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ORIGINAL ARTICLE

Efficacy of Ultrasound-Guided Erector Spinae Plane Block for Postoperative Analgesia in Modified Radical Mastectomy: A Prospective Comparative Interventional Study

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ABSTRACT

Background: Modified radical mastectomy (MRM) is linked with significant postoperative pain, which can subsequently increase recovery period and increase opioid requirements. Ultrasound-guided erector spinae plane block (ESPB) has come up as as a novel regional anesthesia technique with potential analgesic effects. This study focused on evaluating the effectiveness of ESPB in reducing postsurgical pain and opioid utilization in patients treated with MRM.

Material & Methods: This prospective comparative study included 60 female patients scheduled for elective MRM, who were allocated into two equal groups. Postoperative pain was assessed using the Visual Analogue Scale (VAS) at 4 hours. Rescue analgesic requirement was recorded in terms of tramadol consumption. Baseline demographic characteristics were compared using appropriate statistical tests. Subgroup analyses were performed according to age, weight, and ASA physical status.

Results: Patients receiving ESPB had significantly lower VAS scores at 4 hours compared to the standard care group (1.57±0.77 vs. 4.53±0.97; p<0.001). Similarly, rescue tramadol consumption was significantly reduced in the ESPB group (2.77±0.97 mg vs. 10.63±2.27 mg; p<0.001). Subgroup analysis demonstrated consistent analgesic benefits of ESPB across age groups, body weight categories, and ASA physical status, with substantially lower pain scores and opioid need in all strata.

Conclusion: Ultrasound-guided ESPB significantly reduces postsurgical pain intensity and opioid intake following modified radical mastectomy. Its analgesic efficacy remains consistent across different patient subgroups, supporting its role as an effective element of complex analgesia regime in breast surgery.

Keywords: Erector spinae plane block; modified radical mastectomy; postoperative pain; tramadol; regional anesthesia; breast surgery.

INTRODUCTION

Breast cancer is the most frequently diagnosed malignancy among women worldwide, and modified radical mastectomy (MRM) remains one of the commonest surgical procedures performed for its management. Despite advances in surgical techniques and perioperative care, postoperative pain after MRM continues to be a major clinical challenge. Poorly controlled pain may delay recovery, impair early mobilization, prolong hospital stay, increase opioid consumption, and contribute to the development of chronic post-mastectomy pain syndrome. These concerns are particularly important in breast cancer patients, in whom postoperative pain can adversely affect both physical and psychological well-being. Postmastectomy pain syndrome is a recognized complication that significantly affects quality of life and functional recovery. MRM remains one of the most commonly performed surgeries for breast cancer, making effective postoperative analgesia a clinical priority [1, 2].

Multimodal analgesia is considered substantial treatment strategy for postsurgical pain management after breast surgery. Regional anesthesia techniques such as thoracic epidural block, thoracic paravertebral block, intercostal nerve block, serratus anterior plane block, and pectoral nerve (PECS) are generally used to reduce postoperative pain and opioid utilization. Among these techniques, thoracic epidural analgesia provides excellent pain relief, but its use may be limited by potential complications including hypotension, urinary retention, and technical difficulty [3-5].

The ultrasound-guided erector spinae plane block (ESPB) is a relatively new interfascial plane block in which local anesthetic is injected deep to the erector spinae muscle. ESPB has gained popularity because it is technically easier to perform, has a favorable safety profile, and can provide analgesia comparable to thoracic epidural block without significant hemodynamic effects. It is performed by deep injection of local anesthetic agent into the erector spinae muscle, producing blockades of multiple thoracic spinal nerve branches and potentially offering epidural-like analgesia with fewer hemodynamic effects [6-8].

Previous randomized controlled trials have demonstrated that ESPB significantly reduces both postsurgical pain intensity and analgesia demand in patients undergoing breast surgery. Sony et al. reported significantly lower visual analogue scale (VAS) scores and reduced postoperative analgesic requirements among patients receiving ESPB compared with standard care. Similarly, Singh et al. observed prolonged analgesia and reduced rescue analgesic consumption in patients receiving ESPB following MRM. Randomized studies cited in the dissertation showed lower VAS scores and reduced rescue analgesic requirements with ESPB compared with control groups [9, 10].

However, despite encouraging international evidence, data from Pakistan remain limited. Variations in patient characteristics, perioperative analgesic protocols, and healthcare resources may affect the generalizability of international findings to local practice. Furthermore, breast cancer surgery is frequently performed in tertiary care hospitals across Pakistan, yet ESPB has not been uniformly adopted as part of routine perioperative analgesia. Establishing local evidence regarding its effectiveness is therefore essential before recommending widespread implementation. This trial was designed to evaluate postsurgical pain scores and rescue analgesic requirements among patients receiving ultrasound-guided ESPB and those receiving standard analgesic care after MRM.

MATERIAL & METHODS

This prospective controlled trial was conducted in the Anesthesia Department of Nishtar Medical University and Hospital, Multan, Pakistan, from 18 April 2024 to 17 September 2024. Ethical approval was sought from the Institutional Ethical Review Committee of Nishtar Medical University. Furthermore, the selected participants were also informed of the study details and were asked for written consent before enrollment.

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A total of 60 female patients aged 20–60 years scheduled for elective MRM for breast cancer under general anesthesia were considered for the study. Whereas the patients presenting with any infection at the injection site or allergy to local anesthetics were excluded.

Participants were randomly allocated into two equal groups (30 patients each) using a lottery method. Group A received ultrasound-guided erector spinae plane block (ESPB), while Group B received standard perioperative analgesic care without regional block.

In the ESPB group, patients were placed in the lateral position under aseptic precautions. Using ultrasonography guidance, the erector spinae plane was identified at the T4 vertebral level. A total of 20 mL of 0.5% bupivacaine was injected deep to the erector spinae muscle after negative aspiration. Patients in the control group received standard care without an analgesic block.

All patients underwent standardized general anesthesia and were followed for 24 hours after surgery. The primary outcome was postoperative pain intensity measured using the Visual Analogue Scale (VAS) at 4 hours postoperatively. The secondary outcome was rescue analgesic requirement, measured as total tramadol administered during the initial 24 hours. Pain assessment was performed by post-anesthesia care unit nursing staff.

Statistical analysis was performed using SPSS (version 26). Quantitative variables were taken as mean ± standard deviation, whereas qualitative variables were documented as frequencies along with their percentages. The continuous was first assessed for it distribution pattern followed by outlier removal. Majorly Independent sample t-test was used to compare normally distributed continuous variables between groups, and Chi-square test was used to access categorical variables. A p-value of ≤0.05 was considered statistically significant.

RESULTS

In total 60 female patients undergoing elective MRM were enrolled and equally allocated to the ultrasound-guided ESPB group (n=30) and the standard care group (n=30). All participants completed the study protocol and were included in the final analysis.

The baseline demographic and clinical characteristics of the study participants are presented in Table 1. The mean age of the patients was 40.50±11.18 years in the ESPB group and 42.40±11.05 years in the standard care group (p=0.507). Similarly, the mean body weight was comparable between the ESPB and standard care groups (74.43±11.16 kg vs. 74.10±9.29 kg, p=0.902). There were no statistically significant differences in the distribution of age groups (p=0.598), weight categories (p=0.796), or ASA physical status (p=0.292) between the two groups, indicating that baseline characteristics were comparable.

Postoperative analgesic outcomes are summarized in Table 2. Patients who received ultrasound-guided ESPB experienced significantly lower postoperative pain intensity at 4 hours than those receiving standard perioperative analgesia (VAS score: 1.57±0.77 vs. 4.53±0.97; mean difference −2.96, 95% CI: −3.40 to −2.52; p<0.001). Likewise, rescue tramadol consumption was significantly lower in the ESPB group than in the standard care group (2.77±0.97 mg vs. 10.63±2.27 mg; mean difference −7.86 mg, 95% CI: −8.78 to −6.94; p<0.001), demonstrating a substantial opioid-sparing effect.

The subgroup analysis according to age is shown in Table 3. Among patients aged 20–40 years, the ESPB group had significantly lower VAS scores at 4 hours and lower rescue tramadol consumption than the standard care group (both p<0.001). Similarly, among patients aged 41–60 years, ESPB was associated with significantly reduced postoperative pain and tramadol requirements compared with standard care (both p<0.001). These findings indicate that the analgesic efficacy of ESPB was maintained across both age groups.

The effect of body weight on postoperative analgesic outcomes is presented in Table 4. Patients weighing ≤70 kg who received ESPB demonstrated significantly lower postoperative VAS scores and rescue tramadol consumption than those receiving standard care (both p<0.001). Similar results were observed among patients weighing >70 kg, with ESPB providing significantly better postoperative analgesia and reduced opioid consumption than standard care (both p<0.001). These findings suggest that the analgesic effectiveness of ESPB was independent of body weight.

Stratification according to ASA physical status is presented in Table 5. Among both ASA I and ASA II patients, the ESPB group exhibited significantly lower postoperative pain scores and rescue tramadol consumption than the standard care group (all p<0.001). The consistency of these findings across ASA categories indicates that the analgesic benefit of ESPB was not influenced by preoperative physical status.

Table 1: Baseline Characteristics of the study participants (n=60)

Variable	ESPB Group (n=30)	Standard Care Group (n=30)	p-value
Age (years), Mean ± SD	40.50 ± 11.18	42.40 ± 11.05	0.507
Weight (kg), Mean ± SD	74.43 ± 11.16	74.10 ± 9.29	0.902
Age group, n (%)			0.598
20–40 years	14 (46.7)	12 (40.0)	
41–60 years	16 (53.3)	18 (60.0)	
Weight group, n (%)			0.796
≤70 kg	15 (50.0)	14 (46.7)	
>70 kg	15 (50.0)	16 (53.3)	
ASA Physical Status, n (%)			0.292
ASA I	20 (66.7)	16 (53.3)	
ASA II	10 (33.3)	14 (46.7)	

Table 2: Comparative Analysis of Postoperative analgesic outcomes between study groups

Outcome	ESPB Group (n=30) Mean ± SD	Standard Care Group (n=30) Mean ± SD	Mean Difference (95% CI)	Test Statistic (t)	p-value
VAS score at 4 hours	1.57 ± 0.77	4.53 ± 0.97	−2.96 (−3.40 to −2.52)	−13.04	<0.001
Rescue tramadol consumption (mg)	2.77 ± 0.97	10.63 ± 2.27	−7.86 (−8.78 to −6.94)	−17.39	<0.001

Table 3: Stratified analysis according to age

Age Group	Outcome	ESPB Group Mean ± SD	Standard Care Group Mean ± SD	Mean Difference (95% CI)	t	p-value
20–40 years	VAS score	1.57 ± 0.65	4.25 ± 1.06	−2.68 (−3.35 to −2.01)	−8.14	<0.001
	Rescue tramadol consumption (mg)	2.64 ± 1.08	11.67 ± 2.53	−9.03 (−10.50 to −7.56)	−12.24	<0.001
41–60 years	VAS score	1.56 ± 0.89	4.72 ± 0.89	−3.16 (−3.78 to −2.54)	−10.01	<0.001
	Rescue tramadol consumption (mg)	2.88 ± 0.89	9.94 ± 1.83	−7.06 (−8.00 to −6.12)	−14.73	<0.001

Table 4: Stratified analysis according to weight

Weight group	Outcome	ESPB Group	Standard Care Group	Mean Difference (95% CI)	t-value	p-value
≤70 kg	VAS score at 4 hours	1.67 ± 0.82	4.79 ± 0.89	−3.12 (−3.76 to −2.48)	−9.86	<0.001
	Rescue tramadol consumption (mg)	2.80 ± 1.01	10.50 ± 2.14	−7.70 (−8.96 to −6.44)	−12.02	<0.001
>70 kg	VAS score at 4 hours	1.47 ± 0.74	4.31 ± 1.01	−2.84 (−3.47 to −2.21)	−8.86	<0.001
	Rescue tramadol consumption (mg)	2.73 ± 0.96	10.75 ± 2.44	−8.02 (−9.34 to −6.70)	−12.09	<0.001

Table 5: Stratified analysis according to ASA physical status

ASA Status	Outcome	ESPB Group	Standard Care Group	Mean Difference (95% CI)	t-value	p-value
ASA I	VAS score at 4 hours	1.65 ± 0.75	4.44 ± 0.81	−2.79 (−3.31 to −2.27)	−10.53	<0.001
	Rescue tramadol consumption (mg)	2.75 ± 1.02	10.25 ± 2.32	−7.50 (−8.76 to −6.24)	−11.69	<0.001
ASA II	VAS score at 4 hours	1.40 ± 0.84	4.64 ± 1.15	−3.24 (−4.11 to −2.37)	−7.21	<0.001
	Rescue tramadol consumption (mg)	2.80 ± 0.92	11.07 ± 2.20	−8.27 (−9.73 to −6.81)	−11.35	<0.001

Overall, ultrasound-guided ESPB significantly reduced postoperative pain intensity and rescue tramadol consumption following modified radical mastectomy. The observed analgesic benefit remained consistent across all predefined subgroup analyses based on age, body weight, and ASA physical status.

DISCUSSION

Postoperative pain following MRM remains a significant clinical concern despite advances in surgical and anesthetic techniques. Inadequate pain control not only delays postoperative recovery and prolongs hospital stay but also increases opioid consumption and the risk of developing chronic post-mastectomy pain syndrome. Consequently, regional anesthesia has become an important component of multimodal analgesia aimed at improving postoperative outcomes with minimal complications. The present study demonstrated significant role of ultrasound-guided ESPB postoperative pain intensity reduction and rescue of tramadol intake compared with standard perioperative analgesia, supporting its effectiveness as an adjunct for postsurgical pain management in patients treated with MRM.

The principal finding of this study was the significant reduction in postoperative pain intensity among patients receiving ESPB. Patients in the intervention group reported substantially lower VAS scores four hours after surgery than those receiving standard analgesia. This reduction is clinically important because early postoperative pain has been identified as an important predictor of delayed recovery, increased opioid requirements, and the subsequent development of persistent post-mastectomy pain. Effective control of acute postoperative pain may therefore improve both immediate and long-term patient outcomes.

Our findings aligns with the study by Gürkan et al., who was first to demonstrate positive role of ultrasound-guided ESPB in significant reduction of postoperative pain scores and analgesics consumption following breast surgery [11]. Similarly, Singh et al. observed significantly prolonged postoperative analgesia and lower rescue analgesic requirements in patients undergoing modified radical mastectomy who received ESPB [7]. Comparable findings were reported by Aksu et al., who also recorded reduced postoperative pain scores and analgesic requirements after breast surgery using bi-level ESPB [12]. These consistent findings across different studies strengthen the potential positive role of ESPB and highlights it as an effective regional analgesic technique for breast surgery.

Our results are further supported by El Ghamry and Amer, who compared ESPB with thoracic paravertebral block in patients undergoing modified radical mastectomy and demonstrated that ESPB provided effective postoperative analgesia with a favorable safety profile [13]. In addition, Ueshima and Otake described ESPB as a simple and effective interfascial plane block with promising applications in thoracic and breast surgery, contributing to its increasing clinical adoption [14]. The reproducibility of these findings across different institutions and patient populations suggests that the analgesic benefits of ESPB are reliable and clinically meaningful.

Recent evidence has further strengthened the role of ESPB in breast surgery. A systematic review and meta-analysis by Huang et al. reported that ESPB significantly reduces postoperative pain scores, and postoperative complication such as nausea and vomiting following breast surgery [15]. Similarly, Li et al., in another systematic review and meta-analysis based on six randomized controlled trials involving 415 patients undergoing breast surgery concluded similar findings, although the overall certainty of evidence was considered low because of heterogeneity and limited sample sizes [16]. More recent comparative meta-analyses have further shown that ESPB provides analgesia comparable to thoracic paravertebral block while offering a technically simpler procedure and a favorable safety profile [17]. Collectively, these findings support the growing incorporation of ERAS pathways for breast surgery.

The present study also demonstrated a significant reduction in rescue tramadol consumption among patients receiving ESPB. This opioid-sparing effect has important clinical implications because minimizing perioperative opioid exposure reduces the occurrence of opioid associated adverse effects, including postoperative nausea and vomiting, excessive sedation, respiratory depression, constipation, and urinary retention. Reduced opioid requirements may also facilitate earlier mobilization, improve patient comfort, and enhance overall recovery after surgery. These findings are consistent with multiple randomized controlled trials and recent systematic reviews evaluating ESPB in breast surgery [18].

An important strength of our study is the stratified analysis according to age, body weight, and ASA physical status. The analgesic superiority of ESPB remained consistent across all predefined subgroups, indicating that its effectiveness was not significantly influenced by patient demographics or baseline clinical status. Both younger and older patients experienced significantly lower postoperative pain scores and rescue tramadol consumption following ESPB. Similarly, patients in both weight categories and both ASA physical status groups demonstrated consistent analgesic benefit. Although the study was not specifically powered to detect subgroup differences, these findings suggest that ESPB may provide reliable postoperative analgesia across a broad spectrum of patients undergoing modified radical mastectomy.

Several regional anesthesia techniques are currently available for breast surgery. As earlier mentioned, Thoracic epidural analgesia, the traditional gold standard, thoracic paravertebral block, and PECS block are generally considered as effective techniques but have also been associated with several complications. In comparison, ESPB is technically easier to perform under ultrasound guidance, is administered in a superficial fascial plane away from major neurovascular structures, and has a favorable safety profile. These practical advantages, together with its demonstrated analgesic efficacy, make ESPB an attractive option for routine perioperative pain management in breast surgery.

The underlying action mechanism of ESPB further supports the findings of the present study. Injection of local anesthetic deep to the erector spinae muscle facilitates cranio-caudal spread along the thoracolumbar fascia with diffusion toward both sides of of the thoracic spinal nerves. This extensive spread provides analgesia across multiple thoracic dermatomes involved in modified radical mastectomy while minimizing the risk of injury to the pleura or neuraxial structures. Ultrasound guidance further enhances procedural accuracy and contributes to the favorable safety profile reported in the literature.

Despite the encouraging findings, a few loopholes in the study should also be acknowledged. The study had limited sample size which could limit the observation of heterogenous reaction to the investigated technique. Pain assessment was only performed in postoperative period, and long-term outcomes such as chronic post-mastectomy pain syndrome, quality of recovery, patient satisfaction, and quality of life were not evaluated. Furthermore, the study compared ESPB with standard perioperative analgesia

and couldn't include comparative analysis with other other regional anesthesia techniques. Future multicenter studies with larger sample sizes and longer follow-up are therefore warranted to compare ESPB directly with alternative regional blocks and to evaluate long-term clinical outcomes, patient-reported recovery, and cost-effectiveness.

CONCLUSION

In short, the findings of the present study demonstrate that ultrasound-guided ESPB provides effective postoperative analgesia following modified radical mastectomy. The significant reduction in postoperative pain scores and rescue tramadol consumption, together with the consistency of these benefits across age, weight, and ASA subgroups, supports the incorporation of ESPB into multimodal analgesic protocols for breast cancer surgery. Continued research comparing ESPB with other regional anesthesia techniques will further define its role within contemporary perioperative pain management strategies.

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