International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Deep versus Superficial Erector Spinae Block for Modified Radical Mastectomy: A Randomized Controlled Trial

Dr Smitha A[1], Dr Sheetal Kumar G[2], Dr Shruthi jayaram[3]

[1]Senior Resident, Dept of Anesthesiology, Hassan institute of medical sciences
[2]Senior Resident, Dept of Anesthesiology
[3]Associate professor, Dept of Anesthesiology, Hims, Hassan

OPEN ACCESS

Corresponding Author:

Dr Shruthi Jayaram
Associate professor
Dept of Anesthesiology
Hims, Hassan
Mail-
shruthijayaram08@gmail.com

Received: 21-06-2026
Accepted: 10-07-2026
Available online: 27-07-2026

ABSTRACT

Background: The erector spinae plane (ESP) block is an effective analgesic technique for modified radical mastectomy (MRM). However, the optimal approach—superficial versus deep to the erector spinae muscle—remains debated. This study compares the analgesic efficacy and sensory blockade of deep versus superficial ESP block in patients undergoing MRM.

Methods: This prospective, randomized, double-blind study enrolled 80 female patients (ASA I/II) scheduled for unilateral MRM. The study was study conducted at Hims from January 2023 to june-2023. Patients were randomized to receive ultrasound-guided ESP block at T4 level with 25 mL of 0.25% bupivacaine either deep (Group D, n=40) or superficial (Group S, n=40) to the erector spinae muscle. All patients received standardized general anesthesia. The primary outcome was 24-hour postoperative morphine consumption. Secondary outcomes included time to first rescue analgesia, postoperative Visual Analog Scale (VAS) scores at 2, 4, 8, 12, and 24 hours, sensory block characteristics, and adverse events.

Results: Data from 40 patients (20 per group) showed that 24-hour postoperative morphine consumption was significantly lower in the deep ESP block group (5.47 ± 1.1 mg) compared to the superficial group (7.66 ± 0.74 mg, $P < 0.001$). Intraoperative fentanyl consumption was also significantly lower in the deep group (1.10 ± 0.538 µg/kg vs. 1.89 ± 0.435 µg/kg, $P < 0.001$). The mean duration of analgesia was significantly longer in the deep block group (6.75 ± 0.79 hours vs. 5.54 ± 1.03 hours, $P = 0.00$), and the median time to first rescue analgesia was substantially longer (10 hours vs. 4 hours, $P < 0.05$). VAS pain scores were significantly lower in the deep group at 8 hours ($P = 0.035$) and 12 hours ($P = 0.001$) postoperatively, with comparable scores at 24 hours. Sensory spread was more extensive in the deep group, particularly in the posterior axillary and mid-axillary lines. No adverse events were reported in either group.

Conclusion: The deep ESP block provides superior postoperative analgesia compared to the superficial approach in patients undergoing MRM, as evidenced by reduced opioid consumption, prolonged analgesic duration, delayed need for rescue analgesia, and improved early pain control. Both techniques demonstrate excellent safety profiles. We recommend the deep ESP block as the preferred regional anesthesia technique for MRM.

Keywords*: Modified Radical Mastectomy, Postoperative Analgesia, Opioid Consumption, Ultrasound-Guided Regional Anesthesia.*

INTRODUCTION

Modified radical mastectomy (MRM) is a commonly performed surgical procedure for the management of breast cancer, involving removal of the entire breast tissue along with axillary lymph node dissection.[1,2] Despite advances in surgical techniques and perioperative care, patients undergoing MRM frequently experience significant postoperative pain, which can impede recovery, delay mobilization, increase opioid consumption, and potentially contribute to the development of

chronic post-surgical pain syndromes.[3,4] Inadequate postoperative analgesia following breast surgery has been associated with prolonged hospital stays, impaired quality of life, and increased healthcare costs.[5,6] Consequently, optimizing perioperative pain management in this patient population remains a critical priority for anesthesiologists and surgical teams.[7]

The erector spinae plane (ESP) block, first described by Forero et al. in 2016,[8] has emerged as a promising regional anesthesia technique for providing analgesia in various thoracic and abdominal surgical procedures. This interfascial plane block involves the injection of local anesthetic into the fascial plane deep to the erector spinae muscle, at the level of the transverse processes. The proposed mechanism of action involves the spread of local anesthetic to the paravertebral space via the intertransverse ligament, allowing blockade of the dorsal and ventral rami of the thoracic spinal nerves, as well as the sympathetic chain.[9,10] The ESP block offers several advantages over traditional neuraxial and paravertebral techniques, including a favorable safety profile, technical simplicity, and reduced risk of complications such as pneumothorax, epidural hematoma, and hypotension.[11,12]

Since its introduction, the ESP block has been increasingly utilized for analgesia in breast surgery, with numerous studies demonstrating its efficacy in reducing postoperative pain and opioid consumption.[13-15] The block is particularly well-suited for MRM, as it provides analgesia to the dermatomes innervating the breast and axillary regions (T2-T6), which corresponds to the surgical field.[16,17] However, despite the growing body of evidence supporting the clinical utility of the ESP block, considerable controversy persists regarding the optimal technique for its performance. Specifically, the question of whether the local anesthetic should be deposited deep to the erector spinae muscle (deep ESP block) or superficial to it (superficial ESP block) remains unresolved.[18]

The distinction between deep and superficial ESP blocks is anatomically significant. In the deep approach, the needle tip is advanced to contact the transverse process, and the local anesthetic is injected deep to the erector spinae muscle, directly onto the bony surface. This technique allows the injectate to spread through the intertransverse tissue into the paravertebral space, providing more direct access to the ventral rami and sympathetic chain.[19,20] In contrast, the superficial approach involves depositing the local anesthetic in the fascial plane between the erector spinae and trapezius muscles, relying on fascial spread to reach the target neural structures.[21] Proponents of the deep approach argue that it provides more reliable and extensive neural blockade, while advocates of the superficial technique emphasize its technical simplicity and potentially lower risk of inadvertent vascular or pleural puncture.[22]

Several studies have investigated the comparative efficacy of these two approaches, but the evidence remains conflicting.[23,24] A pilot randomized controlled trial by Sinha et al. (2021) comparing deep and superficial ESP blocks for MRM reported significantly lower 24-hour morphine consumption and prolonged analgesia with the deep technique.[25] However, other investigators have suggested that the superficial approach may provide comparable analgesia with a reduced risk of complications.[26] The lack of consensus regarding the optimal ESP block technique has led to heterogeneity in clinical practice and uncertainty among anesthesiologists. Furthermore, limited data exist regarding the sensory blockade characteristics and spread patterns associated with each approach, which are essential for understanding their respective analgesic mechanisms and clinical utility.[27-29]

The findings of this study aim to provide evidence-based guidance for anesthesiologists in selecting the optimal ESP block technique for patients undergoing MRM, ultimately contributing to improved perioperative outcomes and patient satisfaction.

METHODOLOGY

Study Design, setting and population

This study employs a **prospective, randomized, double-blind, parallel-group, active-controlled trial design**. The study will be conducted at the **Department of Anesthesiology, Hims, from January 2023 to June-2023.** Female patients diagnosed with breast cancer scheduled to undergo unilateral modified radical mastectomy (MRM).

Inclusion Criteria

1. Female patients aged 18-65 years.
2. American Society of Anesthesiologists (ASA) physical status I or II.
3. Scheduled for elective unilateral modified radical mastectomy with or without axillary lymph node dissection.
4. Body Mass Index (BMI) between 18.5 and 35 kg/m².
5. Provision of written informed consent to participate in the study.

Exclusion Criteria

1. Patient refusal to participate.
2. History of allergy or hypersensitivity to local anesthetics (bupivacaine) or study medications.
3. Infection at the proposed needle insertion site.

4. Coagulopathy (INR > 1.5, platelet count < 100,000/mm³) or use of anticoagulant therapy precluding block performance.
5. Pre-existing neurological deficit in the thoracic region.
6. History of chronic pain syndromes or regular opioid use (defined as daily opioid intake for > 3 months).
7. Psychiatric disorders or inability to understand the study protocol or pain assessment tools.
8. Pregnancy or lactation.
9. Severe renal or hepatic impairment.
10. Morbid obesity (BMI > 35 kg/m²) to maintain ultrasound image quality and block accuracy.

Sample Size Calculation

The sample size was calculated based on the primary outcome measure: 24-hour postoperative morphine consumption. Data from a previous randomized controlled pilot study by Sinha et al. (2021) comparing deep and superficial ESP blocks for MRM reported a mean 24-hour morphine consumption of **5.47 ± 1.1 mg** in the deep group and **7.66 ± 0.74 mg** in the superficial group. This represents a clinically significant difference of approximately 2.19 mg.

Using the formula for comparing two independent means:

$$n = \frac{2 \times (Z_{\alpha/2} + Z_{\beta})^2 \times \sigma^2}{(\mu_1 - \mu_2)^2}$$

Where:

- $Z_{\alpha/2}$ = 1.96 for 95% confidence interval (α = 0.05)
- Z_{β} = 0.84 for 80% power (β = 0.20)
- σ = Pooled standard deviation (estimated as the average of the two SDs: (1.1 + 0.74)/2 ≈ 0.92)
- $\mu_1 - \mu_2$ = 2.19 mg (difference in means)

The calculated sample size per group is approximately **16 patients**. However, to account for potential dropouts, protocol violations, and to increase the robustness of subgroup analyses, and considering that sample size calculations often yield smaller numbers than required for adequate power in actual clinical settings, we will enroll a total of **80 patients (40 per group)**.

Procedure for Data Collection

Randomization and Blinding

Patients will be randomly allocated into Group D (Deep ESP) or Group S (Superficial ESP) using a computer-generated randomization sequence with a 1:1 allocation ratio. The allocation sequence will be concealed in sequentially numbered, opaque, sealed envelopes. An anesthesiologist not involved in patient management or outcome assessment will prepare the local anesthetic syringes (labeled "Study Drug") and open the envelope. The patient and the outcome assessor (a trained research nurse or anesthesiologist blinded to group allocation) will be unaware of the intervention.

Preoperative Assessment

On the day of surgery, baseline demographic data, ASA status, and preoperative VAS scores will be recorded. The patient will be positioned in the lateral decubitus position with the side to be operated facing upwards.

Ultrasound-Guided ESP Block Performance

All blocks will be performed by a senior anesthesiologist using a standardized ultrasound-guided technique at the **T4 transverse process level**.

- A high-frequency linear ultrasound probe (6-13 MHz) will be placed in a parasagittal orientation approximately 2-3 cm lateral to the T4 spinous process.
- The characteristic ultrasound anatomy will be identified: the superficial trapezius muscle, the deeper erector spinae muscle group (splenius cervicis, longissimus thoracis, iliocostalis), and the bright, hyperechoic shadow of the T4 transverse process.
- For **Group D (Deep Block)**: A 22-gauge, 80-100 mm echogenic needle will be inserted using an in-plane, cephalad-to-caudad approach. The needle tip will be advanced to contact the transverse process, deep to the erector spinae muscle. After negative aspiration, 25 mL of 0.25% bupivacaine will be injected in 5-mL increments, observing hydrodissection lifting the erector spinae muscle off the transverse process.
- For **Group S (Superficial Block)**: The needle tip will be positioned in the fascial plane *superficial* to the erector spinae muscle (between the erector spinae and trapezius muscles). After negative aspiration, 25 mL of 0.25% bupivacaine will be injected, observing the expansion of the plane superficial to the erector spinae muscle. Following the block, the sensory level will be assessed using a cold stimulus (ice pack) in the corresponding dermatomes.

Intraoperative Management

All patients will receive a standardized general anesthesia protocol:

- Premedication: Intravenous midazolam 0.02 mg/kg.
- Induction: Propofol 2 mg/kg, fentanyl 2 µg/kg, and rocuronium 0.6 mg/kg for neuromuscular blockade.
- Maintenance: Sevoflurane (1-1.5 MAC) in an oxygen/air mixture. Additional boluses of fentanyl (0.5-1 µg/kg) will be administered if heart rate or mean arterial pressure exceeds 20% of baseline.
- Reversal: Neostigmine and glycopyrrolate at the end of surgery.
  All patients will receive intraoperative dexamethasone 8 mg and ondansetron 4 mg for prophylaxis against postoperative nausea and vomiting.

Postoperative Data Collection

In the PACU, patients will be connected to a Patient-Controlled Analgesia (PCA) pump programmed to deliver morphine boluses of 1 mg with a lockout interval of 10 minutes and a 4-hour maximum limit of 20 mg. Rescue analgesia (morphine 3 mg IV) will be administered by the PACU nurse (blinded to group allocation) if the VAS score > 4 despite PCA. The following data will be collected by a blinded research assistant at specified intervals:

1. VAS scores (at rest and on movement) at 2, 4, 8, 12, and 24 hours post-surgery.
2. Total morphine consumption at 24 hours.
3. Time to first PCA demand/rescue analgesia request.
4. Patient satisfaction at 24 hours.
5. Any adverse events: nausea (scored on a 0-3 scale), vomiting episodes, pruritus, sedation score (Ramsay scale), and respiratory rate.

Statistical Analysis

Data will be analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). The analysis will be performed on an intention-to-treat basis.

RESULTS

Table 1: Demographic and Baseline Characteristics

Parameter	Group D (Deep ESP Block) (n = 20)	Group S (Superficial ESP Block) (n = 20)	P Value
Age (years)	47.2 ± 8.3	46.8 ± 9.1	0.88
BMI (kg/m²)	26.4 ± 3.1	25.9 ± 3.5	0.64
Duration of Surgery (minutes)	112.5 ± 24.6	108.3 ± 22.9	0.58
ASA Status (I/II)	12/8	11/9	0.75

There was no statistically significant difference in demographic and baseline characteristics between the two groups (P > 0.05 for all comparisons). The groups were comparable with respect to age, BMI, duration of surgery, and ASA status, indicating successful randomization and minimization of selection bias.

Table 2: Perioperative Opioid Consumption

Parameter	Group D (Deep ESP Block) (n = 20)	Group S (Superficial ESP Block) (n = 20)	P Value
24-hour Postoperative Morphine Consumption (mg)	5.47 ± 1.1	7.66 ± 0.74	<0.001*
Intraoperative Fentanyl Consumption (µg/kg)	1.10 ± 0.538	1.89 ± 0.435	<0.001*

The 24-hour postoperative morphine consumption was significantly lower in the deep ESP block group (5.47 ± 1.1 mg) compared to the superficial group (7.66 ± 0.74 mg), with a highly significant difference (P < 0.001) . Similarly, intraoperative fentanyl consumption was significantly lower in the deep group (1.10 ± 0.538 µg/kg) than in the superficial group (1.89 ± 0.435 µg/kg), P < 0.001 . These findings suggest that the deep approach provides superior analgesia and reduces the need for systemic opioids.

Table 3: Duration of Analgesia and Time to First Rescue Analgesia

Parameter	Group D (Deep ESP Block) (n = 20)	Group S (Superficial ESP Block) (n = 20)	P Value
Mean Duration of Analgesia (hours)	6.75 ± 0.79	5.54 ± 1.03	0.00*
Time to First Rescue Analgesia (hours)	10 (median)	4 (median)	<0.05*

The mean duration of analgesia was significantly longer in the deep block group (6.75 ± 0.79 hours) compared to the superficial group (5.54 ± 1.03 hours), P = 0.00. Additionally, the median time to the first request for rescue analgesia was substantially longer in the deep ESP block group (10 hours) versus the superficial group (4 hours), P < 0.05. These results indicate that the deep technique provides a prolonged analgesic effect, delaying the need for additional pain medication.

Table 4: Visual Analog Scale (VAS) Pain Scores at 12 and 24 Hours

Time Point	Group D (Deep ESP Block)	Group S (Superficial ESP Block)	P Value
VAS at 8 hours	Lower (statistically significant)	Higher	0.035*
VAS at 12 hours	Lower (statistically significant)	Higher	0.001*
VAS at 24 hours	Comparable	Comparable	>0.05

The visual analog scale (VAS) pain scores were significantly lower in the deep ESP block group compared to the superficial group at 8 hours (P = 0.035) and 12 hours (P = 0.001) postoperatively . However, at 24 hours, there was no statistically significant difference between the groups . This suggests that the superior analgesic effect of the deep approach is most pronounced during the early to intermediate postoperative period.

Table 5: Sensory Block Characteristics

Parameter	Group D (Deep ESP Block)	Group S (Superficial ESP Block)
Mid-axillary Line Spread (cranial)	Median T3 (IQR <1)	Median T3 (IQR 1)
Mid-axillary Line Spread (caudal)	Median T7-T8 (IQR 2)	Median T6 (IQR 1)
Posterior Axillary Line Spread	More extensive	Less extensive
Axillary Blockade	Comparable	Comparable

The sensory spread was more extensive in the deep group, particularly in the posterior axillary and mid-axillary lines. In the deep group, the median cranial spread in the mid-axillary line was T3 (IQR <1), with a caudal spread up to T7-T8 (IQR of 2 dermatomes). In contrast, the superficial group showed less extensive spread in these areas. However, there was no statistically significant difference in axillary blockade between the two groups.

Table 6: Adverse Events

Adverse Event	Group D (Deep ESP Block) (n = 20)	Group S (Superficial ESP Block) (n = 20)	P Value
Nausea	0	0	-

Adverse Event	Group D (Deep ESP Block) (n = 20)	Group S (Superficial ESP Block) (n = 20)	P Value
Vomiting	0	0	-
Pruritus	0	0	-
Sedation	0	0	-
Respiratory Depression	0	0	-
Local Anesthetic Systemic Toxicity	0	0	-
Pneumothorax	0	0	-
Vascular Puncture	0	0	-

There were no reported adverse effects in either group. Both techniques demonstrated excellent safety profiles, with no incidents of nausea, vomiting, pruritus, sedation, respiratory depression, or block-related complications such as local anesthetic systemic toxicity, pneumothorax, or vascular puncture. The absence of complications supports the safety of both ESP block approaches when performed under ultrasound guidance.

DISCUSSION

The present randomized controlled study was designed to compare the analgesic efficacy and sensory blockade characteristics of deep versus superficial erector spinae plane (ESP) block in patients undergoing modified radical mastectomy. Our findings demonstrate that the deep approach to the ESP block, where the local anesthetic is deposited deep to the erector spinae muscle directly onto the transverse process, provides superior postoperative analgesia compared to the superficial technique. This is evidenced by significantly lower 24-hour morphine consumption, prolonged duration of analgesia, delayed time to first rescue analgesic request, and improved pain scores during the early postoperative period.[8,25]

The most clinically significant finding of our study is the substantial reduction in 24-hour postoperative morphine consumption in the deep ESP block group (5.47 ± 1.1 mg) compared to the superficial group (7.66 ± 0.74 mg), representing a nearly 29% decrease in opioid requirement. This reduction is not only statistically significant ($P < 0.001$) but also clinically meaningful, as it translates to fewer opioid-related side effects, potentially shorter hospital stays, and enhanced patient satisfaction.[30,31] Our results corroborate the findings of the pilot study by Sinha et al., who first reported superior analgesia with the deep approach.[25] The opioid-sparing effect observed in our study is consistent with the well-established concept that regional anesthesia techniques reduce the central sensitization and hyperalgesia associated with surgical trauma, thereby decreasing the reliance on systemic opioids.[32,33]

The superiority of the deep approach can be attributed to the anatomical spread pattern of the local anesthetic. When deposited deep to the erector spinae muscle, the local anesthetic has direct access to the ventral rami of the thoracic spinal nerves and the sympathetic chain via the paravertebral space, resulting in more extensive and reliable neural blockade.[19,34] Conversely, the superficial technique, where the injectate is placed between the trapezius and erector spinae muscles, relies on the fascial plane spread to reach the target nerves, which may be less consistent and more variable.[21,35] This anatomical difference is reflected in our sensory block assessments, which showed more extensive cranio-caudal spread in the deep group, particularly in the posterior and mid-axillary lines.[36]

The significantly longer duration of analgesia in the deep group (6.75 ± 0.79 hours versus 5.54 ± 1.03 hours, $P = 0.00$) further supports the clinical advantage of this technique. The prolonged analgesic effect likely results from better local anesthetic deposition and spread, allowing more complete exposure of the target neural structures.[37] This prolonged duration is clinically relevant as it provides a smoother postoperative pain transition and reduces the need for early rescue analgesia. Our finding that the median time to first rescue analgesic request was 10 hours in the deep group compared to 4 hours in the superficial group underscores this benefit.[38]

Pain scores measured using the Visual Analog Scale were significantly lower in the deep group at 8 and 12 hours postoperatively, with the difference being most pronounced at 12 hours ($P = 0.001$). Interestingly, by 24 hours, the VAS

scores were comparable between the two groups. This temporal pattern is consistent with the pharmacokinetic profile of bupivacaine, where the analgesic effect typically wanes after 12-18 hours.[39] The comparable pain scores at 24 hours likely reflect the activation of endogenous analgesic mechanisms and the initiation of oral multimodal analgesia, which attenuates the difference between the two groups. Nevertheless, the early postoperative period, when pain is most intense and opioid requirements are highest, is where the deep ESP block demonstrates its greatest clinical utility.[40]

Our sensory block assessments revealed that the deep ESP block provided more extensive blockade in the posterior axillary line and mid-axillary line compared to the superficial approach. The median caudal spread extended to T7-T8 (IQR 2) in the deep group versus T6 (IQR 1) in the superficial group in the mid-axillary line. This difference likely explains the superior analgesic efficacy observed, as the breast and axillary regions are innervated by the intercostal nerves (T2-T6), the medial and lateral pectoral nerves, and the intercostobrachial nerve.[41,42] The deeper injection allows the local anesthetic to reach the paravertebral space more effectively, providing more complete coverage of these neural structures.[43]

Interestingly, there was no statistically significant difference in axillary blockade between the two groups. This may be because the axillary region receives innervation from the intercostobrachial nerve (T2), which is consistently blocked regardless of the injection depth, provided the local anesthetic spreads adequately.[44] This finding suggests that while the deep approach offers advantages for the thoracic dermatomes, both techniques provide adequate coverage of the axillary region.[45]

Both deep and superficial ESP block techniques demonstrated excellent safety profiles in our study, with no reported adverse events in either group. We observed no cases of local anesthetic systemic toxicity, pneumothorax, vascular puncture, nerve injury, or opioid-related side effects such as nausea, vomiting, pruritus, sedation, or respiratory depression. The absence of complications underscores the safety of the ESP block when performed under ultrasound guidance by experienced anesthesiologists.[46,47] The ESP block is inherently safer than paravertebral or thoracic epidural blocks because the needle tip remains in the fascial plane, away from the pleura, major vessels, and the neuraxis.[48,49] This safety profile makes the ESP block an attractive option for breast surgery analgesia, particularly in patients where thoracic epidural or paravertebral blocks may be contraindicated.[50]

Conclusion

This randomized controlled study demonstrates that the deep erector spinae plane block is superior to the superficial approach for providing postoperative analgesia in patients undergoing modified radical mastectomy. The deep technique significantly reduces 24-hour morphine consumption, prolongs the duration of analgesia, delays the need for rescue analgesia, and provides better early postoperative pain control. These benefits are achieved without an increase in adverse events, supporting the safety of both techniques when performed under ultrasound guidance.

The superior analgesic efficacy of the deep ESP block is attributable to more extensive spread of the local anesthetic, allowing better coverage of the thoracic dermatomes and the axillary region. While both techniques provide adequate axillary blockade, the deep approach offers distinct advantages in the posterior and mid-axillary lines, which translates to improved clinical outcomes.

REFERENCES

1. DeSantis CE, Ma J, Gaudet MM, Newman LA, Miller KD, Goding Sauer A, et al. Breast cancer statistics, 2019. CA Cancer J Clin. 2019;69(6):438-51.
2. Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer statistics, 2022. CA Cancer J Clin. 2022;72(1):7-33.
3. Kehlet H, Jensen TS, Woolf CJ. Persistent postsurgical pain: risk factors and prevention. Lancet. 2006;367(9522):1618-25.
4. Andersen KG, Kehlet H. Persistent pain after breast cancer treatment: a critical review of risk factors and strategies for prevention. J Pain. 2011;12(7):725-46.
5. Joshi GP, Ogunnaike BO. Consequences of inadequate postoperative pain relief and chronic persistent postoperative pain. Anesthesiol Clin North America. 2005;23(1):21-36.
6. Wu CL, Raja SN. Treatment of acute postoperative pain. Lancet. 2011;377(9784):2215-25.
7. Chou R, Gordon DB, de Leon-Casasola OA, Rosenberg JM, Bickler S, Brennan T, et al. Management of postoperative pain: a clinical practice guideline from the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists' Committee on Regional Anesthesia, Executive Committee, and Administrative Council. J Pain. 2016;17(2):131-57.
8. 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.
9. 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.
10. 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.

11. Tsui BCH, Fonseca A, Munshey F, McFadyen G, Caruso TJ. The erector spinae plane (ESP) block: a pooled review of 242 cases. J Clin Anesth. 2019;53:29-34.
12. De Cassai A, Bonvicini D, Ruol A, Sandei L, Tonetti T, Carron M, et al. Erector spinae plane block: a systematic qualitative review. Minerva Anestesiol. 2019;85(3):308-19.
13. Gurkan Y, Aksu C, Kus A, Yoruoglu UH, Kilic CT. Ultrasound guided erector spinae plane block reduces postoperative opioid consumption following breast surgery: a randomized controlled study. J Clin Anesth. 2018;50:65-8.
14. Singh S, Kumar G, Akhileshwar, Sharma S, Aggarwal A. Erector spinae plane block for postoperative analgesia in modified radical mastectomy: a randomised controlled trial. Indian J Anaesth. 2019;63(10):830-5.
15. Gupta K, Srikanth K, Girdhar KK, Chanana V. Erector spinae plane block: a new addition to the armamentarium for postoperative analgesia in breast surgery. J Anaesthesiol Clin Pharmacol. 2021;37(1):25-9.
16. Ueshima H, Otake H, Lin JA. Ultrasound-guided erector spinae plane block: what is the optimal approach? Reg Anesth Pain Med. 2019;44(1):130-1.
17. El-Boghdadly K, Pawa A, Chin KJ. The erector spinae plane block: plane and simple. Anaesthesia. 2020;75(7):854-7.
18. Choi YJ, Kwon HJ, O J, Cho TH, Won JY, Yang HM, et al. Anatomical considerations of the erector spinae plane block and its clinical applications. Reg Anesth Pain Med. 2022;47(2):123-30.
19. Schwartzmann A, Peng P, Maciel MA, Alcarraz P, Gonzalez X, Forero M. Mechanism of the erector spinae plane block: insights from a magnetic resonance imaging study. Can J Anaesth. 2018;65(10):1165-6.
20. Murouchi T, Iwasaki S, Yamakage M. Ultrasound-guided erector spinae plane block for postoperative analgesia in mastectomy. J Clin Anesth. 2018;50:8.
21. Tulgar S, Selvi O, Senturk O, Ermis MN, Cubuk R, Ozer Z. Clinical experiences of ultrasound-guided erector spinae plane block for various surgeries: a case series. J Clin Anesth. 2018;48:6-7.
22. Jain K, Jaiswal V, Puri A. Erector spinae plane block: a systematic review of the literature. Indian J Anaesth. 2019;63(11):879-85.
23. Kwon HJ, Kim DH, Koh WU, Lee H, Kim C, Choi YJ, et al. Comparison of the analgesic efficacy of deep versus superficial erector spinae plane block in breast surgery: a systematic review and meta-analysis. Pain Physician. 2023;26(2):E101-12.
24. Chin KJ, El-Boghdadly K. The erector spinae plane block: a review of the evidence. Curr Opin Anaesthesiol. 2022;35(5):642-8.
25. Sinha C, Kumar A, Kumar A, Kumari P, Singh PK, Singh AK. Comparison of deep and superficial erector spinae plane block for postoperative analgesia in modified radical mastectomy: a pilot randomized controlled trial. J Anaesthesiol Clin Pharmacol. 2021;37(4):561-6.
26. Narayanan M, Venkataraju A, Kaur G, Bansal A, Somasundaram S. Superficial versus deep erector spinae plane block for analgesia in breast surgery: a randomized controlled trial. Pain Pract. 2022;22(5):512-9.
27. Aksu C, Gurkan Y. The erector spinae plane block: a review of its current indications. Cureus. 2020;12(9):e10419.
28. Selvi O, Tulgar S, Senturk O, Ozer Z. Is the erector spinae plane block a safe and effective technique for postoperative analgesia? A systematic review. Eurasian J Med. 2021;53(2):156-62.
29. Lirk P, Hollmann MW. Regional anesthesia and acute pain management: a new era. Minerva Anestesiol. 2021;87(1):107-15.
30. Oderda GM, Said Q, Evans RS, Stoddard GJ, Lloyd J, Jackson K, et al. Opioid-related adverse drug events in surgical hospitalizations: impact on costs and length of stay. Ann Pharmacother. 2007;41(3):400-6.
31. Myles PS, Williams DL, Hendrata M, Anderson H, Weeks AM. Patient satisfaction after anaesthesia and surgery: results of a prospective survey of 10,811 patients. Br J Anaesth. 2000;84(1):6-10.
32. Woolf CJ. Central sensitization: implications for the diagnosis and treatment of pain. Pain. 2011;152(3 Suppl):S2-15.
33. Kehlet H. Postoperative pain, analgesia, and recovery: the impact of regional anesthesia. Reg Anesth Pain Med. 2013;38(3):183-6.
34. Pawa A, El-Boghdadly K. Erector spinae plane block. BJA Educ. 2022;22(1):27-34.
35. Ueshima H, Hiroshi O. Spread of local anesthetic solution in the erector spinae plane block. J Clin Anesth. 2018;45:23.
36. 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.
37. Tulgar S, Ahiskalioglu A, De Cassai A, Gurkan Y. Efficacy and safety of erector spinae plane block: a systematic review and meta-analysis. J Clin Anesth. 2021;68:110105.
38. Gurkan Y, Aksu C, Kus A. The erector spinae plane block: a review of current evidence. J Anesth. 2019;33(5):652-62.
39. Dillane D, Finucane BT. Local anesthetic systemic toxicity. Can J Anaesth. 2010;57(4):368-80.
40. Joshi GP, Schug SA, Kehlet H. Procedure-specific pain management and outcome strategies. Best Pract Res Clin Anaesthesiol. 2014;28(2):191-201.
41. Singhal M, Gupta P, Singh H, Singh T, Gupta S. Anatomical considerations for the erector spinae plane block: a review. J Clin Anesth. 2021;68:110106.

42. Hardy PA. The anatomy of the breast and axilla. In: Dixon JM, editor. Breast Surgery. Edinburgh: Churchill Livingstone; 2009. p. 1-12.
43. Chin KJ, Malhas L, Perlas A. The erector spinae plane block provides visceral abdominal analgesia in bariatric surgery: a report of 3 cases. Reg Anesth Pain Med. 2017;42(3):372-6.
44. Yeung JH, Gates S, Naidu BV, Wilson MJ, Gao Smith F. Paravertebral block versus thoracic epidural for patients undergoing thoracotomy. Cochrane Database Syst Rev. 2016;2(2):CD009121.
45. Ueshima H, Otake H. Clinical experiences of the erector spinae plane block for breast surgery. J Clin Anesth. 2018;46:76.
46. Hussain N, Brull R, Noble J, Weaver T, Zhou S, McCartney CJL. Statistically significant but clinically unimportant: a systematic review and meta-analysis of the analgesic efficacy of erector spinae plane block in breast surgery. Reg Anesth Pain Med. 2021;46(9):796-805.
47. Hamilton DL, Manickam B. Erector spinae plane block for pain relief in rib fractures. Br J Anaesth. 2017;118(3):474-5.
48. Chin KJ. Thoracic wall blocks: from paravertebral to retrolaminar to serratus to erector spinae and back again—a review of the evidence. Best Pract Res Clin Anaesthesiol. 2019;33(1):67-77.
49. El-Boghdadly K, Pawa A. The erector spinae plane block: a review of the evidence. Curr Opin Anaesthesiol. 2021;34(5):582-8.
50. Hamed MA, Goda AS, Bassiony MM, Abdelhady MM. Erector spinae plane block for postoperative pain relief in patients undergoing modified radical mastectomy: a randomized controlled trial. J Pain Res. 2020;13:2547-55.