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A comparative study between ultrasound-guided serratus anterior plane block and conventional IV analgesics for post-operative pain management in modified radical mastectomy

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Abstract

Background: Surgery is the first line of treatment for early, localized, or operable breast cancer and it is associated with severe post-operative pain. Although opioids have been the mainstay for managing post-operative pain, they have undesirable side effects. A variety of methods, including thoracic epidural, paravertebral, and intercostal blocks have been used to manage breast surgery pain; however, each of these blocks has some drawbacks. Serratus anterior plane block is a relatively novel technique that can block the lateral cutaneous branches of the intercostal nerves as well as the long thoracic nerve. This study compares between the effect of serratus anterior plane block and conventional IV analgesia on post-operative pain after modified radical mastectomy.

Results: Post-operative pain scores were significantly lower in the SAPB group in the first 8 h compared to the control group ($P < 0.05$), the time to the first rescue analgesic was significantly longer in the SAPB group with a mean 354 min compared to the control group; the mean is 17.8 min, the total dose of rescue analgesic was significantly lower in the SAPB group with a mean 50 mg in the first 24 h compared to a mean of 212.5 mg in the control group. The patient's satisfaction scores were higher, the incidence of post-operative nausea and vomiting was significantly lower among the SAPB group compared to the control group. No other complications were recorded in either group.

Conclusions: The serratus anterior plane block can be used as one of the modalities in managing the pain of patients undergoing MRM surgery. This procedure was effective in reducing the need for post-operative opioids usage, better patient satisfaction with fewer side effects as post-operative nausea and vomiting. It is simple and easy-to-learn technique.

Keywords: Serratus anterior plane block, Modified radical mastectomy, Post-operative analgesia

Background

Breast cancer is becoming very common among women, and statistics show that one in every eight women develops breast cancer during their lifetime (DeSantis et al. 2014). Modified radical mastectomy (MRM) is the most common surgical procedure for breast cancer (Fecho et al. 2009). Patients undergoing

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breast surgery experience marked acute post-operative pain (about 60%). When post-operative pain is not controlled well, this leads to both psychological and physiological negative consequences (Gärtner et al. 2009). Several ways can be used to manage post-mastectomy pain. Common systemic medications, particularly opioids, have different side effects, such as itching, nausea, vomiting, and respiratory depression. Non-steroidal anti-inflammatory drugs are associated with impaired renal function and hemorrhagic disorders (Gharaei et al. 2013). A thoracic epidural block produces a desirable analgesic effect, but it may result in hemodynamic changes, including hypotension and decreased tidal volume, unnecessary bilateral block, occurrence of epidural hematoma or abscess and dural puncture (Davies et al. 2006). Many regional block techniques can be performed to manage post-mastectomy pain (Sahu et al. 2016), e.g., paravertebral block, which may be associated with potential complications as pneumothorax, nerve damage, and difficult technique despite the use of ultrasound (Krediet et al. 2015). Intercostal nerve block is easy to perform using ultrasound and does not contain the sympathetic block; however, it also has some shortcomings, such as pneumothorax, short duration, high plasma absorption of local anesthetics, and need to block multiple nerve levels (Yakşi and Yakşi 2017).

Serratus anterior plane (SAP) block was introduced as a novel regional block technique to manage unilateral thoracic wall pain. In SAP block, local anesthetics are injected into the serratus plane at the fifth rib level at the mid-axillary line under ultrasound guidance. There are two approaches to the SAP block: superficial in which local anesthetics are injected in the plane between the Latissimus dorsi muscle and the serratus anterior muscle and the deep approach where local anesthetics are injected between the serratus anterior muscle and the intercostal muscles and the ribs. Local anesthetics spread along the plane where the lateral branches of the intercostal nerves pass through leading to lateral chest wall is blockade (Blanco et al. 2013). In some studies, the serratus anterior block managed to provide chest wall analgesia lasting for 12 h following breast surgery. It was also an effective and low-risk method to ameliorate acute post-thoracotomy pain (Khemka et al. 2016). Ultrasound-guided serratus anterior plane block can increase the safety and speed up the procedure (Imani et al. 2016).

The primary outcome measures include the following:

- Assessment of the level of post-operative pain (on a VAS scale scores).

The secondary outcome measures include the following:

- Time needed to the first rescue analgesic in minutes.
- Cumulative dose of rescue analgesic needed (cumulative dose of pethidine needed in milligrams).
- Rate of patient tolerability to the procedure and ranks their satisfaction (on a 1 to 10 scale).
- The incidence of nausea and any attack of post-operative vomiting.
- The incidence of any of the serratus anterior plane blocks complications, e.g., injection site hematoma or signs or symptoms of local anesthetic toxicity.

Methods

This study was approved by the research ethics committee (REC) at the Ain Shams University and after obtaining written informed consents from all patients, it was registered at https://clinicaltrials.gov (NCT05126394), this prospective, randomized, controlled study was conducted over 40 female patients between the age of 20–60 years old, ASA physical status I and II, undergoing modified radical mastectomy at Ain Shams University hospitals in 2020–2021. Refusal to participate, morbid obesity (body mass index > 35 kg/m^2), preoperative physical status American Society of Anesthesia (ASA) III–IV, addiction to narcotics or psycho-active drugs, psychological disorders, and contra-indications to regional anesthesia (coagulopathy, injection site infection or allergy to any of the study drugs) were excluded.

Pre-anesthesia check was done on the night of the surgery, where patients were clinically assessed and routine preoperative laboratory investigations were done: CBC, PT, PTT, INR, liver function tests, kidney function tests, fasting blood sugar, and ECG if indicated. All patients were taught how to use a 100 cm visual analog scale (VAS-0 with end-point labeled "no pain" and 100 to "worst conceivable pain"). In the induction room an IV peripheral cannula was secured and patients were pre-medicated with IV Midazolam (0.05 mg/kg) then they were transferred to the operating room, hemodynamic monitoring was attached to the patient; pulse oximetry, ECG, capnography, and non-invasive blood pressure

monitoring. All patients received general anesthesia, induction was with propofol (1–2 mg/kg), fentanyl (1–2 mcg/kg), and atracurium (0.5 mg/kg), endotracheal tube insertion; anesthesia was maintained using oxygen (60–100%), isoflurane, and supplemental doses of atracurium (0.1 mg/kg) every 30 min and fentanyl (0.5 mcg/kg) every hour guided by blood pressure and heart rate, controlled mechanical ventilation was maintained at tidal volumes (8–10)ml/kg; guided by the end tidal CO_2. Before the beginning of the procedure the first group of patients; randomly picked received ultrasound-guided serratus anterior plane block on the same side of the surgery in the lateral decubitus position with the ipsilateral arm abducted to 90°. The block was performed using a high-frequency linear probe (10–12 MHz) placed in the infra-clavicular region. The probe is then moved latero-caudally towards the mid-axillary line so that the serratus anterior muscle could be observed just as a thin layer on the ribs, at the level of the fifth rib in the plane between the serratus anterior muscle and the intercostal muscles, or more superiorly in the plane between the serratus muscle and the latissimus dorsi muscle. After identifying the appropriate place, 20 ml of bupivacaine at a concentration of 0.25% (5 ml normal saline solution was added to 5 ml bupivacaine 0.5% for each 10 ml syringe) is injected in-plane under ultrasound guidance with a 22 G ultrasound-visible needle. The control group did not receive blockade. After recovery, the patients were taken to post-anesthetic care unit (PACU), and they were evaluated using a modified Aldrete score by the PACU anesthesiologist who decides on their eligibility for transferal to ward.

Further evaluations were carried out by a different investigator who was unaware of the patients' grouping. The degree of post-operative pain was assessed at zero, i.e., just upon arrival to the PACU, 2, 4, 8, 12, and 24 h using the VAS score and the hemodynamic data and respiratory rate were measured during the first 24 h after the end of the surgery. Post-operative analgesia regimen was standard in both groups; patients from each groups received 1 gm of paracetamol Q 8 h. Patients reporting VAS score greater than 40, mean arterial blood pressure, heart rate or respiratory rate > 20% from the baseline, were given Pethidine (50 mg IV) as rescue analgesic. While those reporting VAS score less than 40 with mean arterial blood pressure, heart rate or respiratory rate > 20% from the baseline but still complaining; ketorolac (30 mg IV) was given with a maximum dose of 120 mg/day (Fig. 1).

Sample size determination

Using pass 11 program for sample size calculation and according to (Rahimzadeh et al. 2018), the expected mean time for request of analgesia in intervention group = 323.5 ± 49.7 min and in control group = 16.6 ± 0.1 min, sample size of 20 patients in each group can detect this difference with power 100% and α-error 0.05.

Statistical analysis

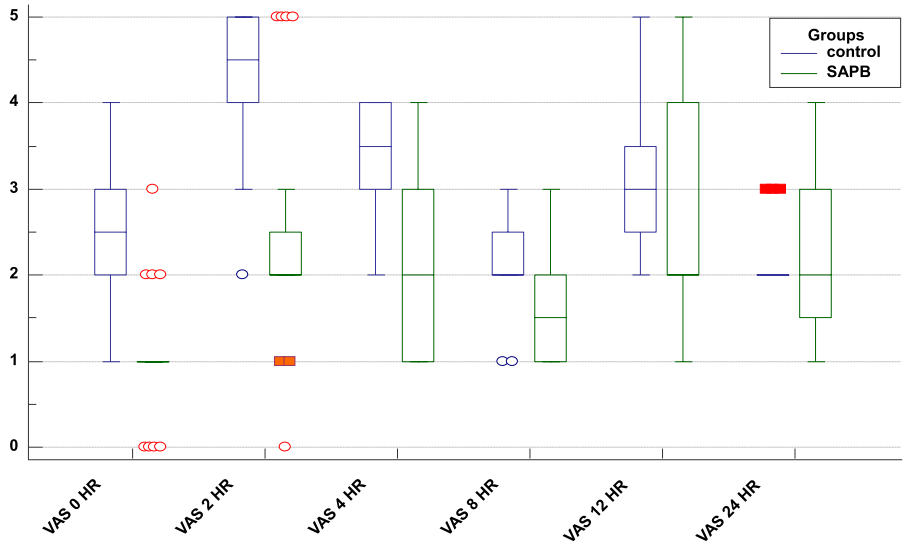
Data were analyzed using Statistical Package for Social Science (SPSS) version 22.0. Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Data presented as mean ± SD were compared using independent *t* test, data presented as percentage were compared using chi-square test. Data presented as median were compared using Mann-Whitney test. *P* value < 0.05 was considered significant.

Results

Groups were comparable in demographic data (in terms of age, weight, BMI, duration of surgery and ASA) and there was no statistically significant difference between groups (*p* value > 0.05) (Table 1).

The cumulative dose of fentanyl consumed intraoperatively was significantly higher in the control group compared to the SAPB group, and time for the first request for pethidine was significantly longer in SABP group compared to the control group. As regards to total dose of analgesic consumption, the total dose of pethidine needed in the control group was significantly higher compared to the SAPB group, and the total dose of ketorolac needed was significantly higher in the control group as well. The level of satisfaction between the groups was examined and the SAPB group patients showed more satisfaction compared to the control group (Tables 2 and 3).

The study main aim was to compare the two groups as regards pain control post-operatively. Visual analog scale (VAS) was used to assess pain post-operatively, pain was assessed at 0, 2, 4, 8, 12, and 24 h post-operatively. The difference was significant between the two groups in the first 8 h post-operatively. After that, there was no statistical difference between the two groups as regards VAS scoring (Table 4).



Nausea and vomiting were also examined between the two groups, and there was significant difference between groups as the control group experienced more incidence of post-operative nausea and vomiting compared to the SAPB group mostly related to more narcotic consumption and higher pain scores (Table 5).

Regarding post-operative mean arterial blood pressure we found that the difference was highly significant at 0 h (p value < 0.001) and 2 h post-operatively (p value < 0.001), the difference was significant at 4 h (p value = 0.002), and 8 h (p value = 0.003), while there was no statistical difference between the two groups at 12 h (p value = 0.089) and 24 h (p value = 0.455), as for post-operative heart rate, it was found that the difference was highly significant at 0 h (p value < 0.001) and 2 h (p value < 0.001) post-operatively, the difference was significant at 4 h (p value = 0.003) and 8 h (p value = 0.013), at 12 h (p value = 0.084) and 24 h (p value = 0.82); there was no statistical difference between the two groups. Regarding post-operative respiratory rate, it was found that the difference was highly significant at 0 h (p value < 0,001) and 2 h (p value < 0.001) post-operatively, the difference was significant at 4 h (p value = 0.004) and 8 h (p value = 0.02), at 12 h (p value = 0.12) and 24 h (p value = 0.77); there was no statistical difference between the two groups.

Discussion

This study showed that serratus anterior plane block resulted in significant analgesia, less total dose of rescue analgesic, longer time to the first analgesic requirement, less incidence of vomiting and higher satisfaction scores than the conventional IV analgesia. Blanco et al. (2013) in their study that was performed on four volunteers found that injection of local anesthetic superficial or deep underneath serratus anterior provides predictable and relatively long-lasting regional anesthesia, which would be suitable for surgical procedures performed on the chest wall. All volunteers reported an effective block that provided long-lasting paraesthesia (750–840 min). There were no side-effects noted in this initial descriptive study. Mayes et al. (2016) performed SAPB on six cadavers with the ultrasound guide and found that the sawtooth plane block appeared to be mediated by blocking the lateral cutaneous branch of the intercostal nerve. Abdallah et al. (2017) in their study that included 225 patients undergoing ambulatory breast cancer surgery; divided them into three groups, namely general anesthesia alone, general anesthesia with Pecs I block, and general anesthesia with serratus anterior plane block. They found that Pecs I and the serratus anterior plane block groups had low rates of post-operative in-hospital opioid consumption, prolonged time to first analgesic request and lower incidence of post-operative nausea and vomiting compared to the conventional opioid-based analgesia group. Chong et al. (2019) who conducted a meta-analysis study on the serratus plane block for post-operative analgesia in breast and thoracic surgery, it showed that SAPB reduced post-operative pain scores compared with non- block patients. Moreover, the post-operative analgesic effect of SAPB was superior to that of the paravertebral block (PVB). The SAPB was a less invasive alternative to PVB for providing post-operative analgesia after breast surgery. SAPB does not only inhibit the post-operative acute pain of breast cancer but treats chronic pain after breast cancer surgery as well. Kazior et al. (2019) in their study was conducted on 20 patients who underwent minimal

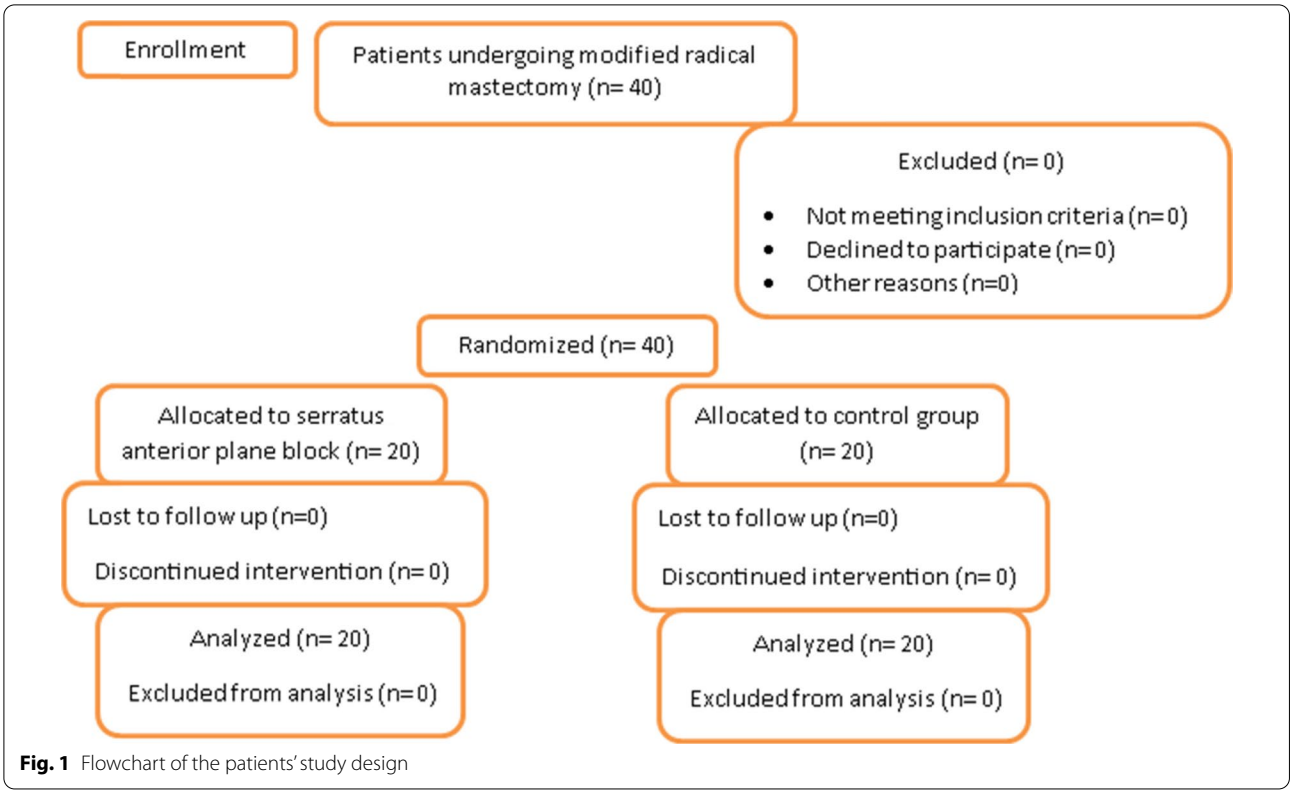


Fig. 1 Flowchart of the patients' study design

Table 1 Comparison between groups as regards demographic data

Demographic data	SAPB group ($n = 20$)	Control group ($n = 20$)	T/Z	*P* value
Age (years)	41.9 ± 9.2	41.7 ± 8	0.07[t]	0.94
BMI (kg/m^2)	26.3 ± 2.8	25.8 ± 2.6	0.59[t]	0.56
Weight (kg)	68.2 ± 8.7	67 ± 7.8	0.46[t]	0.65

Data expressed as mean ± SD, *T* Student's *t* test, *Z* Mann-Whitney test, *SAPB* Serratus anterior plane block

invasive thoracotomy. Patients were randomly divided into two groups. One group received SAPB and the other was the control group. They found that the SAPB group received significantly lower amounts of opioids within 24 h after surgery, and the amount of opioids in the entire treatment process also decreased. The SAPB group patient scored higher in motivational spirometry without obstruction-related complications, as well. Semyonov et al. (2019) in their study was conducted on 104 patients who underwent elective thoracoscopy. Patients were divided into two groups: group 1—the "standard control group" that received standard post-operative pain control with intravenous opioids, NSAIDs and acetaminophen and group 2—the "serratus anterior plane block group." They found that the SAPB group reported significantly lower levels of pain after thoracic surgery as assessed by their VAS scores as compared to the standard pain control group, and the total dosages of morphine and tramadol required for pain relief during the first hours after surgery were significantly lower in the SAPB group compared to the standard pain control group and the incidence of vomiting after surgery was significantly

Table 2 Comparison between groups as regards total dose of fentanyl consumption, time to first request of pethidine (first rescue analgesic), total dose of pethidine consumption, and the level of satisfaction

	SAPB group ($n = 20$)	Control group ($n = 20$)	*t* test	*P* value
Total dose of Fentanyl (mcg)	180 ± 25.1	265 ± 28.6	9.99	**< 0.001**
Time to first request Pethidine (min)	354 ± 115	17.9 ± 6.8	13.05	**< 0.001**
Post-operative pethidine consumption (mg)	50 ± 22.94	212.5 ± 27.5	20.3	**< 0.001**
Level of satisfaction	7.85 ± 0.81	7.15 ± 0.75	2.8	**0.007**

Data expressed as mean ± SD, *T* Student's *t* test, *Z* Mann-Whitney test, *SAPB* Serratus anterior plane block

Table 3 Comparison between groups as regards total dose of ketorolac consumption

	SAPB group ($n = 20$)			Control group ($n = 20$)			*z*	*P* value
	Range	Median	IQR	Range	Median	IQR		
Ketorolac consumption (mg)	0–30	0.0	0.0–30	60–120	75	60–90	5.6	**< 0.001**

Data expressed as range, median; *IQR* Inter quartile range, *z* Mann-Whitney test, *SAPB* Serratus anterior plane block

Table 4 Comparison between groups as regards visual analog score

Visual analog score	SAPB group ($n = 20$)	Control group ($n = 20$)	Mann-Whitney test	
			z	*p* value
0 h	1 (1–1)	2.5 (2–3)	4.6	**< 0.001**
2 h	2 (2–2.5)	4.5 (4–5)	3.6	**< 0.001**
4 h	2 (1–3)	3.5 (3–4)	3.9	**< 0.001**
8 h	1.5 (1–2)	2 (2–2.5)	2.5	**0.01**
12 h	2 (2–4)	3 (2.5–3.5)	1.57	0.12
24 h	2 (1.5–3)	2 (2–2)	0.6	0.54

Data expressed as range, median; *IQR* Inter-quartile range, *z* Mann-Whitney test, *SAPB* Serratus anterior plane block

lower in SAPB group compared to the control group. Mazzinari et al. (2019) in their study that was conducted on 60 adult females undergoing oncologic breast surgery, they compared the analgesic effect of SAPB and conventional intravenous analgesia on post-operative pain management. The results showed that compared with traditional intravenous analgesia, the SAPB group had a lower post-operative pain scoring and longer time to rescue analgesia which reduced the need for opioids after breast cancer surgery. Chen et al. (2019) in their study that included 40 adult patients undergoing video-assisted thoracic surgery, patients were randomized to receive either SAPB or LA infiltration of incision. The SAPB group showed lower VAS scores compared to the LA group, post-operative sufentanil consumption in the SAPB group during 0–8 h was significantly lower compared with the LA group. The use of rescue analgesia was also significantly lower in the SAPB group, comparable rescue analgesia was implemented to the two groups at 12–24 and 24–48 h. The incidence of PONV in the SAPB group was lower than that in the LA group as well. Saroa et al. (2020) in their study that included 60 female patients aged between 20 and 80 years, scheduled to undergo modified radical mastectomy, patients were randomized to receive post-operative IV-PCA with or without ipsilateral serratus anterior muscle block administered in the study group just after induction. They found that; the heart rate as well as mean blood pressure in the control group was found to be statistically higher at all the time intervals up to 24 h as compared to the block group and the total morphine dose and rescue analgesic consumption as well incidence of post-operative nausea and vomiting was higher in group that received IV-PCA only. Viti et al. (2020) in their study where they randomly divided 94 patients undergoing Video-assisted thoracoscopic surgery major lung resection into two groups: the control group, which received intravenous and oral analgesics and the intervention group, which received systemic analgesics plus pre-emptive SAPB. They found that SAPB provided better pain control, entailing a better performance during post-operative rehabilitation exercises in terms of duration and quality of incentive spirometry and diminished the patient's need for rescue analgesics during the early post-operative period. Hu et al. (2021) in their systematic review and meta-analysis that included 13 eligible and authentic studies; consisting of 826 subjects who underwent breast surgery. The systematic review and meta-analysis revealed that ultrasound-guided SAPB decreased opioid consumption to a significant level and relieved pain after breast surgery. In addition, SAPB decreased the occurrence of PONV. Procedure-related complications were not seen in the studies included in the analysis.

Rahimzadeh et al. (2018) in their study that included 60 patients who underwent mastectomy under general anesthesia, in their study, patients were divided into two

Table 5 Comparison between groups as regards nausea and vomiting

Nausea and vomiting	SAPB group ($n = 20$)		Control group ($n = 20$)		$\chi 2$	*P* value
	No.	%	No.	%		
Yes	1	5	9	45	6.5	**0.01**
No	19	95	11	55		

The data expressed as percentage, χ^2 Chi square

groups; the SAP block group and the control-group. A (PCA) device was used to deliver fentanyl in both groups. The total consumption of fentanyl was significantly lower in the SAB group than in the control group. Duration of the time to first PCA request was remarkably longer in the SAB group than in the control group, on the other hand; no significant difference was found in the pain scores between the two groups, which is against our findings, because the patients received PCA that provided fentanyl in a continuous manner. Shang et al. (2020) in their study that was conducted on 60 patients aged 18 to 65 years about the analgesic effect of serratus anterior plane block in thoracoscopic surgery compared to local infiltration with local anesthetic found that; the number of patients requiring additional analgesia at 6 h and 12 h after surgery was significantly higher in the control group vs. the SAPB group, but there was no significant difference between groups in analgesia requirement after 12 h, but there were no significant differences between groups in the incidence of post-operative nausea and vomiting, but their study was different from ours in terms of type of surgery (thoracoscopic surgery) and the control group received wound infiltration with local anesthetics.

In 2011, Blanco (2011) described a new technique of regional anesthesia, the PECs and PECs II (modified pectoralis muscle blocks). PECS I consists of an interpectoral injection between the pectoralis major and minor muscles, it causes blockade of the medial and the lateral pectoral nerves. PECS II involves the same interpectoral injection as well as an additional subpectoral injection between the pectoralis minor and serratus anterior muscles, it results in blockade of the medial and the lateral pectoral nerves as well as those affected by SAPB, the intercostobrachial nerve, lateral cutaneous branches of the intercostal nerve, long thoracic nerve and the thoracodorsal nerve. It can be as effective as SAPB in MRM, but it needs two injections (Blanco et al. 2012). Forero et al. (2016) first reported the use of an ultrasound-guided ESP block, an interfascial plane block where local anesthetic drugs are injected into the superficial or deep portion of the erector spinae using ultrasound guidance, and then through the costotransverse foramina into the region of the spinal nerves and the origins of the dorsal and ventral rami, it can provide a widespread cutaneous sensory blockade of posterior chest wall, while sparing the anterior and lateral chest walls, and the abdominal wall (Zhang et al. 2020). It will not provide full analgesia in cases of MRM.

Conclusions

The serratus anterior plane block can be used as one of the modalities in managing the pain of patients undergoing MRM surgery. This procedure was effective in reducing the need for post-operative opioids usage, better patient satisfaction with fewer side effects. It is simple, easy-to-learn technique, making it an excellent alternative to the conventional thoracic epidural, intercostal nerve, and paravertebral nerve blocks for breast surgeries.

Abbreviations

SAPB: Serratus anterior plane block; MRM: Modified radical mastectomy; VAS: Visual analogue score; ASA: American Society of Anesthesia; U/S: Ultrasound; PACU: Post-anesthesia care unit; REC: Research Ethics Committee; PCA: Patient controlled analgesia.

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Not applicable.

Authors' contributions

HG designed the study, revised the literature, performed the analysis, followed up the patients, and wrote and critically revised the manuscript. HF designed the study, performed the analysis, and wrote and critically revised the manuscript. RF revised the literature, performed the analysis, and critically reviewed the manuscript. RG revised the literature, followed up the patients, measured and assessed the VAS scoring, time to the first rescue analgesic, total dose of analgesics, patients' satisfaction, incidence of postoperative nausea and vomiting, patients' vital data, collected the data, performed the analysis, and critically reviewed the manuscript. MF followed up the patients, measured and assessed the VAS scoring, time to the first rescue analgesic, total dose of analgesics, patients' satisfaction, incidence of postoperative nausea and vomiting, patients' vital data, collected the data, performed the analysis. All authors approved the final version of the manuscript.

Funding

None.

Availability of data and materials

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

After approval of the ethical committee in the Faculty of Medicine, Ain Shams University number FMASU M D 83/2020, this prospective, randomized, controlled study was conducted over 40 females undergoing modified radical mastectomy for 1 year from March 2020 to March 2021. Written informed consent was obtained from the patients after explaining the procedure and its potential complications.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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