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ORIGINAL RESEARCH REGIONAL ANESTHESIA

Effectiveness of ultrasound guided erector spinae plane block compared to serratus anterior block in modified radical mastectomy: a randomized comparative trial

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ABSTRACT

Background & objectives: Acute postoperative pain occurs in approximately 40-60% of patients undergoing breast surgeries. Multiple thoracic wall blocks have been developed to reduce complications associated with thoracic epidural and paravertebral block including erector spinae plane block (ESPB) and serratus anterior plane block (SAPB).

We evaluated and compared ESPB versus SAPB, regarding safety and efficacy to relieve acute postoperative pain in patients undergoing modified radical mastectomy (MRM) under general anesthesia (GA).

Method0ology: We recruited 60 female patients, ASA II - III, undergoing MRM under GA, and assigned them into one of the two equal groups: group 1 (SAPB group) and group 2 (ESPB group). The primary outcome was postoperative morphine consumed in the first 24 hours. Secondary outcomes included intraoperative fentanyl consumption, numeric pain rating scale (NRS) scores at rest and movement, post-operative nausea, vomiting and overall patient satisfaction.

Results: There was a significantly reduced consumption in postoperative morphine in ESPB group compared to SAPB group (1.70 ± 1.88 vs 4.50 ± 3.03 mg). Intraoperative fentanyl consumption was significantly lower in ESPB group compared to SAPB group (130.6 ± 44.41 vs 160.0 µg ± 53.18; P = 0.031). ESPB group showed significantly lower scores of NRS scores at rest as well as on movement.

Conclusion: Erector spinae plane block provides more effective intraoperative as well as postoperative analgesia compared to serratus anterior plane block in patients undergoing modified radical mastectomy under general anesthesia.

Key words: Modified Radical Mastectomy; Regional Anesthesia; Nerve Block; Breast Cancer

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1. INTRODUCTION

Breast cancer is considered one of the most prevalent malignancies among females. Surgical interventions including modified radical mastectomy (MRM) are considered the main management approaches used.[1] Severe acute postoperative pain has been reported in about 40-60% of patients, with 10-50% of patients developing post mastectomy pain syndrome (PMPS) that can results in long-term disabilities.[2] Opioids have been considered the cornerstone for management of acute perioperative pain, but their use had been associated with multiple undesired side effects. Opioids associated side effects include oversedation, respiratory depression, urine retention, itching in addition to nausea and vomiting. Different analgesic modalities including regional blocks had merged to achieve adequate analgesia with lowering the incidence of opioid side effects. Over time, thoracic paravertebral block became the gold standard regional technique for breast surgeries. However, serious complications may occur such as pneumothorax and spinal cord injury.[3]

Different fascial plane blocks developed over the last years targeting to provide analgesia with lower complications of other regional techniques.[4] Ultrasound guided serratus anterior plane block (SAPB) was described by Blanco et al. It was utilized for breast analgesia and lateral thoracic wall surgery.[5] Then ultrasound guided erector spinae plane block (ESPB) was described by Forero and colleagues as a novel regional analgesic technique for acute and chronic thoracic pain.[6] Both blocks have been used for perioperative analgesia of breast surgeries since introduced. Although data suggests that both blocks are simple and safe to perform, more studies are needed to assess their safety and efficacy. The current study aim is to assess and compare the analgesic efficacy and safety of ESPB compared to SAPB in female patients undergoing modified radical mastectomy.

2. METHODOLOGY

This trial was held at the National Cancer Institute, Cairo University from January to May 2020 as a randomized comparative study. The study was conducted after receiving institutional anesthesia department approval and approval of the ethical committee at the Faculty of Medicine, Cairo University (Codes: N-65\2019 ms and MS-268-2019, respectively). The clinical trial was registered with ID NCT04606147. The study was single-blind, with the outcome assessor investigator being blinded to the block performed. Informed consent was taken from all patients participated in the study.

Our plan was to study post-operative morphine consumption in the first 24 hours as a continuous response variable from independent control and experimental groups with a 1:1 ratio. The ESPB group was compared to the SAPB group. In previous trials, mean postoperative morphine consumption for the SAPB group was 9.7 ± 2.1 mg (Gupta et al.) and for the ESPB group was 1.9 ± 2.01 mg (Singh et al.) [7-8]. Assuming a true difference of 7.8 between the groups, a sample size of 14 subjects per group was needed to achieve 90% power with a type 1 error probability of 0.01. To ensure normal distribution, 30 patients per group were recruited.

Sixty female patients, scheduled for modified radical mastectomy under general anesthesia, were recruited to the study. Eligible patients were randomized into one of the 2 study groups, using computer-generated random numbers in opaque envelopes, with an allocation ratio of 1:1. SAPB group received the serratus anterior plane block (SAPB), and ESPB group received the erector spinae plane block (ESPB).

Inclusion criteria included female patients aged 18-65 years, ASA II-III physical status, and BMI between 20-35 kg/m². Exclusion criteria included patient's refusal, known hypersensitivity or contraindications to the study drugs, psychological disorders, chronic pain, contraindications to regional anesthesia, pregnancy.

At the preoperative assessment clinic, patient history, and physical examinations were conducted. The Numeric Pain Rating Scale (NPRS, 0 = no pain to 10 = worst pain) was illustrated to all patients.

In the preoperative area, patients underwent clinical assessment, with heart rate, blood pressure, and oxygen saturation monitored. An 18-gauge intravenous line was established, followed by premedication with intravenous midazolam (0.01-0.02 mg/kg). Standard ASA monitoring was applied. Induction of anesthesia included fentanyl 2 µg/kg and propofol 2 mg/kg IV, with rocuronium 0.5 mg/kg IV for intubation. Anesthesia was maintained with sevoflurane 2-2.5% in oxygen-enriched air. Multimodal analgesia included paracetamol 1 g and ketorolac 30 mg IV. Intraoperative rescue fentanyl in a bolus of 1 µg/kg was given and recorded in cases of inadequate intraoperative analgesia.

Full resuscitation equipment was prepared in advance to ensure safety before initiating the blocks.

2.1. Serratus Anterior Plane Block:

The patient in supine position, a 6–13 MHz ultrasound linear transducer was placed in the midaxillary line at the level of the fifth rib. The skin overlying the target entry site was anesthetized using 3 mL of 1% lidocaine, and a 22-gauge needle was advanced under ultrasound guidance to the fascial plane deep to the serratus anterior muscle. After confirming the needle position with 1 mL saline, 30 mL of 0.25% levobupivacaine was injected.

Table 1: Demographic data of patients enrolled in this study, intra and post operative opioid consumption

Variable	Group1 SAPB N=30	Group2 ESPB N=30	P value
Demographic Data:			
Age in years	49.30 ±10.79	46.30 ± 9.31	0.274
BMI kg/m2	28.53 ±4.28	28.31 ±3.19	0.888
ASAII	26 (84.7%)	27 (90%)	1.0
ASAIII	4 (13.3%)	3 (10%)	1.0
Side of Surgery:			1.0
Right	13 (43.4%)	13 (43.4%)	
Left	17(56.6%)	17(56.6%)	
Postoperative Morphine consumption in 24 hours(mg)	4.50±3.03	1.70 ±1.88	<0.001
Intraoperative fentanyl consumption(µg)	160.0 ±53.18	130.6 ±44.41	0.031

Data were presented as: Mean ± SD, patient number and (percentage) %.

2.2. Erector Spinae Plane Block:

In sitting position, using the same ultrasound transducer, the probe was placed at the T5 level to identify the transverse process. A skin wheal with 3 mL of 1% lidocaine was raised, and an echogenic block needle was advanced to the transverse process under ultrasound guidance. After confirming the position with 1 mL saline, 30 mL of 0.25% levobupivacaine was injected. Both blocks were performed using the Fujifilm Sonosite M-Turbo Ultrasound system. Post-block, lung ultrasound was performed to exclude pneumothorax.

In the PACU, NPRS scores, MAP, and HR were recorded upon arrival and monitored for 2 hours. Patients received multimodal analgesia (paracetamol 1 g/8 hours, ketorolac 30 mg/8 hours IV and rescue morphine analgesia was given in a bolus dose of 3 mg/dose in cases with reported NPRS ≥ 4. NPRS, MAP, and HR were recorded up to 24 hours postoperatively. Any reported side effects such as respiratory depression, nausea, vomiting, or sedation, were recorded. PONV was assessed on a four-point scale, and inj ondansetron IV was administered for moderate or severe cases. Sedation was assessed using Ramsay Sedation Scores.

The primary outcome was total morphine consumption postoperatively within 24 hours. Secondary outcomes were total fentanyl consumption intraoperatively, degree of postoperative sedation using Ramsay sedation scores (RSS) at PACU, NPRS at rest and during movement at 2, 4, 8, 12, 16, 20 and 24 hours postoperatively, the incidence of PONV, time to first rescue analgesia; block-related complications (e.g., systemic toxicity, pneumothorax, arterial puncture); morphine-related complications (e.g., respiratory depression, urine retention, pruritus) and overall patient satisfaction.

2.3. Statistical Analysis

Data was analyzed using SPSS version 23.0. Mean and standard deviation used to present quantitative data; meanwhile, median and range for qualitative data as appropriate. Normality tests determined the use of parametric or non-parametric tests. Independent group comparisons employed t-tests (parametric or non-parametric). Repeated measures ANOVA (parametric) or Friedman tests (non-parametric) were used for time-effect analysis on vitals. Post-hoc pairwise comparisons were Bonferroni adjusted. Proportion independence was tested using Chi-square and Fisher Exact tests. A two-tailed $P < 0.05$ was considered significant.

3. RESULTS

The comparison of demographic data between the two groups showed no statistical significance. ESPB group (ESPB) exhibited a statistically significant reduction in total postoperative morphine consumption, averaging 1.70 mg ± 1.88, compared to 4.50 mg ± 3.03 in SAPB group (SAPB). Additionally, patients in ESPB group required significantly less intraoperative fentanyl, with a mean of 130.6 µg ± 44.41, compared to 160.0 µg ± 53.18 in SAPB group (Table 1). ESPB group also demonstrated significantly lower numeric pain rating scale scores compared to SAPB group both at rest and during movement at all measurement points (Table1, Figure 2). Significant percentage of patients 50% in ESPB group compared to 23.3% of patients in SAPB group didn't receive morphine in the first 24 hours (Table 1). While ESPB group was associated with a longer duration of analgesia, reduced postoperative nausea and vomiting, better Ramsey scores, and higher overall satisfaction rates compared to SAPB group, these differences were not statistically significant (Table 2). No block-related complications were observed in either group.

4. DISCUSSION

More than 50% of patients who undergo breast surgeries suffer from acute pain, with more than 30% experience persistent pain of 6 to 12 months, a condition known as post-mastectomy pain syndrome (PMPS).[2] According to the severity of pain it can lead

Table 2: Time to 1st postoperative analgesia (hours), Ramsay score, PONV, Block related complications and Overall satisfaction among two study groups

Variable Time to 1st postoperative analgesia (hours)	Group1 SAPB N=30	Group2 ESPB N=30	P value
Immediate post operative	5 (16.7%)	1 (3.3%)	0.195
2hrs	5 (16.7%)	4 (13.3%)	1.00
4hrs	4 (13.3%)	3 (10%)	1.00
8hrs	4 (13.3%)	3 (10%)	1.00
12hrs	1 (3.3%)	0	1.00
16hrs	0	1 (3.3%)	1.00
20hrs	1 (3.3%)	1 (3.3%)	1.00
24hrs	3 (10%)	2 (6.7%)	1.00
Nil	7 (23.3%)	15 (50%)	0.032
Ramsey sedation score			
Adequate sedation= 2-4	28 (93.33)	30 (100%)	0.23
High level of sedation 5-6	0	0	
Inadequate sedation = 1	2 (6.66%)	0	
2 hrs postoperative score= 2	29 (96.3%)	30 (100%)	1.00
2 hrs postoperative score >2	1 (3.3%)	0	
2 hrs postoperative score <2	0	0	
Postoperative Nausea and Vomiting			
NO PONV	17 (56.6%)	20 (66.66%)	0.724
Mild PONV	10 (33.33%)	8 (26.66%)	
Mod PONV	3 (10%)	2 (6.66%)	
Severe PONV	0	0	
Overall satisfaction			
Satisfied	23 (76.7%)	27 (90%)	0.166
Unsatisfied	7 (23.3%)	3 (10%)	

Data were presented as: number of patients and (percentage%)

to long-term disabilities and interfere with the quality of life of these patients.[3] Various analgesic techniques, including regional and opioid analgesia, have been reported to improve perioperative pain conditions. Additionally, regional anesthesia has been shown to attenuate the surgical response system and reduce the progression of malignancy.[9]

In this study, we compared a relatively new block (ESPB), introduced in 2016, with an older block (SAPB), introduced in 2013. The following conclusions were demonstrated: the performance of ESPB for modified radical mastectomy resulted in better analgesic effects, reduced intraoperative and postoperative opioid consumption, lower pain scores at rest and with movement, and a longer duration of analgesia compared to SAPB.

The erector spinae muscle (ESM) is formed by the spinalis, longissimus thoracis, and iliocostalis muscles. Running bilaterally from the skull to the pelvis and sacral region, it extends from the spinous to the transverse processes, reaching the ribs and creating a fascial plane where local anesthetic can be injected.[10] While the mechanism of action is not fully understood, the injected local anesthetic (LA) spreads in the fascial plane in both cranial and caudal directions, with approximately 3.4 mL of LA required per dermatome. Studies have reported that the spread covers only from 3 to 6 vertebral levels in the craniocaudal direction.[11] The lateral spread is limited to the lateral border of the ESM corresponding to the ribs' angle and thoracolumbar fascia. Mechanisms of action include effects on intercostal nerves, ventral and dorsal rami, and diffusion to the epidural space and neural foramina, as observed in anatomical studies.[12]

Early practice suggested that ESPB spread into the paravertebral space, potentially diffusing into the epidural space to block spinal nerves, although this has been confronted by some cadaveric studies that lack to confirm the spread of dye to the paravertebral gutter. Another explanation is that the ESM acts as a reservoir, slowly releasing LA to the adjacent paravertebral space. Imaging studies have shown that only a small fraction of injectate enters the paravertebral and epidural spaces within the first 30-60 minutes, with most of the volume remaining in the ESM.[13]

When performing SAPB, local anesthetic can be injected near the axilla, where the local anesthetic can spread between the serratus anterior and latissimus dorsi muscles blocking the long thoracic, intercostobrachial, thoracodorsal nerves in addition to the lateral cutaneous branches of

the intercostal nerves (T3–T9), while sparing the suprascapular nerve, pectoral nerves, and anterior cutaneous nerves, making the block less effective for analgesia of the medial, upper, and deeper parts of the breast.

In the original article by Blanco et al., two potential spaces for SAPB were described: a superficial and deep plane. The superficial plane lies between the pectoralis minor muscle and the SAM, while the deep plane lies between the SAM and the fifth rib at the midaxillary line. The deep level, theoretically closer to the intercostal space, allows for more local anesthetic diffusion to the intercostal nerves compared to the superficial plane, which is closer to brachial plexus nerves (thoracodorsal and long thoracic nerves). The deep plane is not related to the surgical field, while the superficial plane's local anesthetic may spoil the surgical field. The efficacy of both techniques has been investigated in multiple studies with no clear conclusion as to which plane is better.[5,14-15]

ESPB has the advantage of blocking intercostal nerves (ventral rami), whereas SAPB only blocks the lateral cutaneous branches of the intercostal nerves. Whereas SAPB provides analgesia for brachial plexus-derived pain by blocking the thoracodorsal and long thoracic nerves.

Multiple studies have demonstrated the efficacy of both techniques for postoperative analgesia in breast surgeries, including reduced opioid consumption and better pain scores.[8,13, 16-18]

Compared to PVB (one of the gold standard regional techniques in breast surgery), most authors affirm that ESPB provides great advantages when compared to other interventions performed near to the neuroaxis. ESPB has shown equivalent efficacy to PVB in randomized trials, demonstrating comparable results regarding lowering pain scores as well as opioid consumption.[19]

Gupta et al. compared the analgesic efficacy of ultrasound-guided paravertebral block versus serratus anterior plane block for MRM and concluded that SAPB is less effective than PVB. Although neither block is the first choice in most situations, they remain suitable alternatives, especially when the gold standard technique poses significant risks or is contraindicated.

Several studies compared ESPB to SAPB for MRM. In a superiority study conducted by Gad et al., they concluded that ESPB offers superior analgesia compared to regarding first time to receive analgesia, intra- and postoperative fentanyl consumption, pain scores.[20] Another study by Sagar et al. highlights the superior analgesic efficacy of the ESPB compared to the SAPB. Their findings suggest that ESPB provides longer-lasting analgesia and better pain scores, while maintaining comparable postoperative analgesic consumption. This makes ESPB a potentially more effective option for managing postoperative pain.[21]

The study by Bedwey et al. further supports the advantages of the ESPB over the SAPB. Their findings highlight that ESPB not only provides better analgesia but also reduces morphine consumption, lowers cortisol levels, and decreases the incidence of postoperative nausea and vomiting (PONV). These benefits make ESPB a compelling choice for postoperative pain management.[22] Furthermore, Niyma et al., investigated the analgesic efficacy of ESPB compared to SAPB concluding the superiority of ESPB with lower VAS scores at rest and with movement, lower morphine consumption and longer first time to receive analgesia.[23]

In a systematic review by Muhammad et al., their study revealed that while ESPB exhibits statistically superior analgesic efficacy compared to SAPB, the difference lacks clinical significance. Additionally, the safety profiles of the two techniques are similar, and current evidence does not definitively establish the superiority of one block over the other.[24]

Moreover, ESPB is an effective alternative to both paravertebral and epidural blocks whenever there are any contraindications for their performance such as, thrombocytopenia, antiplatelet or anticoagulant treatments, or coagulopathy.[11-18] ESPB carries lower risk of complications since critical structures like major vessels and pleura are far from the target area. Although SAPB is simple, its proximity to the pleura increases the risk of pneumothorax, as observed in case reports and our center's experience. Additionally, muscle hematomas were noted in five SAPB patients, likely due to the injection site's proximity to the surgical area during MRM, potentially causing muscle edema or hematoma and affecting surgery. Conversely, ESPB is not related to the breast surgical field and any muscle hematoma development will not impact the surgery.[25]

5. LIMITATIONS

The limitations of this study included being a single center study with single blinded method, as blocks were performed with the patients awake. Additionally, the long-term effects (chronic pain) were not studied.

6. CONCLUSION

Ultrasound guided erector spinae plane block can be considered safer and provides more effective in perioperative analgesia for patients undergoing modified radical mastectomy compared to ultrasound guided serratus anterior plane block in the form of less intraoperative fentanyl consumption, less postoperative morphine consumption, less numeric pain scale scores and less block associated complication

7. References:

1. Fecho K, Miller NR, Merritt SA, Klauber-DeMore N, Hultman CS, Blau WS. Acute and persistent postoperative pain after breast surgery. Pain Med. 2009;10(4):708–15. PubMed DOI: 10.1111/j.1526-4637.2009.00611.x
2. Smith WC, Bourne D, Squair J, Phillips DO, Chambers WA. A retrospective cohort study of post mastectomy pain syndrome. Pain. 1999;83(1):91–5. PubMed DOI: 10.1016/s0304-3959(99)00076-7
3. Chappell AG, Yuksel SS, Sasson DC, Wescott AB, Connor LM, Ellis MF. Post-mastectomy pain syndrome: an up-to-date review of treatment outcomes. JPRAS Open. 2021;30:97–109. PubMed DOI: 10.1016/j.jpra.2021.07.006
4. Garg R, Bhan S, Vig S. Newer regional analgesia interventions (fascial plane blocks) for breast surgeries: review of literature. Indian J Anaesth. 2018;62(4):254–62. PubMed DOI: 10.4103/ija.IJA_46_18
5. Blanco R, Parras T, McDonnell JG, Prats-Galino A. Serratus plane block: a novel ultrasound-guided thoracic wall nerve block. Anaesthesia. 2013;68(11):1107–13. PubMed DOI: 10.1111/anae.12344
6. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med. 2016;41(5):621–7. PubMed DOI: 10.1097/AAP.0000000000000451
7. Gupta K, Srikanth K, Girdhar KK, Chan V. Analgesic efficacy of ultrasound-guided paravertebral block versus serratus plane block for modified radical mastectomy: a randomised, controlled trial. Indian J Anaesth. 2017;61(5):381–6. PubMed DOI: 10.4103/ija.IJA_62_17
8. Singh S, Kumar G, Akhileshwar. Ultrasound-guided erector spinae plane block for postoperative analgesia in modified radical mastectomy: a randomised control study. Indian J Anaesth. 2019;63(3):200–4. PubMed DOI: 10.4103/ija.IJA_758_18
9. Sekandarzad MW, van Zundert AAJ, Lirk PB, Doornebal CW, Hollmann MW. Perioperative anesthesia care and tumor progression. Anesth Analg. 2017;124(5):1697–708. PubMed DOI: 10.1213/ANE.0000000000001652
10. Henson B, Kadiyala B, Edens MA. Anatomy, back, muscles. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2023. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537074/
11. De Cassai A, Tonetti T. Local anesthetic spread during erector spinae plane block. J Clin Anesth. 2018;48:60–1. PubMed DOI: 10.1016/j.jclinane.2022.110834
12. Adhikary SD, Bernard S, Lopez H, Chin KJ. Erector spinae plane block versus retrolaminar block: a magnetic resonance imaging and anatomical study. Reg Anesth Pain Med. 2018;43(7):756–62. PubMed DOI: 10.1097/AAP.0000000000000798
13. Chin KJ, El-Boghdadly K. Mechanisms of action of the erector spinae plane (ESP) block: a narrative review. Can J Anaesth. 2021;68(3):387–408. PubMed DOI: 10.1007/s12630-020-01875-2
14. Tan KW, Sayed Masri SN, Musthafa QA, Mohd Azidin A, Nik Mohamed Kamil A, Izaham A, et al. Analgesic efficacy of the superficial versus deep serratus plane blocks for mastectomy with axillary clearance: a randomized controlled trial. Medicine (Baltimore). 2022;101(35):e30515. PubMed DOI: 10.1097/MD.0000000000030515
15. Edwards JT, Langridge XT, Cheng GS, McBroom MM, Minhajuddin A, Machi AT. Superficial vs. deep serratus anterior plane block for analgesia in patients undergoing mastectomy: a randomized prospective trial. J Clin Anesth. 2021;75:110470. PubMed DOI: 10.1016/j.jclinane.2021.110470
16. Hu NQ, He QQ, Qian L, Zhu JH. Efficacy of ultrasound-guided serratus anterior plane block for postoperative analgesia in patients undergoing breast surgery: a systematic review and meta-analysis of randomised controlled trials. Pain Res Manag. 2021;2021:7849623. PubMed DOI: 10.1155/2021/7849623
17. Gürkan Y, Aksu C, Kuş A, Yörükoğlu UH, Kılıç CT. Ultrasound guided erector spinae plane block reduces postoperative opioid consumption following breast surgery: a randomized controlled study. J Clin Anesth. 2018;50:65–9. PubMed DOI: 10.1016/j.jclinane.2018.06.033
18. Gürkan Y, Aksu C, Kuş A, Yörükoğlu UH. Erector spinae plane block and thoracic paravertebral block for breast surgery compared to IV-morphine: a randomized controlled trial. J Clin Anesth. 2020;59:84–8. PubMed DOI: 10.1016/j.jclinane.2019.06.036
19. Ivanusic J, Konishi Y, Barrington MJ. A cadaveric study investigating the mechanism of action of erector spinae blockade. Reg Anesth Pain Med. 2018;43(6):567–71. PubMed DOI: 10.1097/AAP.0000000000000789
20. Gad M, Elsharkawy H, El-Boghdadly K, El-Masry R, El-Morsy G, El-Sherif F, et al. A superiority study of the analgesic efficacy of ultrasound-guided erector spinae plane block compared to serratus anterior plane block using bupivacaine-dexamethasone for modified radical mastectomy. Res Opin Anesth Intensive Care. 2023;10(4):296–304. DOI: 10.4103/roaic.roaic_33_23
21. Sagar S, Loha S, Paswan A, Pratap A, Prakash S, Rath A. Comparison of erector spinae plane block and serratus anterior plane block for modified radical mastectomy: a prospective randomised study. Anestezi Dergisi. 2022;30(4):264–71. DOI: 10.54875/jarss.2022.59320
22. Bedewy AAE, Mohamed MS, Sultan HM, Khalil MS. Comparison between erector spinae plane block versus serratus anterior plane block regarding analgesia and stress response after modified radical mastectomy: randomized controlled trial. Anesth Pain Med. 2024;14(2):e123456. PubMed DOI: 10.5812/aapm-142189
23. Nyima T, Palta S, Saroa R, Kaushik R, Gombar S. Ultrasound-guided erector spinae plane block compared to serratus anterior muscle block for postoperative analgesia in modified radical mastectomy surgeries: a randomized control trial. Saudi J Anaesth. 2023;17(3):311–7. PubMed DOI: 10.4103/sja.sja_716_22
24. Muhammad QA, Khan M, Ali S, Ahmed R, Hussain M, Shahid A, et al. Analgesic efficacy and safety of erector spinae versus serratus anterior plane block in thoracic surgery: a systematic review and meta-analysis of randomized controlled trials. J Anesth Analg Crit Care. 2024;4(1):3. PubMed DOI: 10.1186/s44158-023-00138-y
25. Desai M, Narayanan MK, Venkataraju A. Pneumothorax following serratus anterior plane block. Anaesth Rep. 2020;8(1):14–6. PubMed DOI: 10.1002/anr3.12034

