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Serratus anterior plane block (posterior approach) versus erector spinae plane block in modified radical mastectomy; A randomized comparative trial

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ABSTRACT

Background: Regional analgesia as Erector Spinae Plane Block (ESPB) and Serratus Anterior Plane Block (SAPB) were used successfully for the control of perioperative pain in females undergoing modified radical mastectomy (MRM).

Methods: The trial included 56 females aged between 20 and 60 years old who had undergone MRM and were allocated into two groups (28 patients in each), group (I) for SAPB (posterior approach) and group (II) for ESPB. Measurements included demographic data, hemodynamic change, oxygen saturation, pain intensity by the visual analogue scale (VAS), sensory loss including axillary coverage and shoulder pain, incidence of neuropathic pain, total analgesic requirements, patient satisfaction and complications.

Results: Demographic data, hemodynamic changes and oxygen saturation showed statistically insignificant differences. There were insignificant differences in the visual analogue scale (VAS) for pain at rest and on movement between the two groups on the first postoperative day (p-value >0.278 and 0.111 respectively). ESPB provided significantly more segmental sensory loss than SAPB (posterior approach) (p-value <0.031). We reported statistically insignificant differences in terms of total morphine consumption, the first request for analgesia and total local anaesthetic consumption (p-value = 0.408, 0.916 and 0.574 respectively), axillary sensory loss, inferior shoulder pain (p-value = 0.763), the incidence of neuropathic pain assessed by the Deuleur Neuropathique 4 (DN4) scale after one week and one month (p-value = 1.000 and 0.554 respectively), Neuropathic Pain Scale (NPS) score, and patient satisfaction (p-value = 0.887) between the two groups with no documented complications.

Conclusion: We concluded that SAPB (posterior approach) and ESPB are safe and effective analgesic modalities for MRM with insignificant differences except for the more blocked dermatomes in the ESPB group.

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KEYWORDS
Serratus anterior plane block (posterior approach); erector spinae plane block; visual analogue scale; modified radical mastectomy; ultrasound-guided analgesia

1. Background

For patients with breast cancer, modified radical mastectomy (MRM) is a commonly used surgical procedure. Addressing postoperative pain and its management is crucial during the perioperative period [1]. Multimodal analgesia is suggested encompassing both pharmacological and non-pharmacological analgesic agents as well as regional blocks [2,3]. Peripheral nerve blocks (PNBs) share many advantages with neuraxial epidural analgesia [4]. They include paravertebral block, intercostal nerve block, erector spinae plane block (ESPB), serratus anterior plane block (SAPB) and Pectoralis nerve block I and II (PECS I and II) [5,6]. SAPB is an effective chest wall intermuscular block that is known for its safety and simplicity of implementation [7]. According to Blanco et al. [8], SAPB can reliably and efficiently anaesthetize the anterolateral chest wall. The posterior approach of SAPB numbs the anterior and posterior divisions of lateral branches of T2-T6, intercostobrachial nerve and thoracodorsal nerve [9]. Forero [10] first reported ESPB in 2016. Since then, it has been used successfully in multiple procedures including MRM. It blocks the spinal neuron's dorsal and ventral rami, achieving a multi-dermatomal sensory block of the anterior, posterior, and lateral thoracic and abdominal walls. The present study aimed to assess the efficiency of the posterior approach of SAPB versus ESPB in perioperative pain control for MRM.

2. Material and methods

2.1. Study design

- In June 2021, the ethical committee of the Medical Research Institute authorised this study (IORG0008812), following the Helsinki Declaration (1964) and its subsequent revisions. Each patient

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authorized an informed consent form. Our primary endpoint was the evaluation of the visual analogue scale (VAS) for pain intensity (VAS = 1-10, 0 = no pain, through 10= the extreme degree of pain). Our secondary endpoints were sensory loss distribution including axillary coverage, analgesic requirements, inferior shoulder pain, neuropathic pain, patient satisfaction and complications.

- Based on the previous studies [11,12], the number of participants was determined with G-Power software Version 3.1.9 [13], and the least required sample size was set up to be 25 patients for each group after implementing a power of 80% to identify a standardised effect size in changes in the mean visual analogue scale of 0.815, and level of significance 95% (= 0.05). To account for attrition (withdrawal) bias, each patient withdrawal was compensated by replacement [14,15].
- Between August 2021 and November 2022, a prospective comparative randomized study was done at the Medical Research Institute, Alexandria University. It was designed as a blinded trial, with blindness implemented during recruitment, assessment, data collection, and analysis. It adhered to the consolidated standards of CONSORT 2010 reporting trials [16]. We documented the study prospectively in the Pan African Clinical Trial Registry (PACTR202106819955901).

2.2. Patients

The study encompassed 56 female participants aged between 20 and 60 years undergoing unilateral modified radical mastectomy (MRM) at the Medical Research Institute Hospital, Alexandria University. Exclusion criteria included any contraindication to drugs used, patient refusal, uncooperative patient, bilateral or previous breast surgery, peripheral neuropathy, ASA ≥ III, pregnancy, morbid obesity (BMI ≥40 kg/m^2) and any contraindications to regional anaesthesia.

2.3. Randomization

Patients were randomly assigned to either the posterior approach of Serratus Anterior Plane Block (SAPB) or Erector Spinae Plane Block (ESPB) using a computer-generated randomization table, maintaining a 1:1 allocation ratio.

2.4. Intervention

In the regional anaesthesia block room, each patient was attached to a multi-channel monitor (Dräger Infinity KAPPA, Germany) for standard monitoring. A 22-gauge cannula was inserted on the opposite side of the surgery. After the participant was positioned in the lateral position with the surgery side upmost, each patient received sedation with intravenous midazolam 0.03 mg/kg and fentanyl 0.5 µg/kg three minutes prior to the intervention. Supplemental oxygen was provided through a nasal cannula. Under complete aseptic technique, an Ultrasound linear probe (14 MHz −16 MHz of SonoSite, S nerve, USA) was enclosed with a sterile cover and applied in a sagittal plane. In the ESPB group, the probe was placed at the T4 transverse process at the level of the scapular spine while in the SAPB group; it was placed at the 6th rib in the posterior axillary line (posterior approach of serratus anterior plane block). In both groups, 3 ml of lidocaine was injected to anaesthetize the skin. An epidural needle was introduced in plane in cephalo-caudal direction, targeting the tip of the T4 transverse process and deep to the Erector spinae muscles in the ESPB group (Figure 1a). In the SAPB group; the needle was advanced between latissimus dorsi and serratus anterior muscles (Figure 1b). In both groups, hydro dissection using 1 ml sterile water to approve the appropriate location of the needle tip. Then, we administered 20 ml of bupivacaine (0.25%) and dexamethasone (8 mg) after negative aspiration. The epidural catheter was then inserted 2 cm underneath the muscle. We used a piece of ice every 5 minutes to detect the sensory block level in both groups for 20 minutes at the midclavicular line.

General anaesthesia was induced using fentanyl (1.5 µg/kg) and propofol (1.5–2.5 mg/kg). Atracurium at a dose of 0.5 mg/kg was utilised for neuromuscular relaxation. Maintenance of anaesthesia was with isoflurane at 1–1.5% concentration. Additional rescue boluses of 50-µg fentanyl were administered if the patient's heart rate or mean blood pressure increased by more than 20% from the baseline recorded upon arrival to the operating room. Upon completion of the surgery, any remaining muscle relaxation was antagonised with intravenous atropine (0.015 mg/kg) and neostigmine (0.04–0.08 mg/kg) and the trachea was extubated. We transferred all patients after recovery to the postoperative anaesthesia care unit (PACU).

2.5. Analgesia in PACU

The regional analgesia staff administered a slow infusion of Bupivacaine 0.125% in a 50 ml syringe through the infusion pump and connected to the epidural catheter. Initially, the rate of infusion was 5 ml/h over the first 24 h. If the VAS ≥ 4, we increased the rate of infusion to 8 ml/h and morphine 3 mg was given to the patient intravenously (IV) and could be repeated until VAS > 4. All patients in both groups received IV 30 mg Ketorolac intraoperatively and then every 8 h for the first 24 h postoperatively. Additionally, they were given 1 gm paracetamol IV intraoperatively then every 6 h for the first 24 h

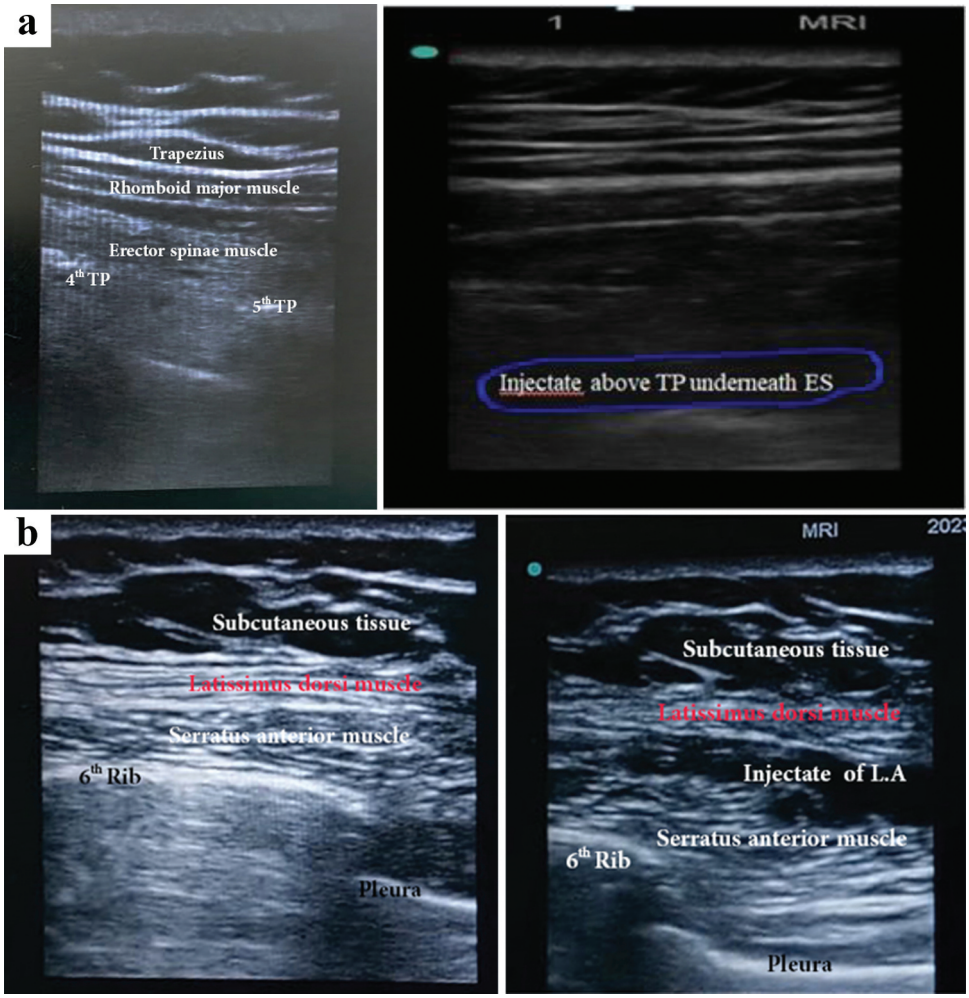

Figure 1. a) left image: it shows the injectate between the Transverse Process (TP) of the fourth thoracic vertebra and the erector spinae muscle. b) right image: it shows the injectate between the latissimus dorsi and serratus anterior muscles.

postoperatively. A physician who was not involved in the research collected all of the measurements.

2.6. Measurements

2.6.1. Primary outcome

- Nociceptive pain assessment using VAS at rest and during arm mobilization or coughing in PACU after recovery then every hour for the first 4 hours and every 4 hours for the rest of the day postoperatively.

2.6.2. Secondary outcome

- Dermatomal sensory block and the total number of anaesthetized dermatomes by absent sensation to a piece of ice at the midclavicular line and axillary area.
- The timing for the first request for analgesia, total morphine (mg) consumption, and the volume of bupivacaine infusion.
- Number of patients reported neuropathic pain measured by the Deuleur Neuropathique 4 (DN4) scale [17]. The DN4 questionnaire is a 10-item survey that was assessed by clinicians. Three items are based on the clinical evaluation, while seven items are linked to pain quality [18].
- Neuropathic pain scale (NPS) [19]. Ten domains of pain are shown on the scale: eight evaluate the distinct characteristics of neuropathic pain (sharp, hot, dull, cold, sensitive, itchy, deep, and surface), and two measure the overall pain (pain intensity and pain unpleasantness). The NPS was divided into: NPS 0 to 29 cm indicates no pain, NPS 30 to 40 cm indicates mild pain, NPS 41 to 70 cm indicates moderate pain, and NPS 71 to 100 cm indicates severe pain [20].

Both DN4 and NPS were assessed at one week and one month postoperatively.

- Inferior Shoulder pain was assessed in all patients on the seventh postoperative day.
- Patient satisfaction with pain management was evaluated before patient discharge from the hospital using a five-point Likert Scale [21] (1 = very dissatisfied, 2 = dissatisfied, 3 = neutral, 4 = satisfied, and 5 = very satisfied).

- Demographic features of the patients: Age (years) and body mass index (kg/m2).
- Changes in hemodynamic: HR, MABP and Oxygen saturation.

All parameters were continuously monitored and recorded on arriving at the regional anaesthesia block room before performing the block, 20 minutes after the block, after induction of anaesthesia, every 20 minutes intraoperatively, every hour in the first 4 postoperative hours and then every 4 hours for the rest of the first 24 postoperative hours

- Complications (for example nausea and vomiting, pneumothorax, allergy to local anaesthetic, systemic toxicity or catheter-related complications).

2.7. Statistical analysis

The data was inputted into the computer and analysed with the IBM SPSS software program version 20 (IBM Corporation, Armonk, New York, 2017). We utilized the Shapiro-Wilk test to check the data distribution. Numbers and percentages were used to describe qualitative data. Range (minimum and maximum), mean and standard deviation, or median and interquartile range (IQR) was used to represent quantitative data. The acquired results were declared significant at the 5% level.

2.7.1. The tests used were

(1) Chi-square test: for categorical variables.
(2) Monte Carlo correction: correction for chi-square when more than 20% of the cells have an expected count less than 5.
(3) Student t-test: for normally distributed quantitative variables.
(4) Mann-Whitney test: for abnormally distributed quantitative variables.
(5) McNemar: applied to evaluate the significance between the two periods.

3. Results

We enrolled 56 patients for the study and conducted a thorough analysis of their data, as illustrated in (Figure 2). Patient demographic details are provided in (Table 1). The heart rate (HR), mean arterial blood pressure (MABP), and oxygen saturation exhibited no significant differences among the groups (Figures 3 and 4). Regarding VAS at rest and movements, there were no significant differences were observed among groups as illustrated (Figure 5). The median number of blocked dermatomes in the ESPB group was 7.0 (range 5–12), while in the SAPB group, it was 6.0 (range 5–8). Notably, there was a significantly higher number of blocked dermatomes in ESPB than in SAPB (p-value = 0.031) (Table 2). Regarding axillary sensory block and

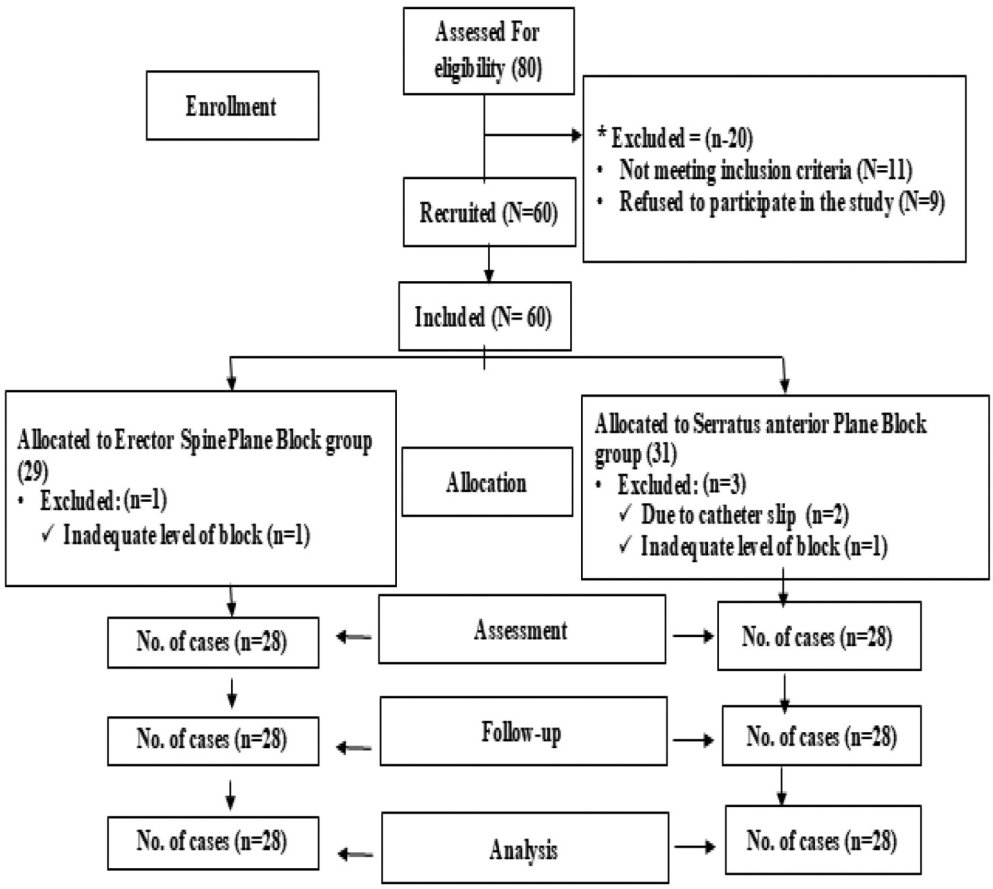

Figure 2. CONSORT flow diagram of the study participants.

Table 1. Comparison of patient demographic data between the two studied groups.

Demographic data	ESPB ($n = 28$)	SAPB ($n = 28$)	t	p
Age (years)				
Min. – Max.	40.0–60.0	40.0–60.0	1.002	0.321
Mean ± SD.	50.46 ± 6.44	52.11 ± 5.81		
Weight (kg)				
Min. – Max.	70.0–100.0	70.0–100.0	1.324	0.191
Mean ± SD.	84.07 ± 8.02	86.86 ± 7.72		
Height (m)				
Min. – Max.	1.50–1.75	1.56–1.75	1.023	0.311
Mean ± SD.	1.64 ± 0.06	1.66 ± 0.05		
BMI (kg/m2)				
Min. – Max.	25.40–39.06	25.68–36.99	0.438	0.663
Mean ± SD.	31.25 ± 3.62	31.65 ± 3.21		

SD: Standard deviation. t: Student t-test. p: p-value for comparing between the two studied groups.

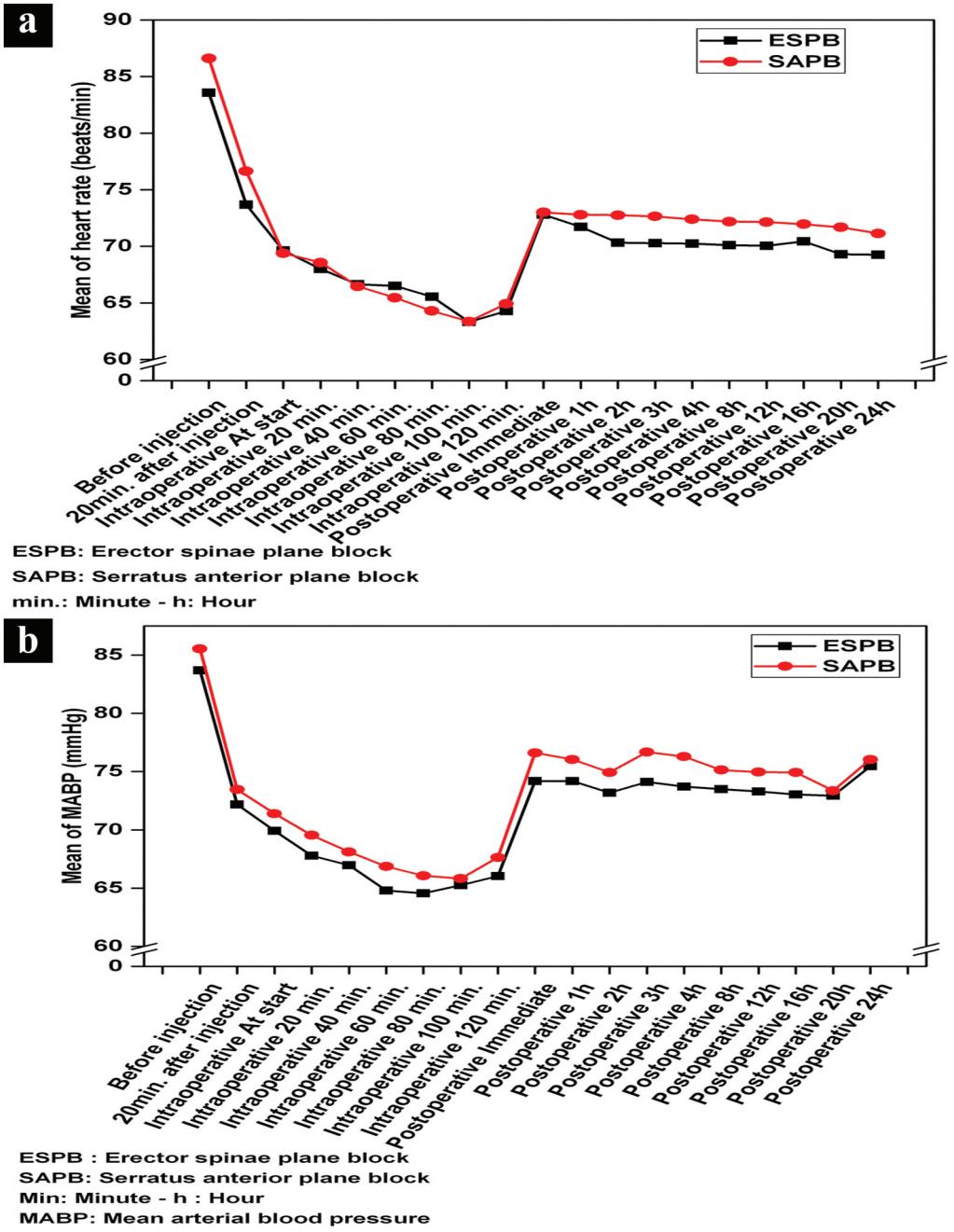

Figure 3. a)comparison between the two groups regarding heart rate (HR) (beats\min). b) and regarding mean arterial blood pressure (MABP) in (mmHg).

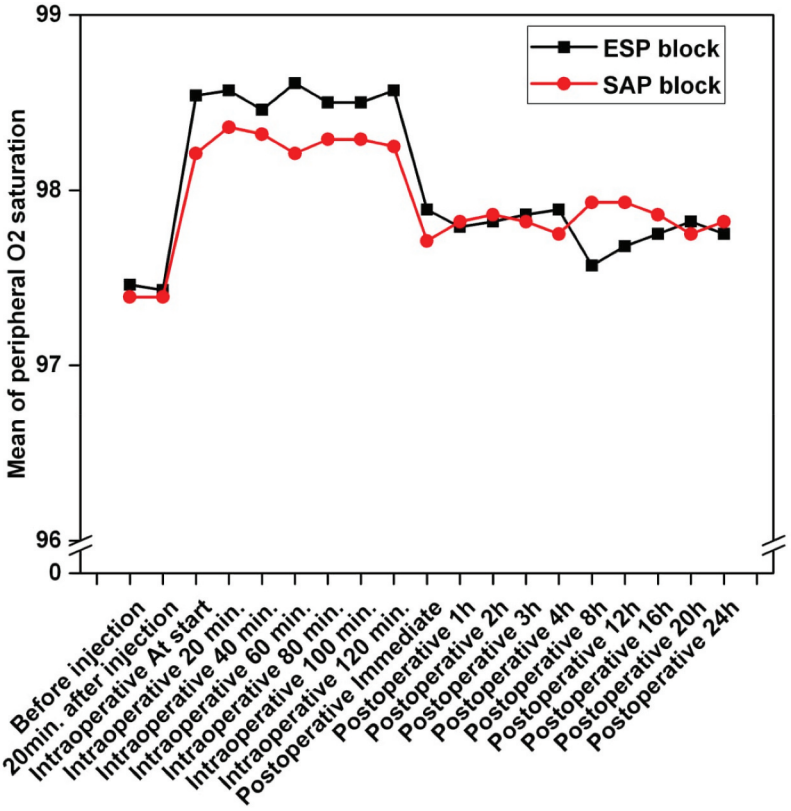

Figure 4. Comparison between the two groups regarding O2 saturation (%).

inferior shoulder pain, there were no significant differences among the groups ($p = 0.763$) (Table 2). The incidence of postoperative acute neuropathic pain, assessed using the DN4 questionnaire after one week and one month, showed insignificant variations (p-value = 1.000 and 0.554, respectively), as presented in Table 3. (p-value = 1.000 and 0.554 respectively) (Table 3). The intensity of the neuropathic pain measured by the neuropathic pain scale after one week and one month were comparable among groups (p-value = 1.000 and 0.554 respectively) (Figure 6). Concerning total morphine consumption, the first request for analgesia and total local anaesthetic consumption, no significant differences were observed among the groups (p-value = 0.408, 0.916 and 0.574 respectively) (Table 4). Patient satisfaction (measured by the Likert Scale) was comparable between both groups before discharge (Table 5). Importantly, no intra-operative need for extra doses of fentanyl or complications were reported in either group.

4. Discussion

The current prospective randomized clinical trial assessed the efficacy of SAPB (posterior approach) versus ESPB in patients undergoing modified radical mastectomy.

In the current trial, no significant differences were observed among groups regarding postoperative VAS values at rest and with movement throughout the first postoperative day. Similar findings were reported by Ahuja et al. [22] and Wang et al. [23] signifying comparable analgesic effects of both ESPB and SAPB (anterior approach) in patients undergoing MRM.

Abdelfatah et al. [24] reported insignificant variations between ESPB and thoracic paravertebral block (TPVB) for analgesia in MRM. According to Aly et al. [25], there were insignificant variations in the VAS between the SAPB and TPVB during rest or while coughing on the first postoperative day; however, at 12 and 18 hours after surgery, the VAS was lower in the TPVB group for patients undergoing thoracotomies.

Contrarily, Sagar et al. [26] observed a lower mean numerical rating scale (NRS) in the ESPB group than the SAPB group at 2, 4, 8 and 12 hours postoperatively in 40 female patients undergoing MRM. In the current study, a catheter with continuous infusion at the block site was employed, potentially explaining the difference in results compared to Sagar et al. [26]. Additionally, the difference in sample size (40 patients) may contribute to the variations in study outcomes.

We reported a significantly higher number of blocked dermatomes in the ESPB group compared to the SAPB group in the present study. In the ESPB group, the maximum dermatomal spread extended from T1 to T12 in certain patients. Conversely, in the SAPB group, the maximum spread ranged from T2 to T9. Consistent with our findings, Malwat et al. [27], observed sensory block from T1 to T8 dermatomes after ESPB for breast operations. Forero et al. [10] and

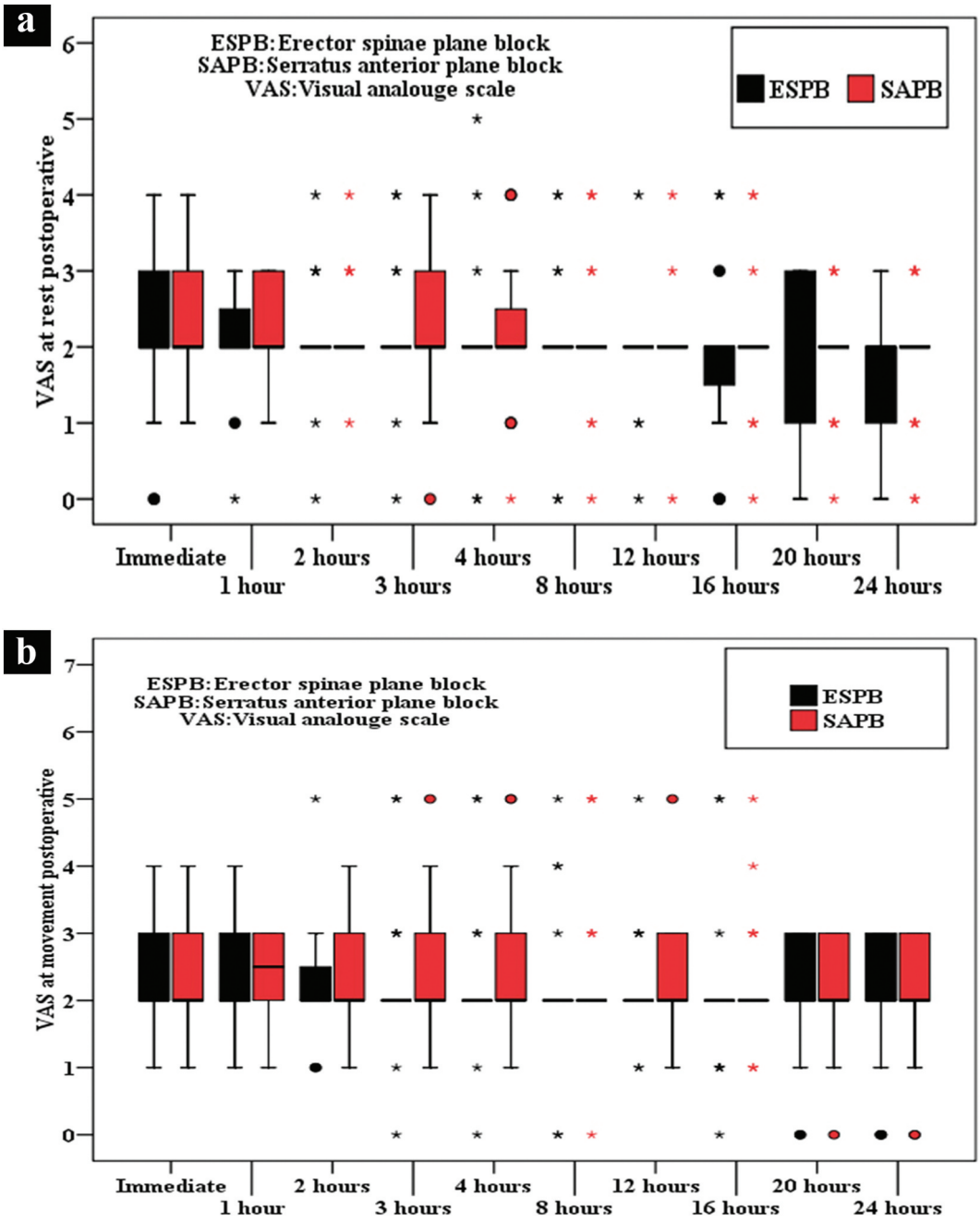

Figure 5. a) changes in the VAS between the two studied groups at rest. b) changes in the VAS between the two studied groups during movement.

Barrios et al. [28] reported a mean dermatomal spread of nine dermatomes in patients who received ESPB for analgesia in acute thoracic pain. The inconsistent dermatomal coverage and variable spread may be due to the discrepancies in the intermuscular planes between the spinalis, iliocostalis, and longissimus thoracic, which together make up the erector spinae muscles. Spread is volume dependent as anticipated by Curatolo [29]. However, despite accounting for this factor, the spread remains inconsistent, with the dorsal rami block emerging as the only consistently observed feature [30].

Blanco et al. [8], also found that the dermatomal block ranged from T2-T9 in the SAPB block, while Okmen et al. [31] conducted SAPB for post-thoracotomy pain control, had a sensory block from T2 to T10 dermatomes.

We reported insignificant differences between the two groups regarding axillary coverage and incidence of inferior shoulder pain. In contrast, Blanco et al. [8] reported better axillary coverage in the serratus block than PEC II, attributing it to the direct injection of local anaesthetic into the mid-axillary line above the lateral cutaneous nerve exit. In patients having MRM, Kaur et al. [32] found that the serratus-intercostal-facial plane (SIFP) group had greater shoulder coverage than the pectoral nerve block II (PEC II) group.

Table 2. Comparison between the two studied groups regarding dermatomal block, axillary and shoulder sensory loss.

	ESPB ($n = 28$)	SAPB ($n = 28$)	Test of sig.	p
Sensory level (Number of dermatomes)				
Min. – Max.	5.0–12.0	5.0–8.0	U = 266.0*	0.031*
Median (IQR)	7.0 (6.0–9.0)	6.0 (6.0–7.0)		
Axillary coverage				
No	7 (25.0%)	8 (28.6%)	$\chi^2 = 0.091$	0.763
Yes	21 (75.0%)	20 (71.4%)		
Inferior shoulder pain				
No	21 (75.0%)	20 (71.4%)	$\chi^2 = 0.091$	0.763
Yes	7 (25.0%)	8 (28.6%)		

IQR: Inter quartile range SD: Standard deviation.
χ^2: Chi-square test U: Mann Whitney test.
p: p-value for comparing between the two studied groups
*: Statistically significant at $p \leq 0.05$.

Table 3. Comparison between the two studied groups regarding the number of patients reporting neuropathic pain (DN4 ≥ 4).

Neuropathic pain by DN4 (Pain score ≥ 4)	ESPB ($n = 28$) No. (%)	SAPB ($n = 28$) No. (%)	x^2	^{FE}p
1st week	3 (10.7%)	4 (14.3%)	0.163	1.000
After one month	7 (25.0%)	9 (32.1%)	0.350	0.554
McNp0	0.125	0.063		

χ2: Chi-square test FE: Fisher Exact p: p-value for comparison between the two studied groups.
p0: p-value for McNemar test for comparing between 1st week and after one month

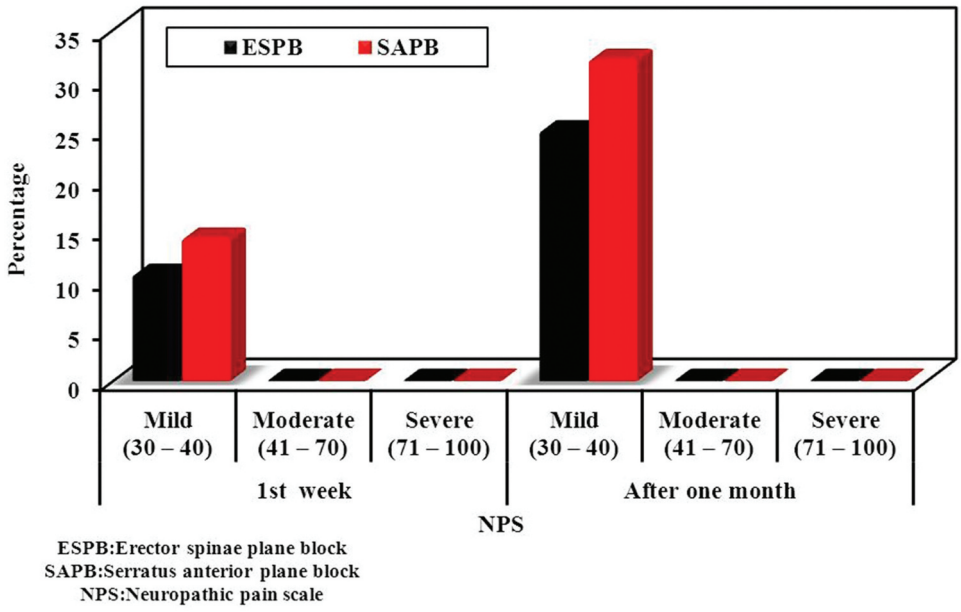

Figure 6. Comparison between the two studied groups regarding neuropathic pain scale.

Table 4. Postoperative analgesic requirements in both groups.

	ESPB ($n = 28$)	SAPB ($n = 28$)	Test	P
Number of patients who requested morphine (%)	7 (25.0%)	9 (32.1%)	$\chi^2 = 0.350$	0.554
Total morphine consumption/24 hours (mg)				
Mean ±SD	5.57 ± 2.07	4.67 ± 2.65	U = 23.0	0.408
First request for morphine (hours)				
Mean ±SD	3.04 ± 2.53	3.17 ± 2.34	t = 0.107	0.916
Total bupivacaine consumption/24 hours (ml)				
Mean ±SD	135.8 ± 28.02	140.14 ± 30.1	t = 0.566	0.574

IQR: Inter quartile range SD: Standard deviation.
t: Student t-test U: Mann Whitney test
p: p-value for comparing between the two studied groups

Table 5. Comparison between the two studied groups regarding patient satisfaction by likert scale (before discharge).

Patient satisfaction (Likert scale)	ESPB ($n = 28$) No. (%)	SAPB ($n = 28$) No. (%)	x^2	^{MC}p
V. unsatisfied	0 (0.0%)	1 (3.6%)	1.824	0.887
Unsatisfied	1 (3.6%)	1 (3.6%)		
Neutral	6 (21.4%)	7 (25.0%)		
Satisfied	10 (35.7%)	11 (39.3%)		
Very satisfied	11 (39.3%)	8 (28.6%)		

χ^2: Chi-square test MC: Monte Carlo.
P: p-value for comparing the two-studied group.

We reported insignificant variations among groups in terms of the first request of analgesia and total morphine and Bupivacaine consumption. Similar findings were reported by Ahuja et al. [22] and Arora et al. [33], who found comparable total tramadol doses in the first 24 hours after breast surgery between TPVB and SAPB groups. Abdelfatah et al. [24], Mostafa et al. [34] and El Ghamry et al. [35], reported insignificant variations in opioid consumption between TPVB and ESPB after breast surgery.

Contrary to our study, Sagar et al. [26] found lower analgesic requirements in the ESPB compared to the SAPB in MRM patients, possibly explained by the absence of a catheter infusion of local anaesthetic.

We also found insignificant variations among groups regarding the incidence and the intensity of neuropathic pain by DN4 scale and NPS. Additionally, there were no differences in the incidence and intensity of neuropathic pain within the same group over time (Table 3, Figure 6).

A systematic review conducted by Yuksel et al. [36], reported that TPVB, PECS II and SAPB either by a single injection or continuous infusion, effectively reduced the prevalence and intensity of chronic neuropathic pain in females with MRM. However, Xin et al., [37] reported that preoperative ultrasound-guided ESPB did not affect the prevalence of neuropathic pain or the chronicity of the pain after breast surgeries.

There were insignificant variations among groups in patient satisfaction before discharge. Abdalfattah et al. [24] found insignificant difference between the ESPB and the TPVB in patients undergoing unilateral MRM regarding patient satisfaction. A meta-analysis by Oh and colleagues [38] revealed that ESPB was superior to the other analgesic modalities in terms of patient satisfaction and recovery.

Finnerty et al. [39] observed that for minimally invasive thoracic surgeries, the ESPB group had a significantly higher level of patient satisfaction, 24 hours after surgery than the SAPB group. The diverse surgical populations investigated may explain the divergent outcomes when compared to the findings of the current study. While post-thoracotomy pain involves both somatic and visceral parts of pain, the somatic aspect of pain mostly causes acute pain following MRM. Compared to SAPB in thoracic surgery, ESPB offers superior pain management, due to the potential spread to the thoracic paravertebral space.

In the current study, no complications or major side effects were reported in either group. Ahuja et al. [22] coinciding with our results, found no complications after ESPB or SAPB in patients undergoing MRM. The perioperative changes in HR and MABP were insignificant between both groups in all measurements. In accordance with the current trial, Elsabeeny et al. [12] reported statistically insignificant differences in the hemodynamic parameters in SAPB and ESPB for patients undergoing MRM.

Several factors may contribute to the varied outcomes in regional blocks for breast surgeries in the published literature. Firstly, the analgesic efficacy of different nerve block procedures may be influenced by using different LAs. Secondly, it is suggested that the volume and concentrations of LAs had an impact on how much of the dermatomes were blocked [40]. Thirdly, the effectiveness and degree of analgesia of the employed regional technique heavily depend on the operator's level of experience. Fourthly, the deposition of LAs at optimal locations in regional nerve blocks can affect the results. Lastly, the presence of a catheter with intermittent or continuous infusion at the block site can also influence the efficacy and duration of regional nerve blocks.

5. Conclusion

SAPB and ESPB are both effective analgesic modalities and good alternatives to IV opioid analgesia because they have fewer adverse effects and good patient satisfaction. ESPB has a more dermatomal block but both of them had comparable axillary coverage, patient satisfaction, and incidence of inferior shoulder pain and neuropathic pain.

List of Abbreviations

ASA	American Society of Anesthesiologists
BMI	Body mass index
DN4	Deuleur Neuropathique 4
ESPB	Erector Spinae Plane Block
GA	General anaesthesia

HR	Heart rate
LA	Local anaesthetic
MABP	Mean arterial blood pressure
MC	Monte Carlo
O2	Oxygen
PACU	Post-anaesthetic care unit
PECS's I-II	Pectoralis Nerve Blocks I-II
PNBS	Peripheral Nerve Blocks
SAPB	Serratus anterior plane block
TPVB	Thoracic paravertebral block
U	Mann Whitney test
USG	Ultrasound-guided
VAS	Visual analogue scale
$\chi 2$	Chi-square test

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Disclosure statement

The authors stated no conflict of interest.

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Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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