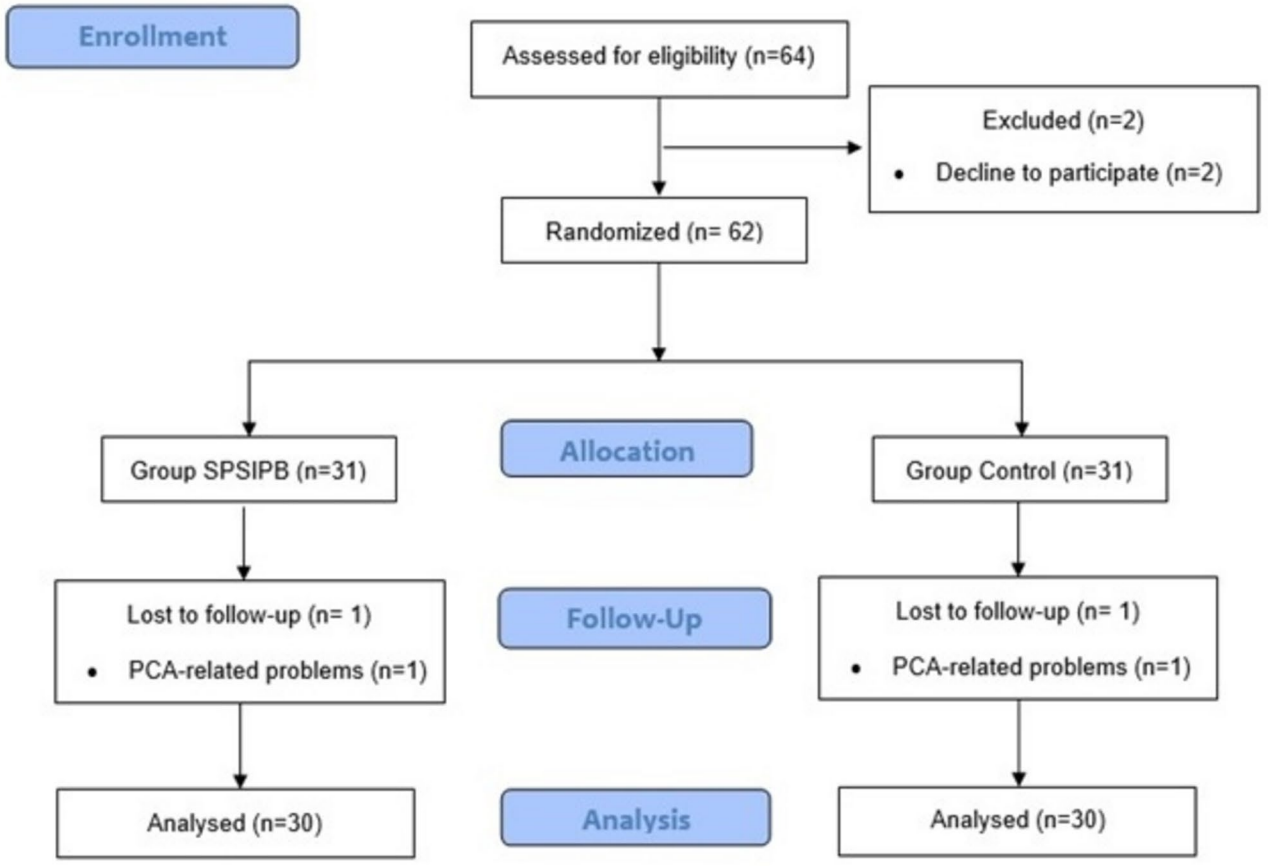


Fig. 2 CONSORT flow diagram

Table 1 Patient demographics and surgical characteristics

Variable	SPSIPB group ($n=30$)	Control group ($n=30$)	*p*-value
Age (years)[#]	55.3 ± 10.2	53.7 ± 10.1	0.539
BMI (kg/m^2)[#]	28.7 ± 4.6	29.3 ± 5.7	0.646
ASA classification (I/II/III)[*]	1/22/7	2/24/4	0.534
Duration of surgery (min)[#]	87.8 ± 43.0	90.4 ± 30.5	0.336
Duration of anesthesia (min)[#]	120.4 ± 45.0	128.5 ± 36.3	0.165
Emergence time (min)[#]	7.93 ± 3.54	6.93 ± 3.42	0.271
Intraoperative remifentanil consumption (μg)[#]	360.8 ± 286.4	714.1 ± 661.0	**0.003**[¥]

ASA, American Society of Anesthesiologists; **BMI**, body mass index; **SPSIPB**, serratus posterior superior intercostal plane block

[#]: mean ± standard deviation

[*]: number of patients (n)

[¥]: $p < 0.05$

Table 2 Comparison of resting and dynamic NRS scores over time

Time	NRS_R/NRS_D[#]	SPSIPB group ($n=30$)	Control group ($n=30$)	*p*-value
0h	NRS_R	1 (0–4)	2 (0–6)	0.01
	NRS_D	2 (0–5)	3 (1–7)	**0.001**[*]
1 h	NRS_R	1 (0–4)	2 (0–4)	0.054
	NRS_D	2 (0–5)	3 (0–5)	0.014
2h	NRS_R	1 (0–4)	1 (0–2)	0.258
	NRS_D	2 (0–5)	2 (0–3)	0.161
6h	NRS_R	0 (0–2)	1 (0–2)	0.164
	NRS_D	1 (0–3)	2 (0–3)	0.180
12 h	NRS_R	0 (0–3)	0.5 (0–2)	0.725
	NRS_D	1 (0–4)	1 (0–3)	0.758
24 h	NRS_R	0 (0–3)	0 (0–2)	0.236
	NRS_D	1 (0–4)	1 (0–2)	0.639

NRS_R, resting Numerical Rating Scale; **NRS_D**, dynamic Numerical Rating Scale; **SPSIPB**, serratus posterior superior intercostal plane block

[#]: median (min-max)

[*]: $p < 0.0083$

Table 3 Cumulative Tramadol consumption and PCA usage

Variable	SPSIPB group ($n=30$)	Control group ($n=30$)	*p*-value
Total number of PCA requests[¥]	5 (0–20)	11 (1–79)	**0.013***
0–12hour opioid consumption (mg)[#]	35.33 ± 22.39	66.00 ± 50.07	**0.014***
12–24hour opioid consumption (mg)[#]	11.33 ± 15.25	18.67 ± 18.14	0.083
Total opioid consumption (mg)[#]	46.67 ± 27.70	84.67 ± 56.24	**0.008***
QoR-15 score 24 h after surgery[¥]	135 (105–150)	124.5 (82–142)	**0.009***

SPSIPB, serratus posterior superior intercostal plane block; **PCA**, patient-controlled analgesia. **QoR**, Quality of Recovery

[#]: mean ± standard deviation

[*]: $p < 0.05$

[¥]: median (min-max)

the SPSIPB group ($p = 0.014$). However, no significant differences in NRS scores were observed between the groups at other time points.

The total number of PCA requests was significantly lower in the SPSIPB group compared with the control group ($p < 0.05$). Furthermore, total tramadol consumption was significantly reduced in the SPSIPB group during the first 12 h and at the end of the 24-hour postoperative period compared with the control group ($p < 0.05$). However, no significant difference in tramadol consumption was observed across the groups between the 12th and 24th hours postoperatively (Table 3). Notably, no rescue analgesia was required in either group.

When comparing the global QoR-15 scores between the two groups, the postoperative QoR-15 global score were significantly higher in the SPSIPB group compared with the control group ($p < 0.05$; Table 3).

In the control group, nausea and vomiting were more frequently observed at 12 and 24 h postoperatively compared with the SPSIPB group (12 h: control, $n = 12$; SPSIPB, $n = 4$; $p = 0.039$; 24 h: control, $n = 20$; SPSIPB, $n = 9$; $p = 0.042$). No significant differences were observed between the groups at other time points. Other side effects were similar between the two groups. In addition, no block-related complications were reported in the SPSIPB group, and no hemodynamic instability occurred in either group during the perioperative period.

Discussion

This study demonstrates that SPSIPB effectively reduces total opioid consumption within the first 24 h following breast cancer surgery. The NRS scores were almost similar between the groups. The QoR-15 scores at 24 h postoperatively showed a significant improvement in the SPSIPB group compared with the control group.

Regional anesthesia plays a crucial role in multimodal analgesic regimens to prevent both acute and chronic postoperative pain. Pharmacological agents targeting nociceptive pathway receptors activated by surgical incisions also contribute to pain management [9, 10]. Patients undergoing mastectomy often experience severe postoperative pain, and although various regional anesthesia techniques have been described to reduce pain intensity, their relative effectiveness remains unclear [11]. Tulgar et al. [8] introduced a novel block, the SPSIPB, in 2023. Their anatomical study demonstrated that this block targets the deep fascia of the RMM, erector spinae muscle, subscapularis/serratus anterior muscles, and intercostal nerves, resulting in an almost complete sensory blockade of the back of the neck, shoulder, and hemithorax. In this study, we applied this innovative regional technique to patients undergoing oncoplastic breast surgery with axillary lymph node dissection.

In a case series involving seven patients who underwent modified radical mastectomy and received SPSIPB before extubation, the mean tramadol consumption was reported as 35.7 mg. Among these patients, one required 100 mg, three required 50 mg, and the remaining three did not require additional analgesics within the first 24 h postoperatively. NRS scores were relatively high in the early postoperative hours but decreased significantly by the 24-hour follow-up [12]. Similarly, another study presenting two cases reported that patients who received SPSIPB did not require additional opioid analgesics during the first 24 h after breast surgery, with the block providing adequate postoperative analgesia [13]. In our study, the mean tramadol consumption during the first 24 h was 46.6 mg in the SPSIPB group and 84.6 mg in the control group, with no difference observed in tramadol consumption between 12 and 24 h. These findings indicate that SPSIPB provided effective analgesia in the postoperative period by significantly reducing opioid consumption.

Remifentanil is a phenylpiperidine opioid analgesic characterized by rapid onset, ultra-short duration of action, and rapid recovery, making it a commonly used agent in intraoperative settings. However, remifentanil is associated with acute opioid tolerance (AOT) and/or opioid-induced hyperalgesia (OIH), two distinct pharmacological phenomena involving different mechanisms [14]. Although all opioids can induce dose-dependent hypersensitivity, short-acting opioids such as remifentanil are more likely to contribute to elevated postoperative pain scores, increased morphine consumption, and pain hypersensitivity. Studies have shown that relatively large doses of intraoperative remifentanil can trigger postoperative hyperalgesia more rapidly and frequently compared with longer-acting opioids [15, 16]. In our study, the SPSIPB group demonstrated significantly lower intraoperative remifentanil consumption and reduced resting and dynamic NRS scores in the PACU. These findings suggest that preoperative administration of SPSIPB as part of a multimodal analgesia regimen may serve as an effective and protective strategy against OIH/AOT associated with remifentanil.

The QoR-15 questionnaire provides a comprehensive assessment of postoperative recovery, encompassing physical, emotional, and psychosocial dimensions [17]. Evaluating the quality of postoperative recovery not only measures the impact of analgesic interventions on pain but also assesses overall recovery, including improvements in physical and psychosocial functioning [18–20]. Previous studies investigating the effects of erector spinae plane block and serratus plane block on postoperative recovery after breast cancer surgery reported that although pain scores at the 24th postoperative hour were similar between the groups, the QoR-15 scores at the same time point were higher in the block groups compared with the control groups [21, 22]. In our study, although no difference was observed between the control and SPSIPB groups in NRS scores at the 24th hour, the global QoR-15 score was significantly higher in the SPSIPB group. These results suggest that the QoR-15 questionnaire offers more meaningful clinical insights into postoperative recovery compared with NRS scoring, as it evaluates pain over 24 h rather than at a specific time point.

This study has some limitations. First, the follow-up period was limited to 24 h postoperatively, and the effects of SPSIPB during longer follow-up periods were not evaluated. Although the impact of SPSIPB on acute pain was assessed, its effects on chronic pain remain undetermined. Second, SPSIPB was not compared with other regional techniques, such as the paravertebral block, which may provide additional insights. Third, the sample

size was calculated based on postoperative opioid consumption, and different results may have been obtained if the primary endpoint had been the QoR-15 score, as in other studies. Finally, we did not evaluate the block duration, length of hospital stay and, the dermatomal coverage achieved by SPSIPB in the study population.

Conclusions

The SPSIPB technique, when incorporated into a multimodal analgesia regimen for oncoplastic breast surgery, effectively reduced opioid consumption. In addition, we have demonstrated that SPSIPB increases Quality of Recovery-15 score in these patients.

Abbreviations

SPSIPB	Serratus posterior superior intercostal plane block
NRS	Numerical rating scale
QoR-15	Quality of Recovery-15
ASA PS	American Society of Anesthesiologists Physical Status
PCA	Patient-controlled anesthesia
RMM	Rhomboid major muscle
SPSM	Serratus posterior superior muscle
PACU	Post-anesthesia care unit
AOT	Acute opioid tolerance
OIH	Opioid-induced hyperalgesia

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-025-03092-0.

Supplementary Material 1

Supplementary Material 2

Acknowledgements

Not applicable.

Author contributions

B.G.K. and Ç.B. designed the study; B.G.K. and Ç.B. supervised and carried out the clinical trial; Ç.B. and E.B. assisted with protocol implementation; B.G.K., Ç.B. and H.B. collected and analyzed the data; B.G.K. and Ç.B. wrote the manuscript and B.K.A. revised the manuscript; All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was performed in accordance with the declaration of Helsinki. Ethical approval from the Ethics Committee of the Zonguldak Bülent Ecevit University was obtained prior to initiation of the study (Protocol No: 2023-12-13/12). The patients were provided with a detailed explanation of the preoperative procedure, and verbal and written informed consent was obtained.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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