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ORIGINAL ARTICLE BREAST SURGERY

Preemptive Analgesic Efficacy of the Ultrasound-Guided Bilateral Superficial Serratus Plane Block on Postoperative Pain in Breast Reduction Surgery: A Prospective Randomized Controlled Study

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Abstract

Purpose Breast surgery is an exceedingly common procedure and associated with an increased incidence of acute and chronic pain. Preemptive regional anesthesia techniques may improve postoperative analgesia for patients undergoing breast surgery. The aim of this study was to evaluate the effect of preoperative bilateral serratus plane block on postoperative opioid consumption in patients undergoing breast reduction surgery.

Methods After ethical board approval, 40 patients undergoing breast reduction surgery were randomized into 2 groups: control group (Group C, $n = 20$) and serratus plane block group (Group SPB, $n = 20$). Group C received bilateral ultrasound-guided 2 ml 0.9% saline subcutaneously each block side, Group SPB received ultrasound-guided bilateral SPB with 0.25% bupivacaine 30 ml each side. The groups were administered the routine general anesthesia protocol. All operations were performed with the mediocentral pedicled reduction mammaplasty technique by the same surgeon. Postoperative analgesia was performed intravenously in the 2 groups twice a day with dexketoprofen trometamol 50 mg and patient-controlled analgesia with fentanyl. Postoperative analgesia was evaluated using the visual analog scale (VAS). Fentanyl consumption, additional analgesia requirement and opioid-related side effects were recorded during the first 24 h after surgery.

Results Compared with control, the VAS score was statistically lower in the SPB group during all measurement times ($p < 0.05$). The 24-h opioid consumption was significantly higher in the control group compared with the SPB group (372.50 ± 39.65 vs. 296.25 ± 58.08 μq, respectively; $p < 0.001$). In addition, the analgesia requirement was statistically lower in the SPB group (8/20 vs. 2/20, respectively, $p < 0.028$). Nausea or vomiting was observed more often in the control group than in SPB block (9/20 vs. 2/20, respectively, $p = 0.013$), whereas other side effects were similar for the two groups.

Conclusions SPB can be used safely bilaterally in the management of pain for breast reduction surgery as it is easy to perform, provides excellent analgesia, and reduces opioid consumption and opioid sparing effect.

Level of Evidence II This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Serratus plane block · Breast reduction surgery · Pain · Preemptive analgesia · Ultrasonography

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Introduction

Preemptive analgesia is treating postoperative pain by preventing central sensitization by preoperative administration of analgesics [1]. Postoperative pain in the breast and chest is a common problem with a highly complicated etiology. Most women undergoing breast surgery suffer

from pain extensive enough to disrupt their daily activities. Breast reduction and breast reconstruction for women with undesirable macromastia and related symptoms are increasingly performed all over the world [2]. Extensive and significant acute postoperative pain occurs due to these surgical procedures in the chest wall [3].

Several regional anesthetic techniques such as thoracic epidural analgesia, paravertebral block or local anesthetic infiltration are used for pain relief on breast surgery. Although the thoracic paravertebral block is a well-defined gold standard treatment for the relief of postmastectomy pain [4], anesthesiologists do not find it convenient to apply due to potential risks [5]. Furthermore, this method requires advanced skills and longer learning time. However; epidural anesthesia and paravertebral blockade are associated with risks, too, such as hypotension and spinal cord trauma due to central neuraxial interventions in the former and pneumothorax and neuraxial blockade complications in the latter. Moreover, coagulation profiles of patients should be taken into consideration when applying these blockades. Serratus plane block (SPB) is a new regional anesthetic technique that provides simple, safe, and effective postoperative analgesia compared to these two methods.

With the introduction of ultrasound (US) into the regional anesthesia practice, there has been a shift from the marking-guided method for needle insertion points to the ultrasound-guided blockade. Particularly this widespread use of ultrasound has made interfascial plane blockade techniques increasingly popular [6, 7]. The newly described blockade techniques, called the truncal, plane or interfascial blocks, can readily be applied under ultrasound guidance and can provide highly effective postoperative analgesia owing to the volume-based spread of local anesthetic drug between two muscle planes. Unlike peripheral nerve blocks, there is no need to block any nerve or nerve plexus. Local anesthetic agents spread throughout the muscle planes to reach the targeted nerve. These blockade methods are given different names in the abdominal and thoracic regions. SPB and PECS I–II blocks have been introduced for use in surgery at the pectoral region, and it has been reported that they provide effective postoperative analgesia [8]. Several case reports about the efficacy of SPB in both acute and chronic pain interventions are available in the literature [9, 10]. Also, some case reports about the effectiveness of serratus plane block in breast reconstruction surgery are available [11]; however, there are no randomized controlled studies in the literature.

The primary aim of this study was to investigate the preoperative effect of bilateral serratus plane block on postoperative opioid consumption in patients undergoing breast reduction surgery.

Material and Method

After obtaining the approval of the institutional ethics committee, a total of 40 patients, who would undergo breast reduction surgery and who agreed to participate in the study, were included. The study was registered with a clinical trials registry (ClinicalTrials.gov, identifier NCT02930733). These patients were in ASA I–II group, in the age range from 18 to 60 years; had no known cardiac, renal, hepatic or hematologic diseases; had no history of peptic ulcer, gastrointestinal bleeding, allergy, chronic pain or routine analgesic use, and they did not use analgesics in the last 24 h.

Patients with central and peripheral neurological diseases, coagulopathy or anticoagulant drug use, allergy to one of the drugs used in the study, and difficult-to-cooperate patients were excluded.

Using a computer program, patients were randomly divided into two equal groups. Group 1 was defined as the control (C) group, and Group 2 was defined as the serratus plane block (SPB) group.

Group 1 (control group) Patients were taken to the regional anesthesia room 60 min before the surgery. For the application of anesthesia, the patient took a lateral decubitus position with the arm placed over the head, exposing the axilla. After dressing the US probe with sterile covers, 2 ml saline was injected subcutaneously at the level of the 4th and 5th ribs in the midaxillary line under US guidance [12]. The same procedure was repeated for the other breast.

Group 2 (serratus plane block group) Patients were taken to the regional anesthesia room 60 min before surgery. For the application of anesthesia, the patient took a lateral decubitus position with the arm placed appropriately to expose the axilla. After dressing the US probe with sterile covers and cleansing the skin, the latissimus dorsi and serratus muscles were visualized at the level of the 4th and 5th ribs in the midaxillary line in a longitudinal parasagittal orientation. Then, using the in-plane technique, a 100-mm ultrasound-visible nerve-blockade needle was advanced from the caudal to the cranial direction toward the fascia between the two muscles (Fig. 1a–c). After ensuring that no blood or air was aspirated, a test dose of 1–2 ml of saline was given. After confirming the intervention site, 30 ml of 0.25% bupivacaine was administered between the two muscles. The same procedure was repeated for the other breast.

Propofol (2 mg kg^{-1}), fentanyl (1–2 μg kg^{-1}), and rocuronium (0.6 mg kg^{-1}) were used for anesthesia induction. Anesthesia was maintained with 1–2% sevoflurane and a mixture of 50% O_2 and 50% N_2O. The muscle relaxant effect was antagonized with 2.5 mg neostigmine

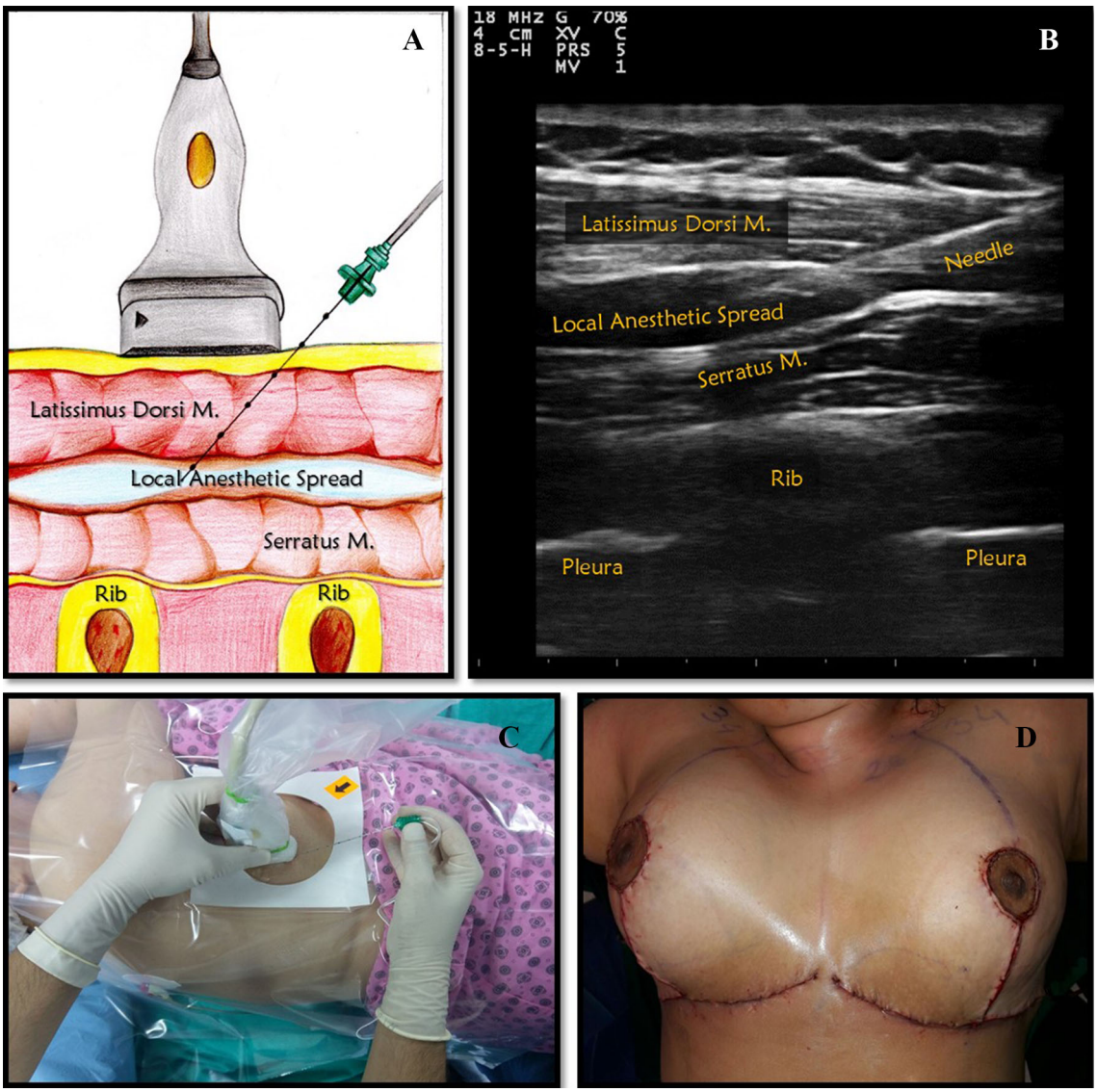

Fig. 1 **a** Basic illustration of serratus plane block (SPB). **b** Sonographic image of SPB. **c** Patient, probe and needle orientation for block procedure. **d** Medial-central pedicle technique of reduction mammoplasty

and 1 mg atropine after the operation. Then, the patients were extubated and taken to the post-anesthetic care unit (PACU).

Surgical Procedure

All operations were performed with the medial-central pedicle technique of reduction mammaplasty by the same surgeon (Fig. 1d). The skin was de-epithelialized according to the technique of medial-central pedicle mammoplasty. The medial-central pedicle, in a pyramidal shape and at 8 mm thickness, was elevated up to the pectoral fascia. The remaining breast segments in the lateral and lower quadrants of the breast were resected according to the key-hole pattern. Following hemorrhage control, the nipple-areola and the medial–lateral dermoglandular flaps were moved to their intended locations using staplers. A Jackson-Pratt drain was placed, extruding from the anterior axillary region. Following the key suturing process, the same procedure was performed in the opposite breast. After achieving symmetry in both breasts, the layers were sutured using the subcuticular technique; the subcutaneous tissue was sutured with 2–0 vicryl, the inverted T-incision was sutured with 3–0 monocryl, and the periareolar incision was sutured with 5–0 monocryl sutures. The patient did not develop any intraoperative complications, and the operation was terminated after dressing.

Postoperative Analgesia

Dexketoprofen 50 mg was given to both of the study groups 30 min before the end of the surgery, and it was repeated every 12 h postoperatively. Patient-controlled analgesia devices (PCA) were connected to the patients in the recovery room after surgery. The PCA device to provide fentanyl at a concentration of 10 μg/ml was programmed to deliver a loading dose of 50 μg, to maintain a 15-min lockout time, and to deliver a dose of 25 μg without any administration of basal infusion. The PCA therapy continued for 24 h. In the recovery room, the patients with VAS scores of 4 or higher were given meperidine at a dose of 25 mg and it was documented. The same protocol was applied to both of the study groups to obtain postoperative analgesia. Patients with Aldrete scores of 9 or higher were transferred to the inpatient facility. Postoperative follow-up procedures and evaluation of the patients were performed by an investigator, who was not informed of the study groups.

The time to the first requirement for analgesia (minutes) was defined as the time between the extubation time and the time when the VAS (visual analogue scale) pain score was ≥ 4. The postoperative pain was assessed in PACU in the hours 1, 2, 4, 8, 12, and 24 using VAS scoring when the patient was both at rest and engaged in physical activity (VAS 0 = no pain, VAS 10 = unbearable pain). Physical activity was defined as moving from the lying position to the half-sitting position. Postoperative opioid consumption was recorded as the consumed amount in the periods of 0–4 h, 4–8 h, 8–24 h, and the overall consumption in 24 h. All side effects related to blockade and opioids were documented.

Sample Size

The sample size was calculated using a preliminary study on 10 patients assigned to two study groups of five. The primary aim of that previous study was to evaluate fentanyl consumption in the first 24 h after surgery. In that preliminary study, fentanyl consumption was found to be 142.50 ± 84.20 μg in Group SPB and 272.80 ± 188.96 μg in Group C. Assuming that a fentanyl consumption amount of less than 130 μg in 24 h would indicate a significant difference between the two study groups; the number of patients 19 (x) to be assigned to each study group was determined to have 85% power and an alpha error of 0.05, using a G*Power version 3.1.9.2 (Kiel University, Kiel, Germany) software.

Statistical Analysis

Statistical analyses were performed using the IBM SPSS 20.0 software (SPSS Inc., Chicago, Illinois, USA). Kolmogorov–Smirnov and histogram tests were used for determining whether the data distribution was normal. The data were presented as mean ± standard deviation (SD). The categorical variables were analyzed using the Chi-square test. Student's t test was used for analyzing the normally distributed data. The Mann–Whitney U test was used for evaluating the data that did not conform to a normal distribution. $p < 0.05$ was considered statistically significant.

Results

A total of 47 patients were included in the study. After randomization, four patients in the control group and three patients in the SPB group were excluded because the surgical procedure deviated from the original plans. Data were analyzed in the two study groups, each containing 20 patients.

Demographic and clinical data are shown in Table 1. There were no statistically significant differences in age, weight, height, duration of surgery, duration of anesthesia, and excised volumes of breasts between the groups ($p > 0.05$).

Compared to the Group C, opioid consumption was statistically significantly lower in Group SPB in the first 24 h and at all time points of evaluation. The 24-h opioid consumption was significantly higher in the placebo group compared to the SPB group (372.50 ± 39.65 vs. 296.25 ± 58.08 μq, respectively; $p < 0.001$) (Table 2).

VAS scores were scaled during physical activity and at rest postoperatively. They were statistically significantly lower at all time points in the Group SPB compared to those found in Group C ($p < 0.05$) (Figs. 2, 3).

The time of first need for analgesic administration was statistically significantly longer in the Group SPB compared to the Group C (135.75 ± 69.40 min and 89.25 ± 38.22 min, respectively) ($p = 0.012$). The need for adjunctive analgesics was statistically significantly higher in Group C compared to the SPB group (8/20 vs. 2/20, respectively, $p < 0.028$). Nausea or vomiting was observed more often in the placebo group than in the Group SPB block (9/20 vs. 2/20, respectively; $p = 0.013$), whereas other side effects were similar for the two study groups.

Discussion

Our study has shown that in breast reduction surgery, performing an US-guided SPB before the surgery provides lower pain scores and less opioid consumption compared to the control group. We also observed opioid-related side

Table 1 Demographic and clinical data of study

	Group C (n = 20)	Group SPB (n = 20)	p
Age (year)	37.60 ± 5.98	36.40 ± 9.52	0.636[a]
Weight (kg)	77.65 ± 7.05	78.95 ± 4.47	0.489[a]
Height (cm)	164.45 ± 7.63	165.85 ± 5.91	0.520[a]
Surgery time (min)	165.50 ± 40.10	161.00 ± 45.47	0.742[a]
Anesthesia time (min)	189.25 ± 41.34	185.50 ± 45.99	0.788[a]
Resected breast mass (g)			
Right breast	1623.20 ± 387.28	1465.55 ± 345.19	0.182[a]
Left breast	1594.25 ± 408.35	1432.95 ± 359.35	0.193[a]
PONV (yes/no)	9/11	2/18	**0.013**[b]
First analgesic requirement time (min)	89.25 ± 38.22	135.75 ± 69.40	**0.012**[a]
Rescue analgesia (yes/no)	8/12	2/18	**0.028**[b]

Values are presented as mean ± standard deviation or number

Bold values denote statistical significance at the $p < 0.05$ level

C control, *SPB* serratus plane block, *PONV* postoperative nausea and vomiting

[a] Independent samples *t* test

[b] Chi-square test

Table 2 Opioid consumption time intervals and total opioid consumption

	Group C (n = 20)	Group SPB (n = 20)	p
0–4 h (μg)	135.00 ± 29.69	113.75 ± 20.64	**0.027**[α]
4–8 h (μg)	108.75 ± 18.63	88.75 ± 26.25	**0.014**[α]
8–24 h (μg)	128.75 ± 42.36	98.75 ± 30.86	**0.026**[α]
Total 24 h (μg)	372.50 ± 39.65	296.25 ± 58.08	**< 0.001**[β]

Values are presented as mean ± standard deviation

Bold values denote statistical significance at the $p < 0.05$ level

C control, *SPB* serratus plane block

[α]Mann–Whitney *U*

[β]Independent samples *T* test

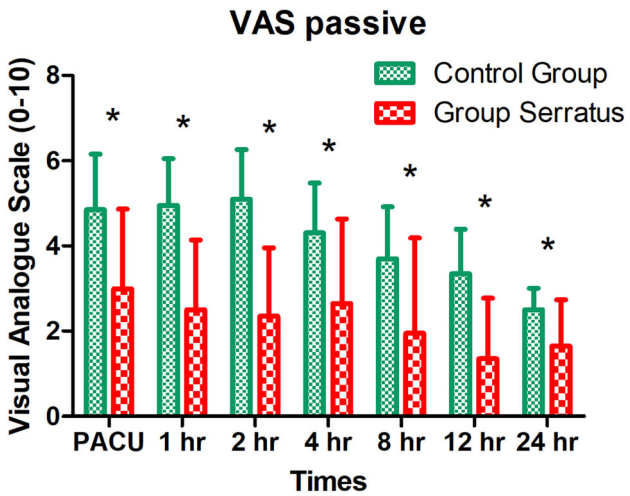

Fig. 2 Passive visual analogue scale

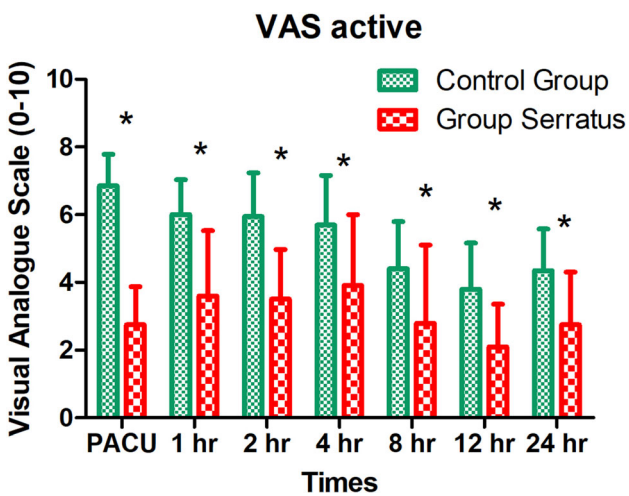

Fig. 3 Active visual analogue scale

effects, including postoperative nausea and vomiting (PONV) less commonly in the SPB group.

Preemptive analgesia is the administration of analgesics before the trauma occurs. Analgesic administration before the surgery has been shown in studies to be capable of

reducing posttraumatic sensitivity. If analgesic therapy is applied after a painful stimulus, then difficulties may be experienced in the management of postoperative pain in such cases because peripheral hypersensitivity and central nervous system hyperexcitability may occur [1]. The preemptive administration of bupivacaine results in a decrease in postoperative pain scores and longer first analgesic recruitment time compared with post-surgery administration [13]. On the other hand, some other studies did not show statistically significant changes in the postoperative pain with preoperative analgesia [14].

Postoperative analgesia management after breast reconstruction surgery is critical for ensuring patient comfort and a favorable treatment process. Breast surgery can cause severe acute pain, and chronic pain may develop in 25 to 60% of patients [15]. Intravenous analgesics including opioids and various regional anesthesia techniques are preferred to provide postoperative analgesia. Opioid-related adverse effects (ORAE) may emerge including sedation, dizziness, nausea, vomiting, dependence, tolerance, and respiratory depression in opioid therapy [16, 17]. We observed that ORAE, including nausea and vomiting, were more common in the control group due to opioid consumption. Alternatively, regional methods can be used, including thoracic paravertebral, thoracic epidural, intercostal, and pectoral nerve blocks [18–21]. Thoracic epidural catheterization and paravertebral block are the gold standards for analgesia management in breast surgery [4, 22]. Long-term clinical experience is needed for performing thoracic epidural catheterization or paravertebral block. Both techniques are associated with failed intervention rates of up to 15%. Moreover, they may cause serious complications such as spinal cord injury, dural puncture, total spinal anesthesia or pneumothorax [23]. Intercostal nerve block requires multiple injections during the procedure. Serious complications such as pneumothorax may occur.

Pectoral nerve (PECs) and serratus plane block (SPB) are two of the truncal blocks, which have been introduced for use in the thoracic region in recent years. Two randomized controlled trials, evaluating the use of PECs-1 block alone and PECs-1 block in combination with PECs-2 block in breast augmentation surgery, reported that effective postoperative analgesia was achieved [21, 24]. Another randomized study with truncal blocks demonstrated that erector spinae plane block provides superior analgesia and greater patient satisfaction compared to tumescent anesthesia in reduction mammoplasty [25]. The combination of PECs and SPB was reported for breast augmentation surgery with better analgesic scores [26]. To date, there have been no randomized controlled studies about SPB use in breast reconstruction surgery in the literature. Compared to PECS-1 + 2, the requirement for a lower number of injections may be one of the advantages of SPB with regard to patient comfort.

Neural innervation in the chest wall comprises three groups [22]. The first group includes the lateral pectoral nerve (C5–7) extending between the pectoralis major and the minor muscles, and the medial pectoral nerve (C8–1) located beneath the pectoralis minor muscle. Both of these nerves innervate both muscles. The second group consists of the spinal nerves (T2–6) located between the intercostal muscles, and they give rise to the lateral and anterior branches to innervate the chest wall. The third group is composed of the long thoracic nerve (C5–7) and the thoracodorsal nerve, innervating the serratus anterior and latissimus dorsi muscles, respectively. PECs-1 block anesthetizes the medial and lateral pectoral nerves, which innervate the pectoral muscles. The local anesthetic agent is administered in the space between the fascial planes of the pectoralis major and minor muscles. Pecs-2 block is performed to obtain blockade of the upper intercostal nerves with the administration of the local anesthetic agent in the space between the pectoralis minor and serratus anterior muscles.

The most recently introduced modification of these two blockade methods is the serratus plane block which was first described in 2013 by Blanco, reporting that this method provided sufficient analgesia in the lateral anterior and posterior parts of the thoracic wall by blocking the lateral and anterior cutaneous branches of the second to the sixth intercostal nerves, as well as the thoracodorsal and long thoracic nerves inducing sensory paresthesia in the dermatomes between T2 and T9. SPB involves the administration of the local anesthetic either in the space between the serratus and the latissimus dorsi muscles (superficial SPB) or deep to the serratus muscle (deep SPB). The level of the injection affects the duration of blockade rather than determining the involved dermatomes. Both primarily target the lateral cutaneous intercostal nerves. In his descriptive study performed on only 4 patients injecting levobupivacaine 0.125% with gadolinium, Blanco found that superficial injection provided a longer analgesia duration (750–840 min = 12.5–14 h) compared to that produced by deep injections (330–600 min = 5.5–10 h) [8]. The duration of anesthesia of local anesthetics varies widely and is affected by many factors such as the concentration and volume of the LA, local tissue conditions, and the site of injection. The 0.25% bupivacaine block onset time is 10–15 min, and the duration of analgesia may last for up to 26 h [27, 28]. Some authors have mentioned that dexamethasone added to the site of injection in brachial plexus nerve blocks prolonged the effect by 6–8 h [29]. Others have recommended the use of liposome bupivacaine, either alone or combined with bupivacaine, as

it has a longer duration of action and performed comparative studies between them [19, 30, 31].

Mayes et al. [32] have reported in their 2016 article that SPB provides the analgesic effect by blocking the lateral cutaneous branches of the intercostal nerves and is an effective method to apply during the surgery of the superficial layers of the lateral thorax.

There are many case reports in the literature about serratus anterior plane block administered for analgesia during reconstructive surgery of the breasts [11, 33]. Bhoi et al. reported a patient who underwent SPB in combination with sedation to obtain primary anesthesia during breast surgery. However, sedation was applied in this patient and the site of surgery in the breast was not specified [34]. Yao et al. [35] reported that SPB reduced opioid-related side effects and contributed to the healing process in oncologic breast surgery. A cohort study conducted by Abdallah et al. [36] reported that PECS I block and serratus anterior block may be useful when used as an adjunct to general anesthesia in breast cancer surgery and the authors recommended that further randomized controlled trials should be performed. We found that no randomized controlled studies were available in the literature about bilateral SPB administered for obtaining postoperative analgesia after breast aesthetic surgery; therefore, we aimed to contribute to the literature with our study.

The limitations of this study include the following. Firstly, the follow-up period was the first 24 h postoperatively. The follow-up period could have been longer and might have yielded different results. Another limitation was that the sample size was determined based on the primary objective of determining the postoperative opioid consumption. There is a requirement for further large-scale studies in this scope.

In conclusion, SPB block can be used safely bilaterally in the management of pain for breast reduction surgery as it is easy to perform, provides excellent analgesia, and reduces opioid consumption.

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Compliance with Ethical Standards

Conflict of interest The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Ethical Approval Institutional Review Board approval was obtained.

Informed Consent Written informed consent was obtained from all subjects (patients) in this study.

References

1. Woolf CJ, Chong MS (1993) Preemptive analgesia—treating postoperative pain by preventing the establishment of central sensitization. Anesth Analg 77(2):362–379. https://doi.org/10.1213/00000539-199377020-00026
2. Broyles JM, Tuffaha SH, Williams EH, Glickman L, George TA, Lee Dellon A (2016) Pain after breast surgery: etiology, diagnosis, and definitive management. Microsurgery. https://doi.org/10.1002/micr.30055
3. Wallace MS, Wallace AM, Lee J, Dobke MK (1996) Pain after breast surgery: a survey of 282 women. Pain 66(2–3):195–205
4. Vila H Jr, Liu J, Kavasmaneck D (2007) Paravertebral block: new benefits from an old procedure. Curr Opin Anaesthesiol 20(4):316–318. https://doi.org/10.1097/ACO.0b013e328166780e
5. Tahiri Y, Tran DQ, Bouteaud J, Xu L, Lalonde D, Luc M, Nikolis A (2011) General anaesthesia versus thoracic paravertebral block for breast surgery: a meta-analysis. J Plast Reconstr Aesthet Surg 64(10):1261–1269. https://doi.org/10.1016/j.bjps.2011.03.025
6. Elsharkawy H, Pawa A, Mariano ER (2018) Interfascial plane blocks: back to basics. Reg Anesth Pain Med 43(4):341–346. https://doi.org/10.1097/aap.0000000000000750
7. Gurkan Y, Kus A (2017) Fascial plane blocks in regional anaesthesia and new approaches. Turk J Anaesthesiol Reanim 45(2):85–86. https://doi.org/10.5152/tjar.2017.040401
8. Blanco R, Parras T, McDonnell JG, Prats-Galino A (2013) Serratus plane block: a novel ultrasound-guided thoracic wall nerve block. Anaesthesia 68(11):1107–1113. https://doi.org/10.1111/anae.12344
9. Ahiskalioglu A, Alici HA, Yayik AM, Celik M, Oral Ahiskalioglu E (2017) Ultrasound guided serratus plane block for management of acute thoracic herpes zoster. Anaesth Crit Care Pain Med 36(5):323–324. https://doi.org/10.1016/j.accpm.2017.01.008
10. Ahiskalioglu A, Yayik AM, Celik EC, Ahiskalioglu EO, Emsen M (2018) Two plane two block for surgical anesthesia: ultrasound-guided serratus and erector spinae plane blocks. J Clin Anesth 47:19–20. https://doi.org/10.1016/j.jclinane.2018.03.004
11. Khemka R, Chakraborty A, Ahmed R, Datta T, Agarwal S (2016) Ultrasound-guided serratus anterior plane block in breast reconstruction surgery. A A Case Rep 6(9):280–282. https://doi.org/10.1213/xaa.0000000000000297
12. McGuirk S, Fahy C, Costi D, Cyna AM (2011) Use of invasive placebos in research on local anaesthetic interventions. Anaesthesia 66(2):84–91. https://doi.org/10.1111/j.1365-2044.2010.06560.x
13. Ke RW, Portera SG, Bagous W, Lincoln SR (1998) A randomized, double-blinded trial of preemptive analgesia in laparoscopy. Obstet Gynecol 92(6):972–975. https://doi.org/10.1016/s0029-7844(98)00303-2
14. Moiniche S, Kehlet H, Dahl JB (2002) A qualitative and quantitative systematic review of preemptive analgesia for postoperative pain relief: the role of timing of analgesia. Anesthesiology 96(3):725–741. https://doi.org/10.1097/00000542-200203000-00032
15. Andersen KG, Kehlet H (2011) Persistent pain after breast cancer treatment: a critical review of risk factors and strategies for prevention. J Pain 12(7):725–746. https://doi.org/10.1016/j.jpain.2010.12.005
16. Benyamin R, Trescot AM, Datta S, Buenaventura R, Adlaka R, Sehgal N, Glaser SE, Vallejo R (2008) Opioid complications and side effects. Pain Physician 11(2 Suppl):S105–S120
17. Gago Martinez A, Escontrela Rodriguez B, Planas Roca A, Martinez Ruiz A (2016) Intravenous ibuprofen for treatment of post-operative pain: a multicenter, double blind, placebo-

controlled, randomized clinical trial. PLoS ONE 11(5):e0154004. https://doi.org/10.1371/journal.pone.0154004
18. Kang CM, Kim WJ, Yoon SH, Cho CB, Shim JS (2017) Postoperative pain control by intercostal nerve block after augmentation mammoplasty. Aesthetic Plast Surg 41(5):1031–1036. https://doi.org/10.1007/s00266-017-0802-6
19. Tan P, Martin MS, Shank N, Myers L, Wolfe E, Lindsey J, Metzinger S (2017) A comparison of 4 analgesic regimens for acute postoperative pain control in breast augmentation patients. Ann Plast Surg 78(6S Suppl 5):S299–S304. https://doi.org/10.1097/sap.0000000000001132
20. Gardiner S, Rudkin G, Cooter R, Field J, Bond M (2012) Paravertebral blockade for day-case breast augmentation: a randomized clinical trial. Anesth Analg 115(5):1053–1059. https://doi.org/10.1213/ANE.0b013e318264ba33
21. Karaca O, Pinar HU, Arpaci E, Dogan R, Cok OY, Ahiskalioglu A (2019) The efficacy of ultrasound-guided type-I and type-II pectoral nerve blocks for postoperative analgesia after breast augmentation: a prospective, randomised study. Anaesth Crit Care Pain Med 38(1):47–52. https://doi.org/10.1016/j.accpm.2018.03.009
22. Wahba SS, Kamal SM (2014) Thoracic paravertebral block versus pectoral nerve block for analgesia after breast surgery. Egypt J Anaesth 30(2):129–135. https://doi.org/10.1016/j.egja.2013.10.006
23. Giebler RM, Scherer RU, Peters J (1997) Incidence of neurologic complications related to thoracic epidural catheterization. Anesthesiology 86(1):55–63. https://doi.org/10.1097/00000542-199701000-00009
24. Ekinci M, Ciftci B, Celik EC, Karakaya MA, Demiraran Y (2019) The efficacy of different volumes on ultrasound-guided type-I pectoral nerve block for postoperative analgesia after subpectoral breast augmentation: a prospective, randomized, controlled study. Aesthetic Plast Surg 43(2):297–304. https://doi.org/10.1007/s00266-019-01322-8
25. Oksuz G, Bilgen F, Arslan M, Duman Y, Urfalioglu A, Bilal B (2019) Ultrasound-guided bilateral erector spinae block versus tumescent anesthesia for postoperative analgesia in patients undergoing reduction mammoplasty: a randomized controlled study. Aesthetic Plast Surg 43(2):291–296. https://doi.org/10.1007/s00266-018-1286-8
26. Schuitemaker RJ, Sala-Blanch X, Sanchez Cohen AP, Lopez-Pantaleon LA, Mayoral RJ, Cubero M (2019) Analgesic efficacy of modified pectoral block plus serratus plane block in breast augmentation surgery: a randomised, controlled, triple-blind clinical trial. Rev Esp Anestesiol Reanim 66(2):62–71. https://doi.org/10.1016/j.redar.2018.08.001
27. Hadzic A (2017) Hadzic's textbook of regional anesthesia and acute pain management, 2nd edn. McGraw-Hill Education, New York
28. Butterworth JF, Lahaye L (2019) Clinical use of local anesthetics in anesthesia. UpToDate.com. https://www.uptodate.com/contents/clinical-use-of-local-anesthetics-in-anesthesia?csi=92468338-3863-4d6f-860a-eaef407b16d7&source=contentShare. Accessed 19 Apr 2019
29. Kirkham KR, Jacot-Guillarmod A, Albrecht E (2018) Optimal dose of perineural dexamethasone to prolong analgesia after brachial plexus blockade: a systematic review and meta-analysis. Anesth Analg 126(1):270–279. https://doi.org/10.1213/ane.0000000000002488
30. Vandepitte C, Kuroda M, Witvrouw R, Anne L, Bellemans J, Corten K, Vanelderen P, Mesotten D, Leunen I, Heylen M, Van Boxstael S, Golebiewski M, Van de Velde M, Knezevic NN, Hadzic A (2017) Addition of liposome bupivacaine to bupivacaine HCl versus bupivacaine HCl alone for interscalene brachial plexus block in patients having major shoulder surgery. Reg Anesth Pain Med 42(3):334–341. https://doi.org/10.1097/aap.0000000000000560
31. Patel MA, Gadsden JC, Nedeljkovic SS, Bao X, Zeballos JL, Yu V, Ayad SS, Bendtsen TF (2019) Brachial plexus block with liposomal bupivacaine for shoulder surgery improves analgesia and reduces opioid consumption: results from a multicenter, randomized, double-blind, controlled trial. Pain Med. https://doi.org/10.1093/pm/pnz103
32. Mayes J, Davison E, Panahi P, Patten D, Eljelani F, Womack J, Varma M (2016) An anatomical evaluation of the serratus anterior plane block. Anaesthesia 71(9):1064–1069. https://doi.org/10.1111/anae.13549
33. Bonomi S, Salval A, Crippa S (2016) Ultrasound-guided thoracic wall nerve blocks to reduce postoperative pain and eliminate opioid consumption in patients undergoing implant-based breast reconstruction. Plast Reconstr Surg 138(3):543e–544e. https://doi.org/10.1097/prs.0000000000002436
34. Bhoi D, Pushparajan HK, Talawar P, Kumar A, Baidya DK (2016) Serratus anterior plane block for breast surgery in a morbidly obese patient. J Clin Anesth 33:500–501. https://doi.org/10.1016/j.jclinane.2015.09.004
35. Yao Y, Li J, Hu H, Xu T, Chen Y (2019) Ultrasound-guided serratus plane block enhances pain relief and quality of recovery after breast cancer surgery: a randomised controlled trial. Eur J Anaesthesiol 36(6):436–441. https://doi.org/10.1097/eja.0000000000001004
36. Abdallah FW, MacLean D, Madjdpour C, Cil T, Bhatia A, Brull R (2017) Pectoralis and serratus fascial plane blocks each provide early analgesic benefits following ambulatory breast cancer surgery: a retrospective propensity-matched cohort study. Anesth Analg 125(1):294–302. https://doi.org/10.1213/ane.0000000000001975