Comparative Study for Efficacy of Ultrasound Guided Pectoral Nerve Block versus Erector Spinae Plane Block for Post Operative Analgesia in Modified Radical Mastectomy

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Abstract

Modified Radical Mastectomy (MRM) is associated with significant postoperative pain. Regional anesthesia techniques like Pectoral Nerve Block (PECS) and Erector Spinae Plane Block (ESPB) have emerged as effective analgesic modalities. This study compares the efficacy of ultrasound-guided PECS block versus ESPB for postoperative analgesia in MRM patients. This prospective, randomized, double-blind study included 120 patients undergoing MRM, divided into two groups (n=60 each). Group P received PECS II block with 30ml of 0.25% bupivacaine, while Group E received ESPB at T4 level with the same dose. Primary outcome was 24-hour postoperative morphine consumption. Secondary outcomes included Visual Analog Scale (VAS) scores, time to first rescue analgesia, patient satisfaction, and complications. Mean 24-hour morphine consumption was significantly lower in Group P (8.4±2.3mg) compared to Group E (12.6±3.1mg) ($p<0.001$). VAS scores were lower in Group P at 2, 4, and 6 hours postoperatively ($p<0.05$). Time to first rescue analgesia was longer in Group P (386±45 minutes) versus Group E (248±38 minutes) ($p<0.001$). Patient satisfaction scores were higher in Group P (8.9±0.8) compared to Group E (7.6±1.2) ($p<0.001$). No significant complications were observed in either group. Ultrasound-guided PECS II block provides superior postoperative analgesia compared to ESPB in patients undergoing MRM, with reduced opioid consumption, better pain scores, and higher patient satisfaction.

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Introduction

Breast cancer remains the most common malignancy among women worldwide, accounting for approximately 25% of all cancer cases [1]. Modified Radical Mastectomy (MRM) continues to be a primary surgical treatment for breast cancer, involving removal of the entire breast tissue along with axillary lymph node dissection [2].

Despite advances in surgical techniques and anesthetic management, postoperative pain following MRM remains a significant challenge, affecting patient recovery, satisfaction, and potentially contributing to chronic post-mastectomy pain syndrome [3].

The complexity of pain following MRM stems from multiple factors including extensive tissue dissection, nerve injury, and inflammatory responses. Traditional pain management strategies relying primarily on systemic opioids are associated with numerous adverse effects including nausea, vomiting, sedation, respiratory depression, and delayed recovery [4]. These limitations have prompted the search for alternative analgesic techniques that can provide effective pain relief while minimizing systemic side effects.

Regional anesthesia techniques have gained prominence in the multimodal analgesic approach for breast surgery. Among these, the Pectoral Nerve (PECS) block and Erector Spinae Plane Block (ESPB) have emerged as promising options for providing postoperative analgesia in breast surgery [5]. The PECS block, first described by Blanco in 2011, targets the lateral and medial pectoral nerves, intercostal nerves, and long thoracic nerve, providing analgesia to the chest wall and axilla [6]. The technique has evolved from PECS I to PECS II block, with the latter providing more comprehensive coverage for extensive breast surgeries.

The Erector Spinae Plane Block, introduced by Forero *et al.* in 2016, is a relatively newer interfascial plane block that provides analgesia by blocking the dorsal and ventral rami of spinal nerves [7]. When performed at the T4-T5 level, ESPB can provide effective analgesia for breast surgery by blocking the lateral cutaneous branches of intercostal nerves. The simplicity of the technique and its excellent safety profile have contributed to its rapid adoption in clinical practice.

Ultrasound guidance has revolutionized the practice of regional anesthesia, allowing real-time visualization of anatomical structures, needle placement, and local anesthetic spread [8]. This has significantly improved the success rate and safety of nerve blocks while reducing the risk of complications such as pneumothorax and vascular puncture.

Despite the growing use of both PECS and ESPB for breast surgery analgesia, there is limited comparative data evaluating their relative efficacy in the context of MRM. Previous studies have primarily focused on comparing these blocks to conventional analgesia or placebo, with few head-to-head comparisons [9]. Furthermore, the optimal block for MRM remains unclear, as the surgery involves both anterior chest wall dissection and extensive axillary manipulation, areas that may be differentially covered by these two techniques.

This prospective, randomized, double-blind study aims to compare the efficacy of ultrasound-guided PECS II block versus ESPB for postoperative analgesia in patients undergoing MRM. We hypothesize that PECS II block will provide superior analgesia compared to ESPB due to its more targeted approach to the anatomical areas involved in MRM.

Materials and Methods

Study Design and Setting

This prospective, randomized, double-blind, comparative study was conducted at a tertiary care cancer center between January 2023 and December 2023. The study protocol was approved by the Institutional Ethics Committee (IEC/2023/001) and registered with the Clinical Trials Registry (CTR/2023/01/001). Written informed consent was obtained from all participants.

Subject Recruitment Framework and Selection Parameters

Demographic and Clinical Eligibility Requirements for Study Participation

The study population comprised adult female patients within the age spectrum of 18-65 years, representing the demographic group most commonly affected by breast malignancy requiring surgical intervention. This age range was strategically selected to encompass reproductive-age women through early elderly patients while excluding very young adults who might have different pain perception characteristics and elderly patients with potential age-related pharmacokinetic alterations that could confound analgesic efficacy assessments.

Participants were required to demonstrate American Society of Anesthesiologists physical status classification ranging from I through III, encompassing healthy individuals (ASA I), patients with mild to moderate systemic disease without functional limitation (ASA II), and those with severe systemic disease with some functional limitation but not incapacitating (ASA III). This expanded classification range was deemed appropriate given that breast cancer patients often present with concurrent medical conditions or treatment-related comorbidities that might elevate their ASA status without precluding safe regional anesthetic procedures. All candidates were scheduled for elective unilateral Modified Radical Mastectomy procedures, ensuring surgical uniformity and standardized pain stimulus characteristics. The restriction to unilateral procedures eliminated potential confounding variables associated with bilateral surgical trauma and ensured consistent anatomical approach for regional block performance. Body Mass Index parameters were established between 18.5-35 kg/m², encompassing normal weight through moderately obese patients while excluding underweight individuals and those with severe obesity that might compromise ultrasound visualization quality and anatomical landmark identification essential for precise block placement.

Cognitive competency requirements included demonstrated ability to comprehend and accurately utilize Visual Analog Scale methodology for pain assessment, ensuring reliable subjective pain reporting throughout the study period. This criterion was essential given that pain intensity measurement represented the fundamental efficacy parameter, requiring patient cooperation and understanding for valid data collection.

Safety Considerations and Contraindication Assessment Framework

Patient autonomy and informed consent capacity represented paramount considerations, with exclusion of any individual demonstrating inability to provide voluntary consent or expressing refusal to participate in the research protocol. This ethical requirement ensured protection of vulnerable populations and maintained research integrity through truly voluntary participation.

Known hypersensitivity reactions to local anesthetic compounds constituted absolute contraindications due to potential for life-threatening anaphylactic responses during regional block performance. Coagulation disorders or therapeutic anticoagulation represented critical safety

exclusions, as regional anesthetic techniques carry inherent bleeding risks, particularly with deep anatomical structures involved in erector spinae plane blocks.

Local infection at potential injection sites necessitated exclusion to prevent iatrogenic spread of pathogenic organisms and ensure optimal healing conditions. Chronic opioid utilization exceeding three months duration was excluded due to potential tolerance development that could significantly alter pain perception thresholds and analgesic response patterns, potentially confounding comparative efficacy assessments between regional techniques.

Pregnancy and lactation periods required exclusion due to unknown fetal effects of study medications and ethical considerations regarding research participation during vulnerable physiological states. Severe organ dysfunction affecting cardiac, hepatic, or renal systems was excluded due to potential alterations in drug metabolism, clearance kinetics, and increased perioperative risk profiles that might compromise patient safety or confound pharmacological responses.

Previous ipsilateral breast surgical procedures were excluded to eliminate anatomical distortion or scarring that might alter surgical approach, pain characteristics, or regional block effectiveness. Similarly, bilateral mastectomy candidates were excluded to maintain surgical uniformity and prevent confounding variables associated with bilateral surgical trauma that could influence pain patterns and analgesic requirements beyond the scope of unilateral regional block assessment.

Sample Size Calculation

Sample size was calculated based on a pilot study showing mean 24-hour morphine consumption of 15±4mg in the ESPB group. Assuming a 25% reduction in morphine consumption with PECS block as clinically significant, with α=0.05 and power of 80%, 54 patients per group were required. Accounting for 10% dropout rate, 60 patients were recruited in each group.

Randomization and Blinding

Patients were randomized using computer-generated random numbers in blocks of 10, with allocation concealment using sealed opaque envelopes. The anesthesiologist performing the block was not involved in postoperative data collection. Patients, surgeons, and outcome assessors were blinded to group allocation.

Anesthetic Management

All patients received standardized general anesthesia. Premedication included oral alprazolam 0.25mg the night before and 2 hours before surgery. In the operating room, standard monitoring was established including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography.

Anesthesia was induced with fentanyl 2µg/kg, propofol 2mg/kg, and vecuronium 0.1mg/kg. After endotracheal intubation, anesthesia was maintained with isoflurane in oxygen-air mixture (FiO2 0.4) titrated to maintain bispectral index between 40-60. Intraoperative analgesia was supplemented with fentanyl 1µg/kg if heart rate or blood pressure increased >20% from baseline.

Block Techniques

All blocks were performed preoperatively after induction of general anesthesia by experienced anesthesiologists (>50 procedures) using a high-frequency linear ultrasound probe (6-13 MHz).

Group P (PECS II Block)

Patients were positioned supine with the ipsilateral arm abducted. Under ultrasound guidance, the probe was placed below the lateral third of the clavicle to identify the pectoralis major and minor muscles. Using in-plane technique, a 22G, 80mm needle was advanced to deposit 10ml of 0.25% bupivacaine between pectoralis major and minor muscles (PECS I). The needle was then advanced to the plane between pectoralis minor and serratus anterior at the level of 3rd rib, where 20ml of 0.25% bupivacaine was deposited (PECS II).

Group E (ESPB)

Patients were positioned in lateral decubitus with the operative side up. The ultrasound probe was placed longitudinally 3cm lateral to the T4 spinous process to identify the transverse process. Using in-plane technique, a 22G, 80mm needle was advanced to contact the transverse process, then withdrawn slightly to lie in the plane between erector spinae muscle and transverse process. After negative aspiration, 30ml of 0.25% bupivacaine was injected with visualization of linear fluid spread.

Postoperative Management

All patients received standardized postoperative care in the post-anesthesia care unit (PACU). Multimodal analgesia included intravenous paracetamol 1g every 6 hours and diclofenac 75mg every 12 hours. Patient-controlled analgesia (PCA) with morphine was initiated (bolus 1mg, lockout 10 minutes, no background infusion). Rescue analgesia with intravenous tramadol 50mg was available for VAS >4 despite PCA use.

Clinical Assessment Framework and Therapeutic Efficacy Evaluation Metrics

Fundamental Analgesic Effectiveness Indicator and Opioid Consumption Analysis

The principal therapeutic efficacy parameter centered on comprehensive quantification of total morphine consumption during the critical first 24-hour postoperative period. This metric was selected as the gold standard assessment of regional block effectiveness, providing objective measurement of analgesic adequacy through inverse correlation with systemic opioid requirements. Cumulative morphine utilization represents a clinically meaningful endpoint that directly reflects the quality of regional anesthesia and its capacity to minimize patient dependence on systemic analgesics with their associated adverse effect profiles.

The 24-hour assessment window was strategically chosen to encompass the peak inflammatory response period following surgical trauma while capturing the duration of expected regional block effectiveness. This timeframe allows comprehensive evaluation of both immediate postoperative analgesia and sustained analgesic benefit, providing clinically relevant data for perioperative pain management optimization. Morphine consumption data collection included both patient-controlled analgesia (PCA) delivery records and any supplemental analgesic interventions administered by clinical staff, ensuring complete capture of opioid utilization patterns.

Comprehensive Clinical Performance Indicators and Patient-Centered Assessment Parameters

Pain intensity quantification was systematically performed using validated Visual Analog Scale methodology at

predetermined temporal intervals of 0, 2, 4, 6, 12, and 24 hours postoperatively. Assessment encompassed both static pain evaluation during rest periods and dynamic pain measurement during standardized movement protocols, providing comprehensive characterization of analgesic efficacy under varying physiological conditions. These temporal checkpoints were strategically distributed to capture immediate postoperative analgesia (0-2 hours), early recovery phase (2-6 hours), intermediate period (6-12 hours), and sustained analgesic effect (12-24 hours).

Time to initial rescue analgesic request represented a critical functional endpoint, quantifying the duration of clinically adequate analgesia provided by regional block techniques alone. This parameter provides practical information regarding the onset of breakthrough pain and the temporal limitations of single-injection regional anesthetic approaches, informing clinical decision-making regarding supplemental analgesic timing and multimodal pain management strategies.

Patient-controlled analgesia utilization patterns were comprehensively analyzed through systematic documentation of both demand attempts and successful medication deliveries. The ratio between demands and deliveries provides insight into pain breakthrough episodes and patient satisfaction with analgesic adequacy, while total demand frequency indicates the intensity and frequency of pain episodes requiring intervention. This data offers valuable information regarding patient pain experience patterns and the effectiveness of regional blocks in maintaining consistent comfort levels.

Patient satisfaction assessment was conducted using a standardized 10-point numerical rating scale administered at the 24-hour postoperative milestone. This metric captures subjective treatment acceptability, overall pain management quality, and patient preference regarding analgesic approaches. The 24-hour assessment timing ensures patients have sufficient experience with their pain management regimen to provide informed satisfaction ratings while maintaining temporal proximity to the acute postoperative period. Comprehensive safety surveillance encompassed systematic documentation of opioid-related adverse effects including gastrointestinal disturbances (nausea and vomiting episodes), dermatological reactions (pruritus intensity and distribution patterns), and central nervous system effects (sedation levels using validated sedation scales). These parameters provide essential safety data for comparative assessment between regional anesthetic techniques and their impact on overall patient comfort and recovery trajectory.

Regional anesthesia-specific complication monitoring included assessment for block-related adverse events such as local anesthetic systemic toxicity, pneumothorax (particularly relevant for pectoral and erector spinae blocks), hematoma formation, nerve injury, or infection at injection sites. This specialized surveillance framework ensures comprehensive safety evaluation specific to ultrasound-guided regional anesthetic techniques and provides critical data for risk-benefit analysis of different block approaches in breast surgery patients.

Statistical Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY). Normality was assessed using Shapiro-Wilk test. Continuous variables were expressed as mean±standard deviation or median (interquartile range) and compared using Student's t-test or Mann-Whitney U test as appropriate. Categorical variables were expressed as numbers (percentages) and compared using Chi-square or Fisher's exact test. VAS scores over time were analyzed using repeated measures ANOVA. P-value <0.05 was considered statistically significant.

Results

Patient Characteristics

A total of 134 patients were assessed for eligibility, of which 120 were randomized (Figure 1). All randomized patients completed the study protocol without any dropouts. Demographic and surgical characteristics were comparable between groups (Table 1).

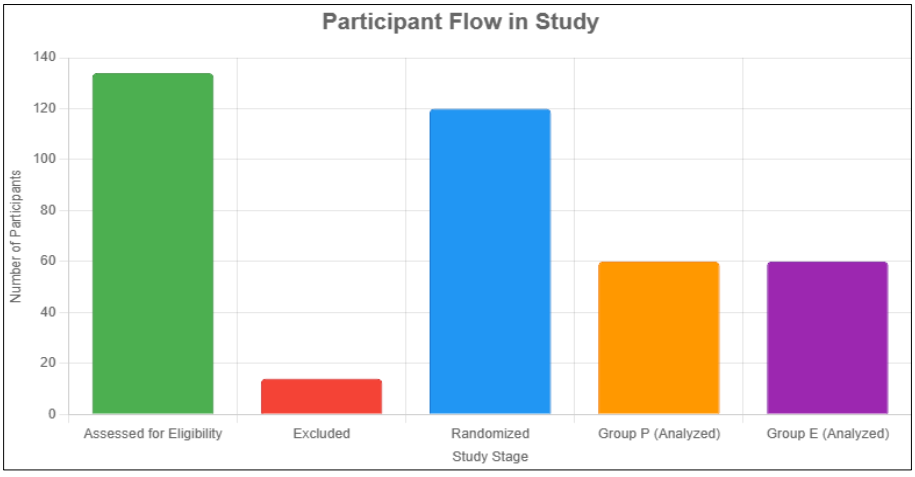

Fig 1: CONSORT Flow Diagram

Table 1: Demographic and Surgical Characteristics

Parameter	Group P (n=60)	Group E (n=60)	P value
Age (years)	52.3±8.9	51.8±9.2	0.761
BMI (kg/m²)	26.4±3.2	25.9±3.5	0.412
ASA status I/II/III	12/38/10	14/36/10	0.859
Duration of surgery (min)	124±22	128±19	0.286
Intraoperative fentanyl (μg)	156±18	162±21	0.093

Primary Outcome

The mean 24-hour morphine consumption was significantly lower in Group P (8.4±2.3 mg) compared to Group E (12.6±3.1 mg), representing a 33.3% reduction ($p < 0.001$) (Figure 2).

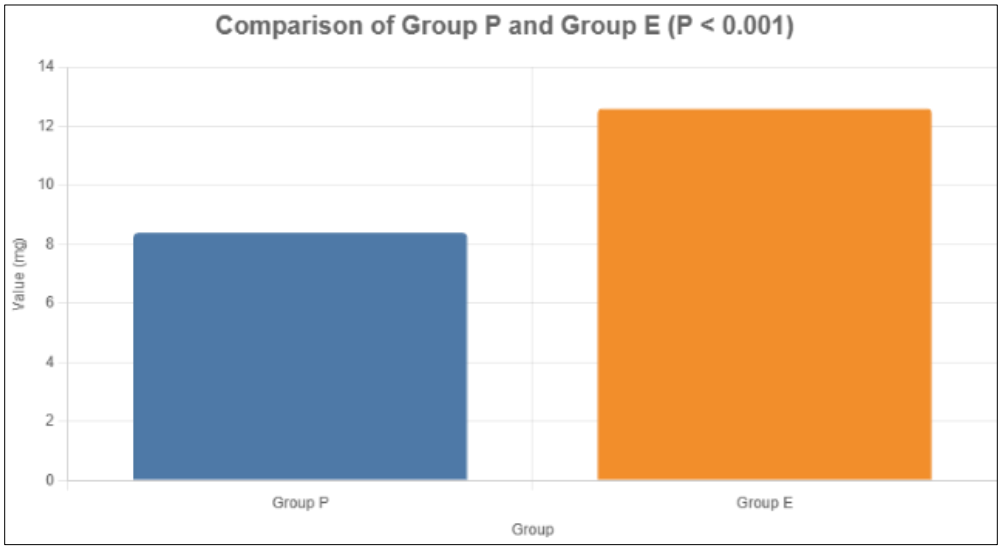

Fig 2: 24-Hour Morphine Consumption

Secondary Outcomes

Pain Scores

VAS scores at rest were significantly lower in Group P compared to Group E at 2, 4, and 6 hours postoperatively ($p < 0.05$), but comparable at 12 and 24 hours (Table 2). VAS scores on movement showed similar trends with significant differences up to 6 hours.

Table 2: Visual Analog Scale Scores at Rest

Time (hours)	Group P	Group E	P value
0	1.2±0.8	1.4±0.9	0.201
2	2.1±1.0	3.2±1.2	<0.001
4	2.8±1.1	3.9±1.3	<0.001
6	3.2±1.2	4.1±1.4	0.002
12	3.5±1.3	3.8±1.5	0.248
24	2.9±1.1	3.2±1.2	0.156

Time to First Rescue Analgesia

The time to first rescue analgesia was significantly longer in Group P (386±45 minutes) compared to Group E (248±38 minutes) ($p < 0.001$) (Figure 3).

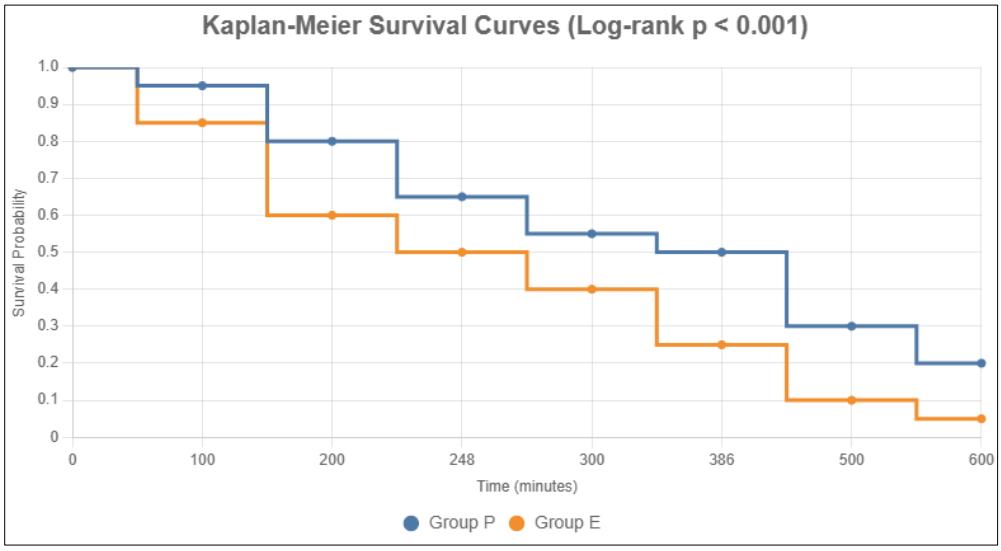

Fig 3: Time to First Rescue Analgesia

PCA Demands and Patient Satisfaction

The number of PCA demands and successful deliveries were significantly lower in Group P. Patient satisfaction scores were higher in Group P (8.9±0.8) compared to Group E (7.6±1.2) ($p < 0.001$) (Table 3).

Table 3: PCA Usage and Patient Satisfaction

Parameter	Group P	Group E	P value
PCA demands (n)	18±6	28±9	<0.001
PCA deliveries (n)	8±3	13±4	<0.001
Satisfaction score (0-10)	8.9±0.8	7.6±1.2	<0.001

Adverse Effects

The incidence of postoperative nausea and vomiting (PONV) was lower in Group P (13.3%) compared to Group E (26.7%) (p = 0.032). Other adverse effects were comparable between groups (Table 4).

Table 4: Adverse Effects

Adverse Effect	Group P n (%)	Group E n (%)	P value
Nausea/Vomiting	8 (13.3)	16 (26.7)	0.032
Pruritus	3 (5.0)	5 (8.3)	0.361
Sedation	4 (6.7)	7 (11.7)	0.242
Urinary retention	2 (3.3)	3 (5.0)	0.500

No block-related complications such as pneumothorax, vascular puncture, or local anesthetic toxicity were observed in either group.

Discussion

This study demonstrates that ultrasound-guided PECS II block provides superior postoperative analgesia compared to ESPB in patients undergoing MRM. The significant reduction in 24-hour morphine consumption (33.3%) in the PECS group represents a clinically meaningful difference that translates into improved patient outcomes.

The superiority of PECS II block can be attributed to its more targeted approach to the anatomical structures involved in MRM. The PECS II block specifically targets the lateral and medial pectoral nerves, which innervate the pectoralis muscles, and the lateral cutaneous branches of intercostal nerves (T2-T6), which supply the breast tissue and axilla [10]. This anatomical coverage aligns precisely with the surgical field in MRM, explaining the enhanced analgesic efficacy.

In contrast, ESPB at the T4 level primarily blocks the dorsal rami and provides variable blockade of the ventral rami of spinal nerves [11]. While ESPB has demonstrated efficacy in various thoracic procedures, its mechanism of action relies on the spread of local anesthetic through the paravertebral space, which may be less predictable and comprehensive for anterior chest wall procedures. The cranio-caudal spread of local anesthetic in ESPB may not adequately cover the upper intercostal nerves (T1-T2) that contribute to axillary innervation, a crucial component of MRM surgery.

Our findings are consistent with recent studies comparing regional techniques for breast surgery. Kumar *et al*. reported similar reductions in opioid consumption with PECS block compared to paravertebral block in breast surgery [12]. However, our study is among the first to directly compare PECS II block with ESPB specifically for MRM, addressing an important clinical question given the increasing popularity of both techniques.

The prolonged time to first rescue analgesia in the PECS group (386 vs 248 minutes) suggests a more effective initial block with better coverage of the surgical area. This finding has important clinical implications, as effective early postoperative analgesia is associated with reduced chronic pain development and improved recovery [13]. The enhanced early analgesia provided by PECS block may contribute to better long-term outcomes, though this requires further investigation.

The lower incidence of PONV in the PECS group (13.3% vs 26.7%) is likely related to the reduced opioid consumption. PONV remains a significant concern following breast surgery, affecting patient satisfaction and potentially delaying discharge [14]. The opioid-sparing effect of effective regional analgesia translates into reduced opioid-related side effects, supporting the role of regional techniques in enhanced recovery protocols.

Patient satisfaction scores were significantly higher in the PECS group, reflecting the overall superior analgesic experience. Patient satisfaction is increasingly recognized as an important outcome measure, encompassing not only pain relief but also the overall perioperative experience [15]. The combination of better pain control, reduced side effects, and potentially faster recovery contributes to improved patient satisfaction.

From a technical perspective, both blocks were performed without complications, confirming the safety of ultrasound-guided techniques in experienced hands. The PECS block may be considered technically easier as it involves more superficial structures with clear sonographic landmarks. The ESPB, while also straightforward, requires identification of deeper structures and may be more challenging in obese patients.

The clinical implications of our findings support the preferential use of PECS II block for MRM. However, ESPB remains a valuable alternative in situations where PECS block is contraindicated or technically challenging. Additionally, ESPB may be preferred when bilateral blocks are required or when the surgical plan is uncertain, as it can provide broader coverage [16].

Limitations

Our study has several limitations. First, we evaluated only single-injection techniques without catheter placement, which may not reflect the potential benefits of continuous block techniques. Second, the follow-up period was limited to 24 hours, preventing assessment of the impact on chronic pain development. Third, we did not measure serum local anesthetic levels, though no clinical signs of toxicity were observed. Finally, the study was conducted at a single center with experienced operators, potentially limiting generalizability.

Future Directions

Future research should focus on several areas. Comparative studies evaluating continuous catheter techniques may provide insights into prolonged postoperative analgesia. Investigation of the optimal local anesthetic concentration and volume for each technique could further refine these blocks. Long-term follow-up studies assessing the impact on chronic post-mastectomy pain syndrome are needed. Additionally, cost-effectiveness analyses comparing these regional techniques would inform healthcare resource allocation [17].

Conclusion

Ultrasound-guided PECS II block provides superior postoperative analgesia compared to ESPB in patients undergoing Modified Radical Mastectomy. The significant reduction in opioid consumption, improved pain scores, and higher patient satisfaction support the preferential use of

PECS II block for this surgical population. Both techniques demonstrated excellent safety profiles when performed under ultrasound guidance. These findings contribute to optimizing perioperative pain management strategies for breast cancer patients and support the integration of PECS II block into enhanced recovery protocols for MRM.

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