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Exploring Regional Anesthetic Techniques and Systemic Analgesic Strategies for Postoperative Pain Management Following Breast Cancer Surgery: A Scoping Review

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Abstract

Purpose

Breast cancer surgery commonly incites development of post-mastectomy pain syndrome (PMPS), which is defined as pain in the mastectomy-adjacent areas persisting beyond three months post-operation. This has promoted research interest in perioperative anesthetic interventions that reduce acute-to-chronic pain pathways. This scoping review therefore mapped existing literature on regional anesthetic techniques and systemic analgesic strategies for postoperative pain management following breast cancer surgery, while also examining associated postoperative outcomes.

Methods

Developed according to Joanna Briggs Institute (JBI) methodology and reported using b the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR), a literature search was conducted in MEDLINE (OVID), Embase (OVID), CINAHL (EBSCO), and ClinicalTrials.gov. Data extraction of included studies evaluated surgery type, regional anesthetic techniques, systemic analgesic strategies, and postoperative outcomes.

Results

Electronic database search yielded 5395 citations. After screening, 201 studies met inclusion criteria. Erector spinae plane block (ESPB) was the most utilized technique among studies incorporating a regional anesthetic technique (n = 76, 40.4%). 154 studies incorporated at least one systemic analgesic mode; multimodal analgesia was the most frequently used approach (n = 69, 44.8%). This was followed by opioid-based analgesia (n = 64, 41.6%). Postoperative opioid consumption was reported as the most frequently used outcome (n = 83, 41.3%).

Conclusions

ESPB, modified pectoral nerve block (PECS II), and serratus anterior plane block (SAPB) were among the most commonly reported regional anesthetic techniques utilized during oncologic breast surgeries. The use of multimodal analgesic strategies across the selected studies predominated, with opioids being the most commonly reported intraoperative drug class. Future research recommends conducting comparative studies across more surgically variable populations for the purpose of reducing the burden of PMPS.

1. Introduction

Breast cancer remains one of the most commonly diagnosed malignancies, with a globally estimated 2.4 million new cases and 700,000 deaths occurring each year [1,2]. Treatment includes surgical resection, manifesting as breast-conserving surgery, total mastectomy, modified radical mastectomy (MRM), partial mastectomy, or nipple-sparing mastectomy, often in combination with axillary lymph node dissection [3]. However, due to long-term morbidity and mortality in breast cancer having significantly improved over time, attention has now shifted toward the management of postoperative pain [4].

Post-mastectomy pain syndrome (PMPS) is defined as pain manifestation in the mastectomy-adjacent areas, persisting beyond three months post-operation. It is primarily a neuropathic pain localized to the ipsilateral thoracic wall, axilla, and arm [5]. Studies find that approximately half of PMPS-affected patients continue to experience symptoms years after the original procedure [3,6,7]. Proposed onset of PMPS stems from injury to the intercostobrachial nerve and other sensory nerves providing sensation to the breast and thoracic wall; its prevalence highlights the broad phenomenon of acute-to-chronic pain transitions across various surgical disciplines [5,8].

Recognition of PMPS has driven research interest in perioperative anesthetic interventions capable of reducing acute-to-chronic pain pathways. In regional anesthetic categories, techniques include thoracic paravertebral blocks (TPVB), pectoral nerve blocks (PECS I and II), serratus anterior plane blocks (SAPB), erector spinae plane blocks (ESPB), and other fascial plane blocks that are slowly rising in popularity. Previous literature has illustrated that incorporation of regional blocks during oncologic breast procedures reduces the level of postoperative opioid consumption, pain scores, and postoperative nausea and vomiting (PONV) in comparison to general anesthesia alone [9–13]. However, there is limited evidence whether utilization of regional blocks during surgery plays a durable role in chronic pain reduction. Single center data suggests that TPVB potentially reduces pain incidence at one year post-operation [14], while other meta-analyses conclude no significant difference across regional techniques in breast pain prevention [12].

Systemic analgesic strategies are also commonly used alongside, or in certain settings, as a substitute for regional blocks, including opioid-based, opioid-free, and multimodal based regimens. Multimodal combinations often include acetaminophen, NSAIDs, gabapentinoids, ketamine, dexmedetomidine, and dexamethasone. The Enhanced Recovery After Surgery (ERAS) Society explicitly recommends multimodal analgesia and opioid-sparing regimens for breast reconstruction, due to 10% of such patients developing chronic opioid use [15,16].

Despite extensive exploration of perioperative pain management strategies in breast cancer surgery, current literature lacks a thorough map of the extent of regional anesthetic techniques and systemic analgesic strategies incorporated in the diverse array of breast cancer procedures, including total and partial mastectomy, radical mastectomy, and axillary lymph node dissection. Many systematic reviews and meta-analyses remain limited to fields of comparing efficacy of a singular regional block versus a control or other technique [9–11,17], or do not include observation of systemic multimodal, opioid-based, and opioid-free strategies used intraoperatively [12,13,18]. Therefore, a scoping review is

necessary in descriptively mapping both regional anesthetic and systemic analgesic strategy utilization in oncologic breast procedures, and additionally mapping relevant postoperative outcomes across contemporary peer-reviewed literature.

Preliminary search of the Joanna Briggs Institute (JBI) Evidence Synthesis journal, Cochrane Database of Systematic Reviews, PROSPERO, and the Open Science Framework (OSF) registry was initiated. No pre-existing scoping reviews addressing the topic of regional and systemic anesthesia in the landscape of breast cancer surgery pain management were identified. Thus, the purpose of this scoping review was to descriptively map both the regional anesthetic techniques and systemic analgesic strategies reported in postoperative pain management for adult patients undergoing oncologic breast surgery, with or without breast reconstruction. Analysis of associated postoperative outcomes in the inpatient setting was also conducted.

2. Review question

In adult patients undergoing oncologic breast surgical procedures, either with or without breast reconstruction, what regional anesthetic treatments and systemic analgesic strategies have been reported for postoperative pain management and what postoperative outcomes have been associated with such approaches?

3. Eligibility Criteria

3.1 Types of participants

The eligibility criteria were established according to the Population, Concept, and Context (PCC) framework as recommended by the JBI. Studies incorporated in this review were selected based on the final inclusion and exclusion criteria. The inclusion criteria for participants were as follows: adult patients (≥ 18 years) undergoing breast cancer surgery, including total mastectomy, partial mastectomy, radial or modified radical mastectomy (MRM), nipple-sparing mastectomy, skin-sparing mastectomy, and immediate/delayed breast reconstruction (implant-based, tissue-expander, or autologous flap); studies involving mixed surgical procedures so long as > 50% of the study population met the surgical eligibility criteria. The exclusion criteria for participants were as follows: pediatric patients < 18 years old; studies focusing on cosmetic breast surgery without oncologic indication, including cosmetic augmentation, reduction mammoplasty, or minor breast procedures.

3.2 Concept and Context

The core concept of this scoping review was to explore the range of regional anesthetic techniques and systemic analgesic strategies used for postoperative pain management following oncologic breast surgery. Postoperative outcomes, including Visual Analog Scale (VAS) and Numeric Rating Scale (NRS) pain scores, postoperative opioid and non-opioid consumption, PONV, length of hospital stay, rescue analgesic requirements, time to first rescue analgesic, and quality of recovery (QoR) reports were also

considered. The conceptual inclusion criteria were as follows: studies evaluating regional anesthetic techniques, systemic analgesic strategies, or multimodal postoperative pain management that simultaneously met participant criteria and studies reporting at least one postoperative outcome. The conceptual exclusion criteria were as follows: studies reporting only “breast-conserving surgery” without further specification of the surgical procedure; regional anesthetic techniques involving continuous catheter administration; studies not involving breast cancer surgery or postoperative pain management; studies focused solely on chronic pain.

The context of selected studies was the perioperative inpatient setting of breast cancer surgery. Studies were eligible regardless of geographic location. No cultural, sex, gender, or religion-based interests were considered in the selection of analyzed studies.

3.3 Types of sources of evidence

Sources of evidence considered peer-reviewed human studies, including randomized controlled trials, prospective and retrospective cohort studies, cross-sectional studies, and studies published in English from January 2021 and onwards. Animal studies, cadaveric studies, laboratory studies, case reports, case series, case-cohort studies, systematic reviews, meta-analyses, narrative reviews, and studies not available in English were excluded. A restriction to studies published from January 2021 onwards was applied after the search was conducted to represent contemporary anesthesiology practices and was not a predefined source criteria.

4. Methods

This review was developed and conducted according to the JBI methodology for scoping reviews [19] and reported using the Preferred Reporting Items for Systematic Reviews and Meta Analyses extension for scoping reviews (PRISMA-ScR) [20]. An *a priori* protocol outlining the objectives and eligibility criteria was published on June 30, 2026 and is available at https://doi.org/10.17605/OSF.IO/FGJUS. Modifications were made after publishing the *a priori* protocol in order to further define the scope of the review and enhance the specificity and consistency of the eligibility criteria. These modifications were formally documented in an updated OSF registration on August 17, 2026 to align the registered protocol with the finalized review methodology.

4.1 Search strategy

A medical sciences librarian specializing in evidence synthesis designed the search strategy in close collaboration with the research team. The search consisted of three concepts: breast cancer reconstruction, pain management, and the post operative period following surgery. Initial pilot searches utilizing relevant keywords and MeSH terms were iteratively refined during team meetings to optimize sensitivity and scope. A second librarian from the Medical Sciences Library Reviews Team peer-reviewed the finalized search before it was translated and adapted for each target database.

Searches were run without language or date restrictions in electronic databases Medline (OVID), Embase (OVID), and CINAHL (EBSCO) on July 17th, 2026, and clinicaltrials.gov on July 20th, 2026. Full search strategies are available in Appendix I.

4.2 Source of evidence screening and selection

Citations retrieved from database searches were uploaded into Covidence [21] for full screening and data extraction. Covidence performed de-duplication upon import, and any further duplicates identified were manually marked and removed from the screening process. All citations and subsequent full texts were screened by two independent reviewers.

In the initial screening phase, titles and abstracts were evaluated against the inclusion criteria. Citations that met the pre-established criteria were then moved to full-text screening where they were again evaluated against the inclusion criteria. Agreement on the inclusion of the article for data extraction or the reason for exclusion was required. A post-hoc date restriction was applied to citations in both full text review and those already moved to data extraction. Only studies published from January 2021 onward were considered to capture the most contemporary scientific evidence on regional anesthetic techniques and systemic analgesic strategies utilized in perioperative pain management in breast cancer surgery. A detailed record of reasons for citations being excluded at full-text screening was maintained (Appendix II). All discrepancies were resolved by group discussion and the final decision for inclusion was made by the PI.

4.3 Data extraction

Data extraction was performed within the Covidence software. The standard data extraction template in Covidence was adapted to fit the needs of the research question, and piloted prior to screening to ensure accuracy and relevance of the data to be collected (Appendix III).

5. Results

5.1 Search results

Complete search of the electronic databases yielded 5395 citations. Duplicates were both manually (n = 62) and automatically removed by Covidence (n = 1528). Titles and abstracts were screened against eligibility criteria (n = 3805) and 3110 citations were deemed irrelevant. Full texts of the remaining citations (n = 695) were retrieved and again assessed against the eligibility criteria. Studies failing to meet the eligibility criteria (n = 494) were excluded with reasons documented (Appendix II), and the remaining studies (n = 201) were included in the final data extraction. See Fig. 1 in Results for the full selection workflow.

5.2 Characteristics of Included Studies

Full characteristics of all 201 included studies can be referenced in Supplementary Table 1. The temporal distribution of published literature displays a maximum of 44 studies published in the year 2025, and a minimum of 22 in the year 2026 (Fig. 2). Note that for the data comprising 2026, it is representative of a partial year and is therefore not comparable to other calendar years.

5.3 Regional Anesthetic Techniques

Among the 201 overall studies included in analysis, 188 studies incorporated at least one regional anesthetic technique as part of a perioperative pain management regimen. ESPB was the most utilized technique among the 188 studies (n = 76, 40.4%). PECS II and SAPB followed with a reported frequency of n = 58 (30.9%) and n = 55 (29.3%), respectively. TPVB was the fourth most reported technique (n = 45, 23.9%) and the PECS I block fifth (n = 34, 18.1%) (Fig. 3). These five blocks were the most commonly reported anesthetic techniques performed in the context of predominantly MRM and unilateral MRM (Table 2). The remaining techniques were reported in 5.0% or less of the studies, including transverse thoracic plane blocks (TTP), thoracic epidurals (TE), serratus posterior plane blocks (SPPB), pecto-serratus plane blocks (PSP), pecto-intercostal fascial blocks (PIFB), retrolaminar blocks (RLB), mid-transverse point blocks (MTP), segmental thoracic spinal anesthesia (STS), and costotransverse blocks (CTB) (Table 2). The sum of the percentages is greater than 100% due to studies reporting the use of more than one regional anesthetic modality.

Table 2

Frequency and distribution of regional anesthetic techniques among included studies. The number and percentage of studies (N = 188) of those reporting the use of at least one regional anesthetic technique) using each regional anesthetic method were analyzed, along with the most frequently associated surgery type. ESPB was the most commonly reported technique (n = 76, 40.4%) followed by PECS II (n = 58, 30.9%). Due to studies reporting more than one technique, the percentages sum over 100%. Abbreviations can be identified in Supplementary Table 1.

Regional Anesthetic Techniques	Number of Studies (n)	% of Included Studies (n/N)	Typical Surgical Procedure(s)
ESPB	76	40.4%	MRM (39/76); Unilateral MRM (22/76)
PECS II	58	30.9%	MRM (24/58); Unilateral MRM (18/58)
SAPB	55	29.3%	MRM (30/55); Unilateral MRM (14/55)
TPVB	45	23.9%	MRM (18/45); Unilateral MRM (13/45)
PECS I	34	18.1%	MRM (11/34); Axillary Lymph Node Dissection (10/34)
RIB	10	5.3%	MRM (4/10); Unilateral MRM (3/10)
TTP	8	4.3%	Unilateral MRM (3/8); Axillary Lymph Node Dissection (3/8)
TE	5	2.7%	Unilateral MRM (2/5); Mastectomy (1/5)
SPPB	5	2.7%	Axillary Lymph Node Dissection (2/5); Unilateral Mastectomy (2/5)
PSP	4	2.1%	Partial Mastectomy (3/4); Sentinel Lymph Node Biopsy (2/4)
PIFB	3	1.6%	MRM (1/3); Unilateral MRM (1/3)
RLB	3	1.6%	MRM (2/3); Unilateral MRM (1/3)
MTP	2	1.1%	Unilateral Mastectomy (1/2); MRM (1/2)
STS	2	1.1%	MRM (1/2); Unilateral MRM (1/2)
CTB	1	0.5%	MRM
Parasternal Intercostal Plane Block	1	0.5%	Unilateral MRM
ITP	1	0.5%	Total Mastectomy (1/1); Unilateral Mastectomy (1/1)

Regional Anesthetic Techniques	Number of Studies (n)	% of Included Studies (n/N)	Typical Surgical Procedure(s)
TAP	1	0.5%	Autologous Flap Reconstruction
STIL	1	0.5%	MRM
IPP	1	0.5%	Partial Mastectomy; Sentinel Lymph Node Biopsy
CAB	1	0.5%	MRM
MINB	1	0.5%	Radical Mastectomy
RISS	1	0.5%	Unilateral MRM

5.4 Systemic Analgesic Strategies

154 studies reported utilizing a specific intraoperative systemic analgesic method, defined as intravenous administration after the induction of general anesthesia and before extubation. Multimodal analgesia was the most frequently used approach, having been incorporated in n = 69 studies (44.8%); this was followed by opioid-based analgesia (n = 64, 41.6%) and opioid-free analgesia (n = 21, 13.6%), visualized in Fig. 4a.

Among these 154 studies, opioids were the most frequently used systemic analgesic drug class (n = 133, 86.4%). Acetaminophen was the second-most reported agent (n = 54, 35.1%), followed by NSAIDs (n = 31, 20.1%), dexamethasone (n = 19, 12.3%), ketamine (n = 11, 7.1%) and dexmedetomidine (n = 10, 6.5%) (Fig. 4b). The other less frequently reported drugs included agents such as magnesium sulfate, esmolol, gabapentin, lidocaine, methocarbamol, clonidine, atropine, norepinephrine, and urapidil. Because studies often utilized more than one systemic analgesic agent intraoperatively, percentages sum over 100%.

5.5 Postoperative Outcomes Evaluated

Among all 201 studies, postoperative opioid consumption was the most frequently used outcome measure (n = 83, 41.3%). VAS scores were used as a measurement of postoperative pain; this was the second most frequently reported outcome (n = 57, 28.4%). The time to first rescue analgesic, either opioid or non-opioid based, was the third most frequently reported outcome (n = 43, 21.4%), followed by NRS at n = 36 (17.9%). PONV was reported in n = 17 studies (8.5%) and total rescue analgesic requirement was reported in n = 12 studies (6.0%) (Table 3). Outcomes pertaining to total opioid consumptions, pain scores, and time to first rescue analgesic administration composed the majority of postoperative outcomes recorded whereas quality-of-recovery (QoR), length of hospital stay, and adverse events were among the minority. Due to studies utilizing more than one postoperative outcome among their selected measures, percentages sum over 100%.

Table 3

Postoperative outcomes reported among included studies (N = 201). Both number and percentage of included studies reporting each kind of postoperative outcome. Postoperative opioid consumption was the most frequently reported (n = 83, 41.3%), followed by VAS pain scores (n = 57, 28.4%). Because studies may have utilized more than one outcome, percentages sum over 100%.

Outcome Category	Outcome Reported	# of Studies	% of Studies
Opioid Analgesic	Postoperative Opioid Consumption	83	41.3%
Pain	VAS Pain Score	57	28.4%
Rescue Analgesia	Time to First Rescue Analgesic	43	21.4%
Pain	NRS Pain Score	36	17.9%
Postoperative Adverse Events	PONV	17	8.5%
Rescue Analgesia	Rescue Analgesic Requirement	12	6.0%
Quality-of-Recovery	QoR-40 Score	10	5.0%
Quality-of-Recovery	QoR-15 Score	9	4.5%
Quality-of-Recovery	Length of Hospital Stay	8	4.0%
Non-Opioid Analgesic	Postoperative Non-opioid Consumption	8	4.0%
Quality-of-Recovery	QoR-9	1	0.5%
Postoperative Adverse Events	Regional Anesthesia-Related Events	1	0.5%
Postoperative Adverse Events	Systemic Analgesic-Related Complications	1	0.5%

6. Discussion

6.1 Regional Anesthetic Techniques

With 188 of 201 studies incorporating at least one regional anesthetic technique, the available literature was primarily centered on several commonly studied regional anesthetic techniques, particularly ESPB, PECS II, SAPB, TPVB, and PECS I. ESPB was the most frequently reported technique, followed by PECS II and SAPB, while other regional techniques appeared less frequently in the literature. This pattern suggests contemporary breast surgery analgesia research has increasingly focused on ultrasound-guided fascial plane blocks, although frequency of investigation should not be interpreted as evidence that one technique is clinically superior to another [22,23].

High frequency of ESPB, PECS II, and SAPB in the present review contrasts with earlier Procedure-Specific Postoperative Pain Management (PROSPECT) guidelines. The 2020 PROSPECT guideline for oncologic breast surgery identified TPVB as the preferred regional anesthetic technique for major breast surgery, with pectoral nerve blocks considered as an alternative [24]. Evidence supporting newer approaches in 2020, such as ESPB, was still comparatively limited. ESPB being the most frequently reported regional technique in this study may reflect the rapid expansion of research evaluating newer ultrasound-guided fascial plane blocks in the years following publication of earlier guidelines [22,23].

Despite the greater representation of ESPB and other newer fascial plane blocks, current comparative evidence does not establish a consistently superior regional technique for breast cancer surgery. A recent Cochrane review, including 39 studies and 2,348 women, compared ESPB, PECS, and SAPB with paravertebral blockade and found that postoperative analgesic effectiveness was generally similar among techniques, with differences in pain scores often small or clinically unimportant. Complication rates were also low across the evaluated regional approaches [18]. These findings are important in interpreting this scoping review: high frequency of ESPB, PECS II, and SAPB likely reflects where research activity has become concentrated rather than demonstrating the efficacy or superiority of such blocks.

PECS II representation may similarly reflect accumulating evidence supporting pectoral nerve blocks as part of multimodal analgesia for breast cancer surgery. A systematic review and meta-analysis of 22 randomized controlled trials found that PECS blocks were associated with reductions in postoperative pain scores, reductions in perioperative opioid consumption, longer time to first rescue analgesia, and lower rates of PONV [25]. These findings support the clinical relevance of pectoral nerve blocks while also possibly providing context for their frequent appearance in this present review. PECS II may be particularly applicable to more extensive breast procedures because it extends beyond the pectoral nerves to provide broader thoracic and axillary analgesia than PECS I, which may explain its greater representation among studies involving MRM and axillary surgery [26–28].

SAPB was also among the most frequently reported techniques. A recent systematic review and meta-analysis of 12 randomized trials involving 799 patients found that SAPB reduced acute postoperative pain and perioperative analgesic consumption compared with multimodal analgesia alone and was associated with a lower PONV incidence. Compared against TPVB, SAPB did not appear inferior across the outcomes assessed [29]. These findings may support the increasing role of SAPB as an alternative chest wall block in breast cancer surgery and partly explain its prominence within the recent literature.

While ESPB, PECS II, SAPB, TPVB, and PECS I accounted for the majority of the regional blockade technique, the remaining approaches were each reported in 5% or fewer of the included studies. These included TTP, TE, SPPB, PSP, PIFB, RLB, MTP, CTB, and other additional techniques. The broad range of less frequently studied approaches illustrates continued innovation in regional anesthesia for breast surgery, but also emphasizes the uneven distribution of evidence. Because they remain supported by relatively few studies, there is limited meaningful comparison with the more established blocks.

Overall, regional anesthesia for breast cancer surgery is characterized by both procedural diversity and a marked focus on ultrasound-guided fascial plane technique. While ESPB, PECS II, and SAPB now represent a large proportion of the published literature, current evidence does not clearly establish that their greater frequency of use or study corresponds to superior clinical efficacy over other established approaches.

6.2 Systemic Analgesic Strategies

In this framework, multimodal analgesia was the most frequently reported approach, followed closely by opioid-based analgesia, then opioid-free analgesia. This pattern is consistent with broader movement toward multimodal and opioid-sparing anesthetic strategies in breast surgery. 2020 PROSPECT guidelines for oncologic breast surgery supports the use of non-opioid medications, including pre- or intraoperative administration of acetaminophen and NSAIDs, while stating that postoperative opioids be reserved primarily for rescue analgesia [24]. ERAS recommendations for breast reconstruction similarly emphasize multimodal analgesia as a means of reducing opioid requirements [15].

Although multimodal analgesia was the most frequently reported strategy, opioids remained the most commonly reported individual intraoperative systemic analgesic class, appearing in 86.4% of studies that specified systemic agents. This suggests multimodal analgesia was more so opioid-sparing rather than entirely opioid-free. Multimodal analgesia does not imply opioid avoidance, but rather incorporation of medications with synergistic analgesic efforts that simultaneously reduce reliance on any single drug class. This interpretation is supported by a 2025 network meta-analysis of 17 randomized controlled trials comparing opioid-based, opioid-sparing, and opioid-free anesthesia. Findings revealed both opioid-sparing and opioid-free approaches improved early postoperative QoR compared to opioid-based anesthesia, while no significant difference in overall QoR was identified between opioid-sparing and opioid-free approaches. Study researchers therefore favored individualized opioid minimization rather than complete opioid elimination [30].

This scoping review identified acetaminophen and NSAIDs as the most frequently reported non-opioid intraoperative agents. This aligns with procedure-specific recommendations that support these medications as foundational components of multimodal analgesia in oncologic breast surgery [24]. Common utilization of these agents may therefore reflect efforts to supplement opioid analgesia with medications targeting pain through different mechanisms.

Dexamethasone, ketamine, and dexmedetomidine were less frequently reported than acetaminophen and NSAIDs but nevertheless represented additional components of intraoperative multimodal analgesia. PROSPECT also recommends dexamethasone for oncologic breast surgery as part of the perioperative analgesic strategy [24]. The lower frequencies of ketamine, dexmedetomidine, magnesium sulfate, gabapentin, lidocaine, clonidine, and other adjuncts demonstrate variation in how multimodal intraoperative regimens are constructed across studies.

Opioid-free analgesia accounted for 13.6% of the systemic strategies in this scoping review, indicating that complete avoidance of intraoperative opioids remains less represented than opioid-containing approaches. Importantly, emerging evidence does not suggest that complete opioid elimination is required to optimize postoperative outcomes. In a recent network meta-analysis, opioid-sparing anesthesia produced the greatest improvement in overall 24-hour QoR, whereas opioid-free anesthesia demonstrated advantages in PONV and pain-related outcomes. Absence of a significant overall QoR difference between opioid-sparing and opioid-free approaches further reveals that reducing intraoperative opioid exposure may be more clinically relevant than eliminating opioids altogether [30]. This may provide useful context for the relatively low prevalence of opioid-free strategies observed in this scoping review.

The diversity of systemic agents identified also highlights considerable heterogeneity in intraoperative analgesic practice. Previous reviews of opioid-sparing strategies in breast reconstruction have similarly noted heterogeneity in analgesic protocols and outcome reporting, limiting direct comparisons between individual approaches [31]. Standardized reporting of medication selection, dosing, timing, accompanying regional techniques, and postoperative outcomes would therefore improve comparisons across future studies.

Comprehensively, findings illustrate that intraoperative systemic analgesic management in breast cancer surgery is most commonly characterized by multimodal, opioid-sparing rather than completely opioid-free approaches. Although opioids remained the predominant individual drug class, their frequent use alongside acetaminophen, NSAIDs, dexamethasone, and other adjunctive agents reflects a broader effort to reduce reliance on opioids while maintaining adequate analgesia.

6.3 Outcomes and Associations

Studies evaluating ESPB, PECS II, and SAPB were predominantly used in patients undergoing MRM, showcasing that such techniques have been studied primarily in the setting of more extensive breast surgery. In contrast, studies evaluating PECS I were associated with greater representation of axillary lymph node dissection, while studies evaluating PSP blocks included partial mastectomy and sentinel lymph node biopsy. The mapped data are consistent with the principle that selecting regional techniques should account for surgical procedure and underlying breast and thoracic wall innervation [32]. Another pattern noted was the marked reporting of opioids as an intraoperative systemic agent (n = 133, 86.4%), while postoperative opioid consumption was the most frequently reported outcome (n = 83, 41.3%). These outcomes represent distinct measures, but highlight the central role of opioid use in both perioperative analgesic management as well as the assessment of postoperative analgesic efficacy. Such patterns characterize where current evidence regarding analgesic strategies across breast cancer surgery is concentrated.

6.4 Gaps in the Evidence Base

One of the most fundamental concerns of the included literature revolves around how regional anesthetics and systemic analgesics were studied in conjunction. Most paired a block with a systemic

regimen, so any given result was a reflection of the whole regimen rather than an isolated component. Attribution is further complicated by variation within individual techniques. ESPB, PECS II, and SAPB were the three most frequently represented techniques in this review, yet their frequency of study does not indicate that they were performed consistently across studies. Local anesthetic concentration, injection volume, and adjuvant use influences the quality and duration of a block, and these parameters can vary considerably across published studies evaluating the same regional technique [33–35]. Future studies might prioritize repeating the evaluation of regional anesthetic and systemic analgesic techniques under standardized conditions within comparable surgical populations, as this would allow findings to be validated across studies and the effects of individual components to be more readily distinguished.

Secondly, there was a limited scope of associated postoperative outcomes measured in the included studies. Postoperative opioid consumption, VAS/NRS pain scores, or time to first rescue analgesic were by far the most frequently reported outcomes, whereas QoR or length of stay only comprised a small minority. Studies using validated QoR questionnaires have shown that regional anesthesia can improve recovery beyond pain control alone, and recent guidance incorporates QoR and patient satisfaction alongside traditional pain and opioid outcomes [36,37]. Therefore, lower pain scores or reduced opioid requirements alone may not fully reflect a patient's postoperative recovery. Pain and opioid use were not measured consistently across studies as there were differences in pain scales, assessment timepoints, and methods of reporting opioid consumption making results difficult to compare. Future studies might therefore use a consistent set of outcomes that evaluates both pain control and the patient's broader postoperative recovery.

Finally, the available evidence was concentrated within a limited range of surgical populations. MRM accounted for a widespread proportion of the literature, with comparatively less evidence examining reconstructive procedures for example. This distinction is clinically relevant because postoperative pain and analgesic needs may vary across breast cancer operations, particularly in reconstructive surgery, where regional analgesic benefits may extend after hospital discharge [38]. Greater representation of diverse breast cancer procedures is therefore needed to establish the applicability of perioperative analgesic strategies across current clinical practices in breast cancer care.

6.5 Strengths and Limitations

Strengths of this scoping review include the consideration of trends in the field rather than comparing efficacies of each method or technique of regional and systemic anesthesia. Secondly, conducting the search strategy through a medical sciences librarian knowledgeable in evidence synthesis and running the search across three biomedical databases captured a vast expanse of both published literature and trial-registry data. Initial searches were not limited by language or date restrictions therefore maximizing retrieval sensitivity. Performing title/abstract and full-text screening independently by two reviewers, with conflicts resolved by discussion was evidence of appropriate scoping review conduct. Ultimately, the inclusion of 201 studies total, each published between 2021 and 2026 provides contemporary evidence of frequently-utilized techniques (e.g. ESPB) versus those that are still emerging (e.g. RISS, STIL, PIFB).

This scoping review also captured the assemblage of postoperative outcomes across a diverse set of mastectomy and reconstruction surgery procedures, providing generalizability of the resulting descriptive map.

The limitations included a restriction to English language publications, potentially excluding relevant studies pertaining to regional anesthesia and systemic analgesia in breast cancer surgery pain management. Another point of limitation was the restricted selection of peer-reviewed study designs; in the initial search, grey literature including abstracts and ongoing clinical trials were not systematically included for analysis, potentially introducing a publication bias. Furthermore, the search strategy was limited to three databases and one trial registry. There was no supplementary search of reference lists or citation chains; thus, pertinent studies indexed elsewhere may have not been included. Included studies were disproportionate in terms of the kinds of surgeries that were performed. MRM and unilateral MRM (Table 2) were the most frequently represented surgery type in the overview of regional anesthetic techniques reported. The results of the present review may be less generalizable to oncoplastic procedures, cosmetic procedures, or reconstruction-based patient populations.

7. Conclusions and recommendations

7.1 Research Implications

Future primary studies should directly compare the commonly used techniques (e.g. ESPB, PECS II, SAPB) within clearly defined breast surgical populations using standardized block techniques, local anesthetic regimens, and postoperative outcome measures. Greater consistency in reporting block location, timing, local anesthetic type, concentration, volume, and use of adjuncts would improve reproducibility and allow for more meaningful comparison across studies.

Second, because the literature was concentrated largely on MRM, future research should include a broader range of operations and should account for differences in surgical extent, axillary intervention, reconstructive technique, and donor-site morbidity. Procedure-specific studies may help determine whether analgesic strategies should be tailored to different breast surgery populations rather than generalized across procedures.

Postoperative outcome reporting was also inconsistent and dominated by acute pain intensity, postoperative opioid consumption, and time to rescue analgesia. This scoping review might suggest incorporation of standardized, patient-centered recovery outcomes, including QoR, PONV, functional recovery, length of stay, patient satisfaction, and longer-term outcomes such as persistent postsurgical pain and prolonged opioid use. Adoption of standardized core outcome sets for perioperative analgesia in breast surgery may improve comparability across studies.

Further investigation is also needed regarding intraoperative systemic analgesic strategies. Although multimodal approaches were commonly reported, opioids remained the most frequently used systemic agents, suggesting that many regimens were opioid-sparing rather than opioid-free. Future prospective

studies should compare opioid-based, opioid-sparing, and opioid-free strategies while accounting for concurrent regional anesthesia and clearly reporting medication selection, dose, timing, and combinations.

Once sufficient homogeneous comparative evidence becomes available, future systematic reviews and meta-analyses may be appropriate to evaluate the relative effectiveness of specific regional techniques or systemic analgesic strategies within defined surgical populations. Such reviews would be strengthened by improved standardization of interventions, patient populations, and postoperative outcome reporting in primary studies.

7.2 Conclusions

Comprehensive literature mapping suggests ESPB, PECS II, and SAPB were the most frequently reported regional anesthetic techniques during breast cancer surgery. Multimodal analgesia was the predominant systemic analgesic strategy, with opioids as the most frequently reported drug class utilized intraoperatively. Most commonly reported outcomes included the measurement of postoperative opioid consumption and VAS pain scores, respectively. However, evidence gathered in this scoping review is limited to certain surgery types, primarily MRM, therefore decreasing the generalizability of this study across regional anesthetic and systemic analgesic approaches. It is likely recommended that comparative studies be conducted across more surgically variable populations for the purpose of preventing PMPS onset.

Declarations

The authors declare there are no competing financial interests or relationships that may have potentially influenced the work.

Ethics approval

Not applicable.

Consent

Not applicable.

Data Availability

Not applicable.

Clinical Trial Number

Not applicable.

Competing Interests

All authors declare no conflicts of interest in the production of this scoping review.

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Author Contributions:

All authors conceptualized the idea for the review, initiated the design, and conducted literature search. All authors contributed toward literature interpretation, manuscript writing and review, and approval for submission.

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Figures

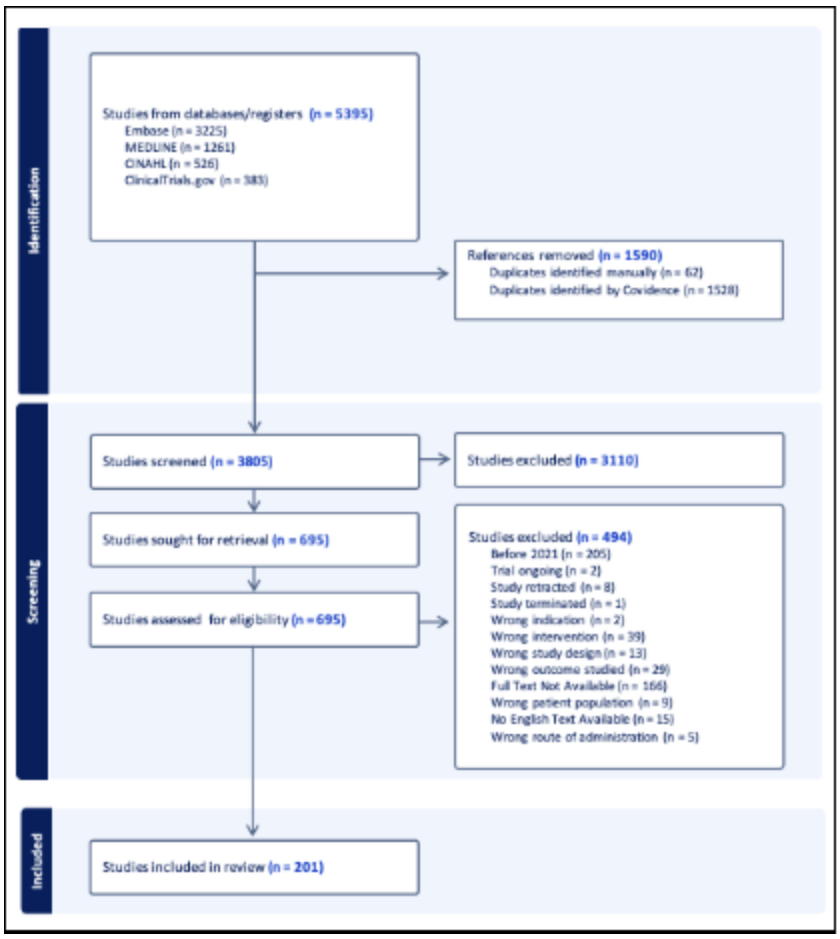

Figure 1

PRISMA-ScR flow diagram of study screening and inclusion. The diagram represents the process of identification, screening, and inclusion in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR).

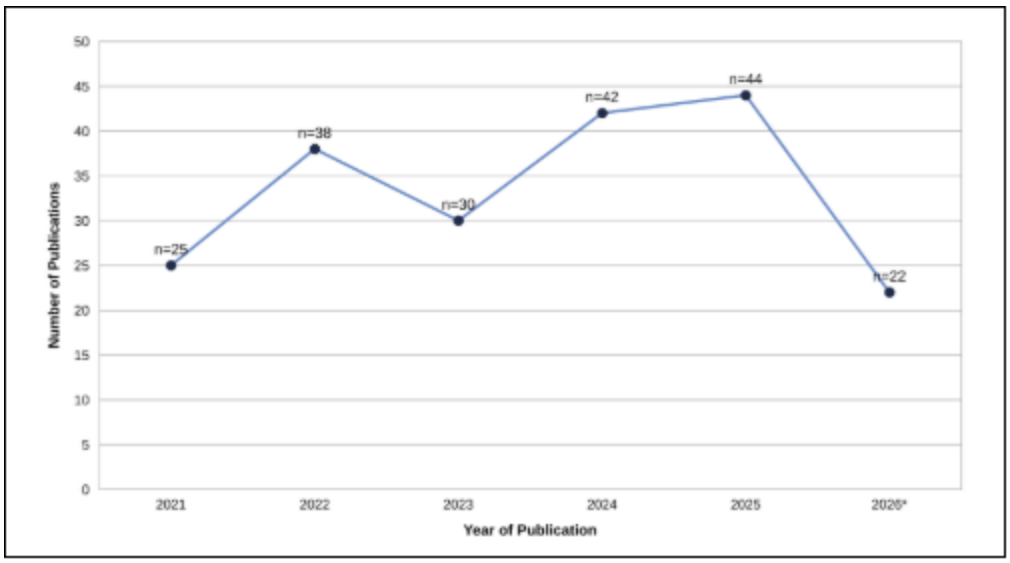

Figure 2

Temporal distribution of included studies, 2021-2026. Total number of included studies (N=201) were published between January 2021 to June 2026. Publication volume rose by 19 studies from 2021 to 2025. *Note that data for 2026 represents a partial year, therefore it is not directly comparable to the other complete calendar years.

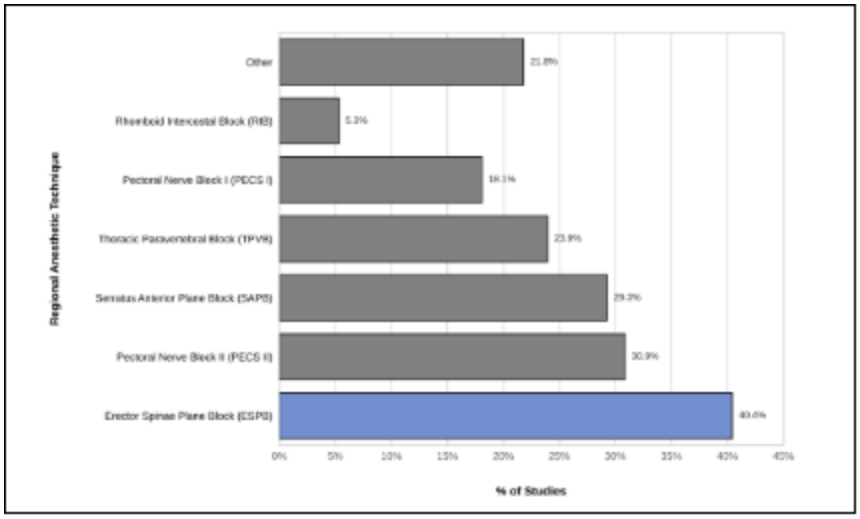

Figure 3

Regional anesthetic techniques used among included studies (N=188). ESPB was the most frequently reported technique at 40.4%, followed by PECS II at 30.9%, and then SAPB at 29.3%. Those falling into the “Other” category are aggregates of techniques that all were reported under 5% of the 188 studies, including TTP, TE, SPPB, PSP, PIFB, RLB, MTP, STS, CTB, ITP, TAP, STIL, IPP, CAB, MINB, RISS, and parasternal intercostal plane blocks. See Table 2 for complete breakdown of percentages.

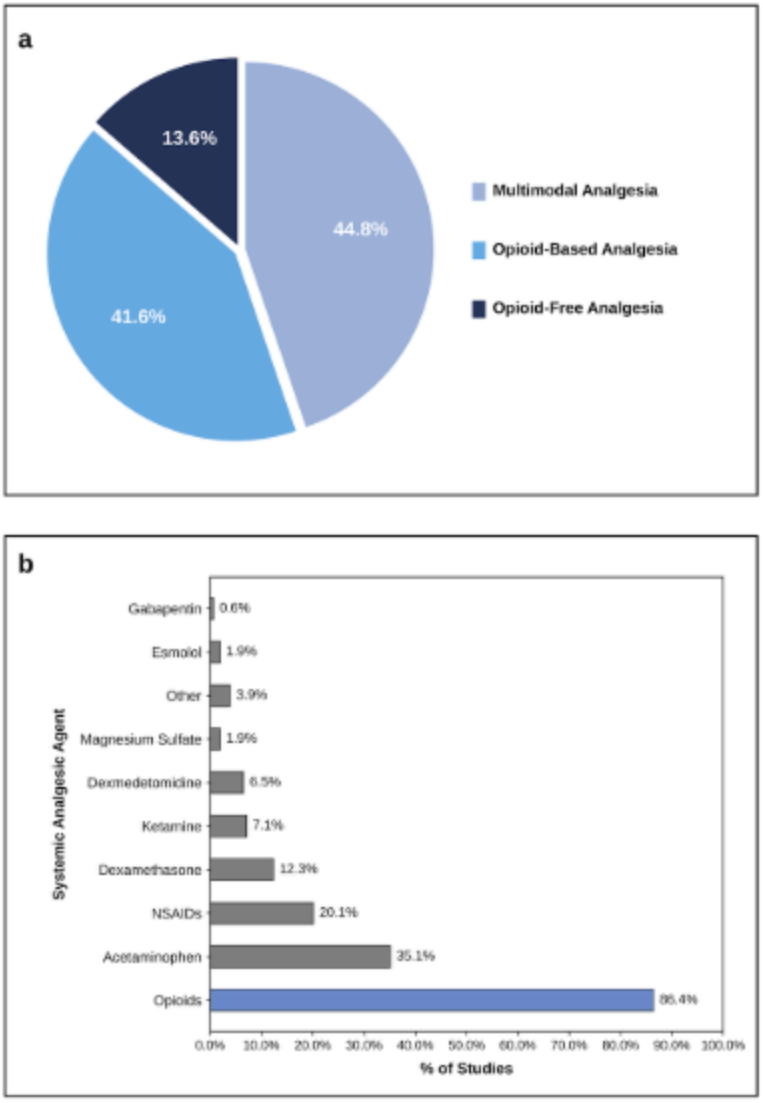

Figure 4

Systemic analgesic strategies and agents used among included studies (N=154). (a) The distribution of systemic analgesic strategies were divided into three main categories: multimodal analgesia (44.8%), opioid-based analgesia (41.6%), and opioid free-analgesia (13.6%). (b) The percentage of studies reporting use of individual systemic analgesic agents administered in the intraoperative setting; among these 154 studies, opioids were reported the most (86.4%), followed by acetaminophen (35.1%) and NSAIDs (20.1%). “Other” category includes lidocaine, methocarbamol, clonidine, atropine, norepinephrine, and urapidil. Because studies often reported the use of more than one agent, percentages sum to more than 100%.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

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- AppendixIISourcesexcludedfollowingfulltextreview.pdf
- AppendixIIIDataExtractionInstrument.pdf