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SYSTEMATIC REVIEW

Opioid-free general anesthesia in breast surgery: a meta-analysis of randomized trials

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Abstract

Background: Opioid-free general anesthesia (OFGA) is increasingly adopted in clinical settings owing to its potential to reduce opioid-associated adverse events. This systematic review and meta-analysis aimed to evaluate the efficacy of OFGA versus opioid-based general anesthesia (OBGA) in breast surgery patients. **Methods**: We systematically searched Cochrane Library, PubMed, Embase, and Web of Science for randomized controlled trials (RCTs) comparing OFGA with OBGA in breast surgery. The primary focus was postoperative nausea and vomiting (PONV) incidence. Data were analyzed using Review Manager 5.3 and Stata V.12.0. Evidence certainty was evaluated using Grading of Recommendations Assessment, Development and Evaluation (GRADE) criteria. **Results**: A total of 6 RCTs involving 493 patients were included in this analysis. Compared with the OBGA group, the OFGA group showed a significant reduction in PONV incidence (risk ratio = 0.17, 95% confidence interval (0.09, 0.31); $p \leq 0.05$, $I^2 = 0\%$), and shorter extubation time. Additionally, the OFGA technique was associated with more stable intraoperative hemodynamics and a lower postoperative neutrophil-lymphocyte ratio. **Conclusions**: Current evidence suggests that OFGA may be a promising alternative for patients undergoing breast surgery. However, higher-powered trials are required to confirm these outcomes. **The PROSPERO Registration**: International Prospective Register of Systematic Reviews (PROSPERO) registration number: CRD42024517527.

Keywords

Opioid-free general anesthesia; Nausea and vomiting; Breast surgery; Immune function; Meta-analysis

1. Introduction

As documented in the 2023 Global Cancer Observatory report by the International Agency for Research on Cancer (IARC), breast neoplasms continue to exhibit the highest incidence rates among all gender-specific malignancies affecting the female population. In 2022, the incidence of breast cancer accounted for 11.6% of all new cancer cases worldwide (ranking second), and the number of deaths accounted for 6.9% of the total cancer-related mortality (ranking fourth) [1]. Surgical tumor resection continues to be a standard treatment, yet it is accompanied by moderate to severe pain after surgery [2, 3]. Traditional opioid based general anesthesia (OBGA) is associated with various adverse events after surgery, such as respiratory depression, chest stiffness, pruritus, chills, urinary retention, nausea, and vomiting [4–6]. Moreover, opioid tolerance and opioid-induced hyperalgesia can further increase the demand for opioids, potentially leading to opioid misuse and dependence [7, 8]. Thus, the perioperative analgesia mode, mainly based on opioid drugs, is gradually facing challenges.

In recent years, opioid-free general anesthesia (OFGA) techniques, which utilize a combination of non-opioid analgesics (such as α2-receptor agonists and N-methyl-D-aspartate antagonists) [9, 10] alongside various regional block techniques have received attention [11–14]. Recent studies suggest that the OFGA protocol combining dexmedetomidine and lignocaine results in better perioperative outcomes than traditional OBGA, with improved hemodynamic stability, reduced anesthetic consumption, optimized recovery trajectories, and diminished postoperative complication rates [15]. Similarly, a retrospective study showed that the combination of ketamine, magnesium, and clonidine was more effective than OBGA in reducing postoperative nausea and vomiting (PONV) and pain scores after breast cancer quadrantectomy [16]. Furthermore, a recent study found that OFGA attenuates perioperative immunosuppression [17]. However, strong, surgery-specific, evidence-based conclusions are still lacking.

Given these considerations, the present investigation was designed to perform a quantitative synthesis of existing evidence regarding OFGA's clinical outcomes in breast oncological procedures through a systematic review methodology with meta-analytic validation.

2. Methods

This evidence synthesis was conducted in strict adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) reporting standards. PRISMA 2020 Checklist is provided in **Supplementary material 1**. The methodological protocol received prior registration on PROSPERO (International Prospective Register of Systematic Reviews) under identifier CRD42024517527.

2.1 Systematic literature retrieval

An exhaustive database interrogation was conducted across PubMed, Embase, Cochrane Library, and Web of Science, encompassing all records through 30 April 2024, with no linguistic constraints imposed. The complete search syntax for each repository is available in Supplementary Materials. Furthermore, manual scrutiny of bibliographies from the selected publications was implemented to capture potentially omitted relevant studies.

2.2 Criteria for selection

2.2.1 Eligibility criteria

Study selection followed the PICOS framework:

(1) Participants (P): patients undergoing breast surgery.

(2) Intervention (I): trials clearly described OFGA technique.

(3) Comparison (C): traditional OBGA technique.

(4) Outcome (O): mandatory reporting of PONV incidence.

(5) Study designs (S): peer-reviewed randomized controlled trials (RCTs).

2.2.2 Exclusion criteria

(1) Patients had not undergoing general anesthesia.

(2) Studies lacking extractable outcome data.

(3) Non-peer reviewed/preliminary reports (conference abstracts, protocols).

(4) Non-randomized or quasi-experimental study designs.

2.3 Data extraction and outcomes measures

The methodological process was rigorously executed by dual independent reviewers who initially conducted duplicate removal through automated EndNote deduplication complemented by manual verification. Subsequently, a two-phase screening protocol was implemented: preliminary title/abstract triage against PICOS criteria followed by full-text appraisal to confirm final eligibility. Utilizing a standardized extraction template, the reviewers systematically retrieved and cross-validated critical parameters including bibliographic identifiers (author names, publication year), demographic profiles (sample size, age distribution), and detailed anesthetic protocol specifications (OFGA *vs.* OBGA regimens).

The primary outcome was the incidence of PONV. Secondary outcomes included intraoperative hemodynamic indicators (bradycardia, hypotension and hypertension), postoperative analgesia indicators (pain score, opioid consumption, time for rescue analgesia, and number of patients who required rescue analgesia), recovery indicators (extubation time and length of post-anesthesia care unit stay), and postoperative immune function indicator (neutrophil-lymphocyte ratio, NLR). For pain scores reported at rest and during movement, only scores during movement were included.

2.4 Quality and risk of bias assessment

The methodological rigor of the included trials was evaluated using the Cochrane collaboration's risk of bias tool across six critical domains: randomization process (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other potential biases. Studies received categorical ratings of low risk, moderate concern, or high risk through standardized domain-specific algorithms.

Concurrently, the GRADE framework was employed to stratify evidence certainty into four hierarchical tiers: high (indicating strong confidence), moderate (suggesting probable real effect), low (reflecting limited confidence), or very low (denoting uncertain estimates).

2.5 Statistical analysis

Quantitative synthesis was conducted utilizing the Cochrane's RevMan 5.3 (The Nordic Cochrane Centre, Oxford, UK) and Stata 12.0 (StataCorp LP, College station, TX, USA), with dual-platform validation to ensure analytical robustness. Dichotomous outcomes were expressed as risk ratios (RR) with 95% confidence intervals (CIs), while continuous variables were analyzed as mean differences (MDs) for uniform units or standardized mean differences (SMDs) for heterogeneous metrics. When studies reported medians with interquartile ranges (IQR) or ranges, these values were converted to means and standard deviations using established statistical methods [18, 19]. Statistical significance was defined as $p < 0.05$. Heterogeneity in the trials was evaluated using the I^2 statistic, wherein $I^2 > 50\%$ was defined as "highly heterogeneous". Considering multiple factors that contributed to the high clinical heterogeneity in this study, a random-effect model was utilized for the studies with low I^2 values.

Subgroup analyses were stratified by geographic region (China, India, Other) and premedication administration status (Yes/No). Publication bias was evaluated through funnel plot symmetry analysis and Egger's linear regression test. Sensitivity analysis tested the robustness of the primary outcome by iteratively excluding individual studies.

Trial sequential analysis (TSA) was performed using TSA software (0.9.5.10 beta, Copenhagen Trial Unit, Copenhagen, Denmark) to control false-positive risks. Stopping boundaries were predefined as: Type I error (α) = 5% (two-sided), and Power ($1 - \beta$) = 80%. The cumulative Z-curve crossing either the monitoring boundary or reaching the required information size (RIS) threshold indicated sufficient evidence.

3. Results

3.1 Screening and eligibility assessment

The systematic search initially yielded 518 potentially eligible records. Following duplicate removal (n = 202), 297 studies were excluded through title/abstract screening based on the PICOS criteria. Full-text assessment of the remaining 19 articles led to the exclusion of 13 studies for the following reasons: OFGA protocol contamination in control groups (n = 2) [20, 21], non-randomized study designs (n = 4) [22–25], conference abstracts without full methodology (n = 4) [26–29], unavailable outcome metrics (n = 3) [30–32]. Six randomized controlled trials [15, 33–37] ultimately met the predefined inclusion criteria. The complete selection workflow is visually summarized in the PRISMA flow diagram (Fig. 1), with critical study characteristics detailed in Table 1.

3.2 Risk of bias

The risk of bias evaluation revealed methodological limitations across the included trials: two studies [15, 33] lacked blinding of outcome assessors, resulting in "unclear risk" ratings for detection bias, while two additional trials [36, 37] omitted double-blind designs, leading to "unclear risk" classifications for performance bias. Furthermore, one trial [36] failed to report sample size calculations, introducing "unclear risk" of selection bias. These methodological constraints are comprehensively visualized in the risk of bias summary (Fig. 2).

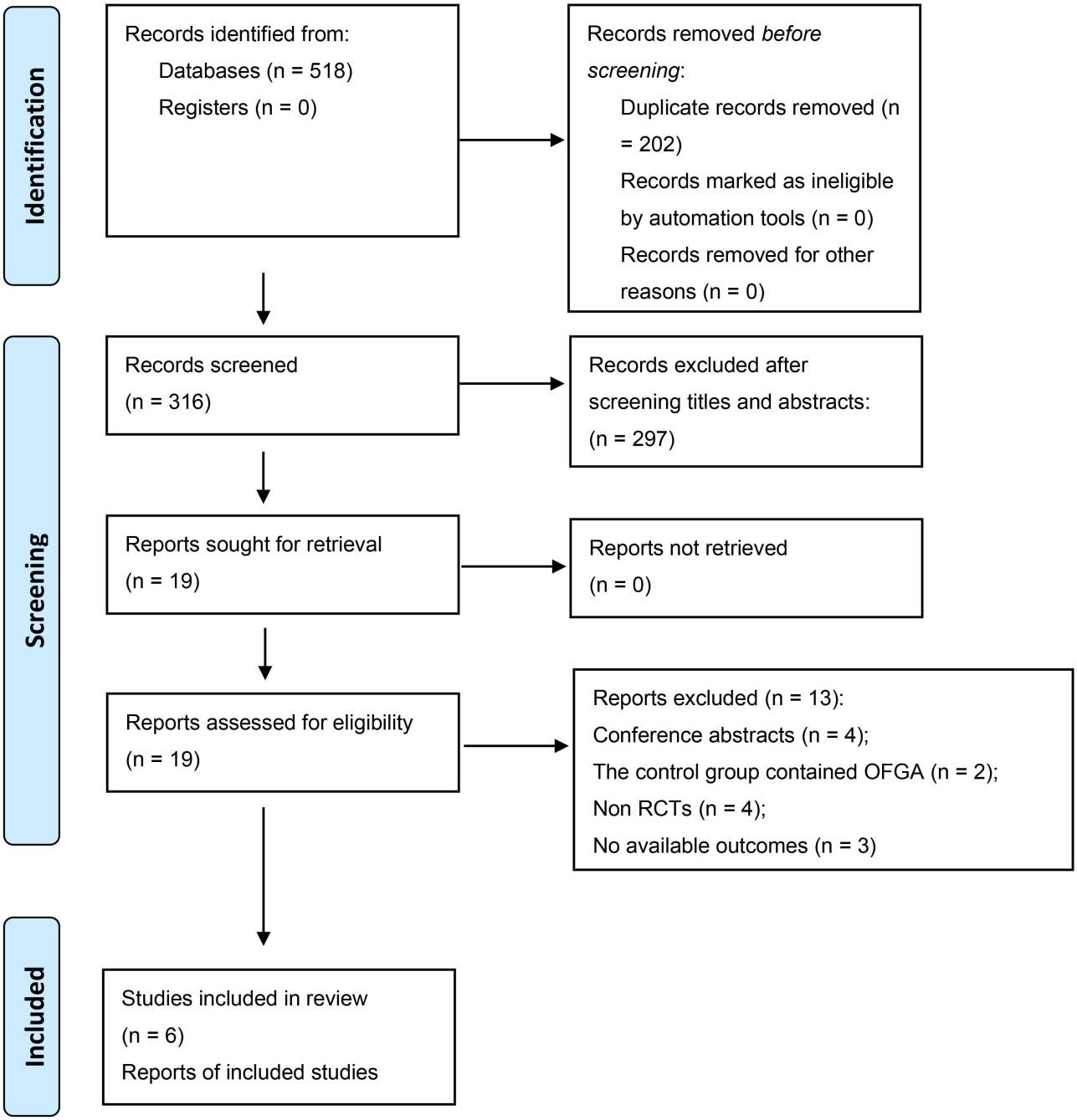

FIGURE 1. PRISMA flow diagram of literature selection process. OFGA, Opioid-free general anesthesia; RCTs, randomized controlled trials.

TABLE 1. Details of included studies.

Study	Country	Type of surgery	Sample size	Premedication	OFGA	OBGA	Postoperative analgesia
Jose 2023	India	Modified radical mastectomy	OFGA: 60 OBGA: 60	Glycopyrrolate 0.004 mg/kg and midazolam 0.02 mg/kg.	Dexmedetomidine 1 µg/kg for 10 min, followed with 0.5 µg/kg/h; lidocaine 1.5 mg/kg, followed with 1.5 mg/kg/h.	Morphine 0.15 mg/kg.	Not reported.
Li 2024	China	Breast cancer surgery	OFGA: 39 OBGA: 40	No Premedication.	Dexmedetomidine 1 µg/kg, lidocaine spray, paravertebral nerve block with 0.25% ropivacaine 20 mL.	Sufentanil 0.4 µg/kg; remifentanil 1–2 ng/mL.	PCIA: sufentanil.
Qian 2023	China	Lumpectomy	OFGA: 37 OBGA: 37	Dexamethasone 5 mg and penehyclidine hydrochloride 0.01 mg/kg.	Dexmedetomidine 0.5 µg/kg over 10 min, esketamine 0.1 mg/kg, lidocaine 1.5 mg/kg, followed with dexmedetomidine 0.1–0.2 µg/kg/h, esketamine 0.1–0.2 mg/kg/h, lidocaine 1–1.5 mg/kg/h.	Sufentanil 0.2–0.4 µg/kg, remifentanil 0.1–0.3 µg/kg/min.	Dezocine for rescue analgesia.
Sarma 2024	India	Breast Cancer Surgery	OFGA: 50 OBGA: 50	No Premedication.	Dexmedetomidine 0.5 µg/kg/h over 10 min, followed with 0.3–0.7 µg/kg/h, magnesium sulfate 40 mg/kg, erector spinae plane block with 0.5% ropivacaine 0.5 mL/kg.	Fentanyl 2 µg/k, followed with 1 µg/kg after every hour intraoperatively.	PCIA: morphine.
Yilmaz 2021	Turkey	Breast Cancer Surgery	OFGA: 30 OBGA: 30	No Premedication.	Pectoral nerve I block with 0.25% bupivacaine 10 mL, pectoral nerve II block with 0.25% bupivacaine 20 mL.	Remifentanil 0.2–0.5 µg/kg/min.	Tramadol for rescue analgesia.
Zhang 2023	China	Breast cancer surgery	OFGA: 40 OBGA: 40	Midazolam 2 mg.	Lidocaine 1.5 mg/kg; paravertebral nerve block with 0.4% ropivacaine 20 mL.	Sufentanil 0.2–0.3 µg/kg, sufentanil 0.05–0.1 µg/kg during surgery.	Flurbiprofen.

OFGA, opioid-free general anesthesia; OBGA, opioid-based general anesthesia; PCIA, patient controlled intravenous analgesia.

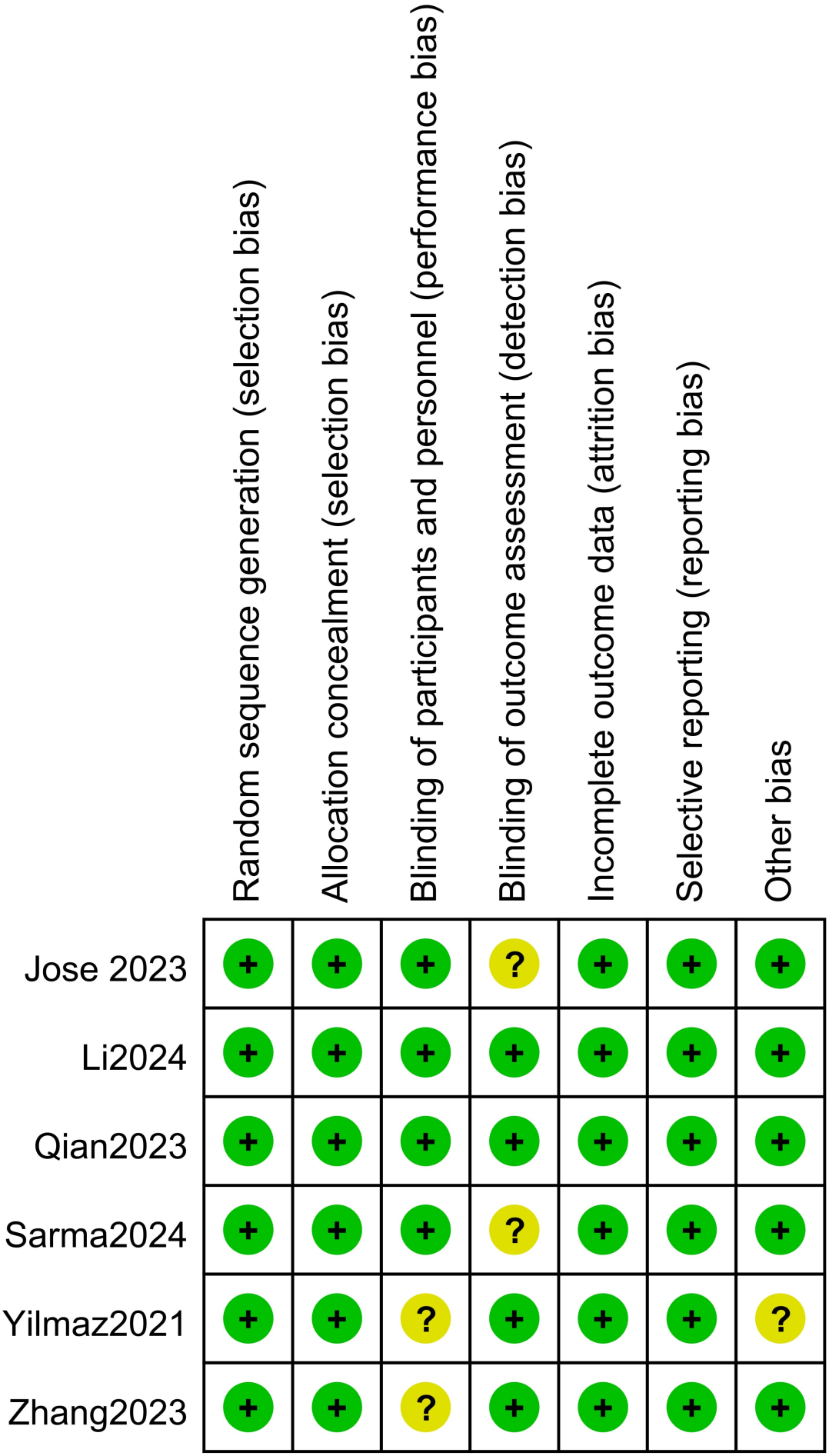

FIGURE 2. Methodological quality assessment for included studies. +, low risk; ?, unclear risk.

3.3 Outcomes

3.3.1 Primary outcome

All the six included trials consistently reported PONV incidence. Meta-analytic synthesis (Fig. 3) demonstrated a statistically significant reduction in PONV occurrence within the OFGA cohort compared to OBGA, yielding a RR of 0.17 (95% CI: 0.09–0.31; $p < 0.05$). Notably, the analysis exhibited negligible interstudy heterogeneity ($I^2 = 0\%$), indicating remarkable consistency across trials. Subgroup stratification by geographic region and premedication status aligned with the primary findings, as detailed in **Supplementary Figs. 1,2**.

3.3.2 Secondary outcomes

3.3.2.1 Intraoperative hemodynamic indicators

Four trials assessed the incidence of intraoperative bradycardia. As presented in Fig. 4A, the results indicated a significantly lower incidence in the OFGA group (RR = 0.28, 95% CI: 0.10–0.75, $p < 0.05$), with low heterogeneity ($I^2 = 0\%$). Moreover, four trials assessed the incidence of intraoperative hypotension. The results, as depicted in the forest plot (Fig. 4B), indicated a significantly lower incidence in the OFGA group (RR = 0.24, 95% CI: 0.10–0.59, $p < 0.05$), with low heterogeneity ($I^2 = 0\%$). Additionally, two trials reported the incidence of intraoperative hypertension. The forest plot (Fig. 4C) indicated no significant difference in incidence between the OFGA group and the OBGA group.

3.3.2.2 Postoperative analgesia indicators

Three trails evaluated pain scores at 24 hours postoperatively. As shown in Fig. 5A, there was no statistically significant difference between the OFGA and OBGA groups (MD = −0.25, 95% CI: −0.95 to 0.44, $p = 0.48$, Fig. 5A), although substantial heterogeneity was observed ($I^2 = 76\%$). Two trials reported postoperative opioid consumption. As illustrated in the forest plot (Fig. 5B), there was no significant difference between the OFGA group and OBGA group (SMD = −0.03, 95% CI: −0.48 to 0.42, $p = 0.89$), with moderate heterogeneity observed ($I^2 = 57\%$). Two trials evaluated the time to first rescue analgesia, and the forest plot (Fig. 5C) showed no significant difference between the OFGA and OBGA groups. Two trials assessed the number of patients who required rescue analgesia, and the forest plot (Fig. 5D) also demonstrated no significant difference in incidence between the two groups.

3.3.2.3 Recovery indicators

Two trials reported extubation time. The result indicated a significantly shortened extubation time in the OFGA group (MD = −2.84 minutes, 95% CI: −4.26 to −1.41; $p < 0.05$, Fig. 6A), with substantial heterogeneity ($I^2 = 61\%$). Moreover, three trials reported the length of post-anesthesia care unit stay, and the results indicated no significant difference between the two groups (Fig. 6B).

3.3.2.4 Immune function indicator

Two trials reported postoperative NLR. The result indicated a significantly lower NLR in the OFGA group (MD = −2.09, 95% CI: −3.12 to −1.05, $p < 0.05$), with low heterogeneity ($I^2 = 6\%$) as shown in Fig. 7.

3.3.3 Evidence certainty and analytical robustness

The GRADE framework stratified evidence certainty across trials, ranging from low to high confidence levels as systematically documented in Table 2. Simultaneously, publication bias evaluation demonstrated a qualitatively symmetric funnel plot configuration for the primary outcome (**Supplementary Fig. 3**), corroborated by nonsignificant Egger's regression results ($p > 0.05$), collectively indicating no statistically significant small-study effects. Sensitivity analysis, employing iterative exclusion methodology, consistently replicated the primary effect estimates (Fig. 8), confirming analytical stability and reinforcing the conclusiveness of the meta-analytic findings.

3.3.4 TSA result

While the cumulative Z-score trajectory failed to attain the required information size (RIS) threshold, its breach of the trial sequential monitoring boundary ($\alpha = 5\%$, power = 80%) demonstrates conclusive evidence adequacy within the accrued dataset, as graphically substantiated in Fig. 9.

4. Discussion

This meta-analysis constitutes the first comprehensive evidence synthesis systematically evaluating OFGA protocols in mammary surgical interventions. Our findings indicate that OFGA is associated with a significant reduction in PONV, improved intraoperative hemodynamic stability, shorter extubation times, and reduced postoperative NLR.

Current international consensus guidelines on PONV management persistently identify female gender and postoperative opioid administration as key predictive determinants in adult populations [38]. Andrews *et al.* [39] suggest that opioid induced PONV may be associated with the activation of chemical trigger receptors in the brainstem. A prospective observational study indicated that a robust positive correlation exists between postoperative opioid dosage escalation and both PONV frequency and escalation [40]. A recent study reported that even when treated with some intervention measures (electrical acupoint stimulation or dexamethasone), the incidence of PONV in breast surgery patients receiving OBGA treatment is still approximately 30% [41]. PONV is associated with a range of postoperative adverse events, including electrolyte imbalance, postoperative bleeding, and decreased sleep quality. In this meta-analysis, we found that the OFGA technique significantly reduced the incidence of PONV compared with OBGA (4.1% *vs.* 27.9%), consistent with previous meta-analyses [42–44].

A key concern for anesthesiologists is whether OFGA can provide adequate analgesia during the perioperative period. Our findings suggest that OFGA offers comparable analgesic efficacy to OBGA, with lower incidences of bradycardia and hypotension, and no increase in hypertension, indicating stable hemodynamic profiles. Unfortunately, due to insufficient data, we were unable to analyze the difference in intraoperative opioid consumption between the two groups. Moreover, postoperative pain score, opioid consumption, and time for rescue analgesia were of no significant difference between

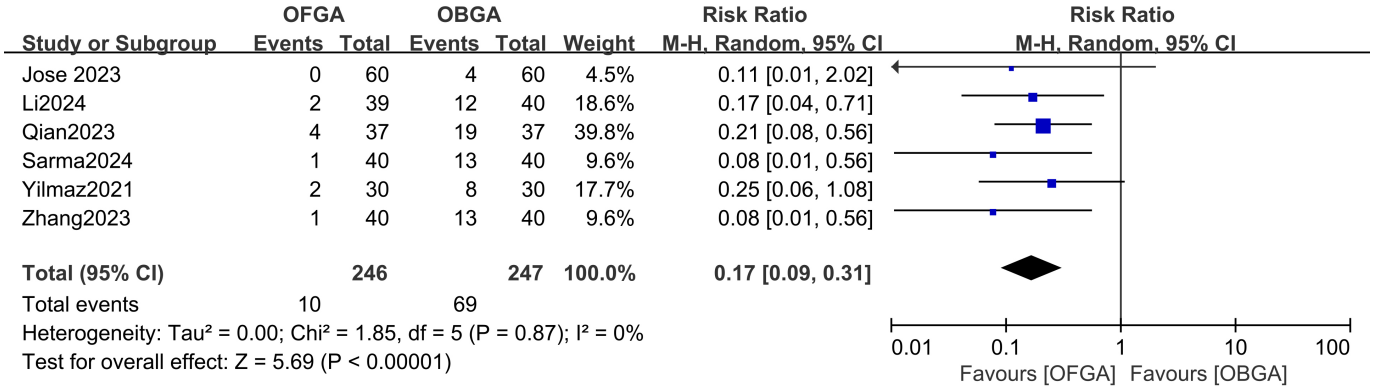

FIGURE 3. Forest plot of postoperative nausea and vomiting (PONV) incidence: opioid-free general anesthesia (OFGA) versus opioid-based general anesthesia (OBGA). CI, confidence interval; M-H, Mantel–Haenszel.

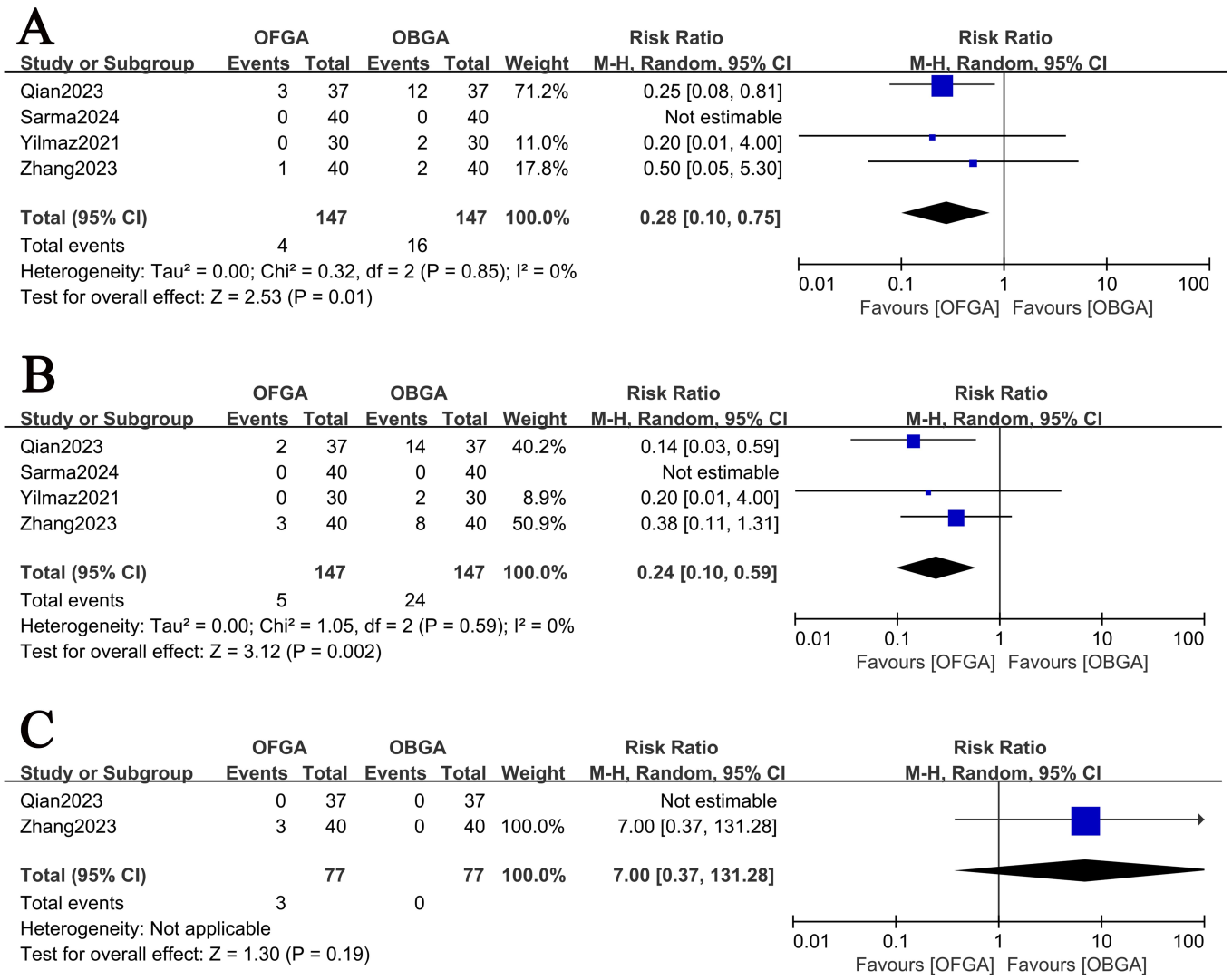

FIGURE 4. Meta-analytic comparison of perioperative hemodynamic outcomes. (A) Bradycardia risk assessment. (B) Hypotension incidence analysis. (C) Hypertension occurrence evaluation between opioid-free general anesthesia (OFGA) and opioid-based general anesthesia (OBGA) cohorts. CI, confidence interval; M-H, Mantel–Haenszel.

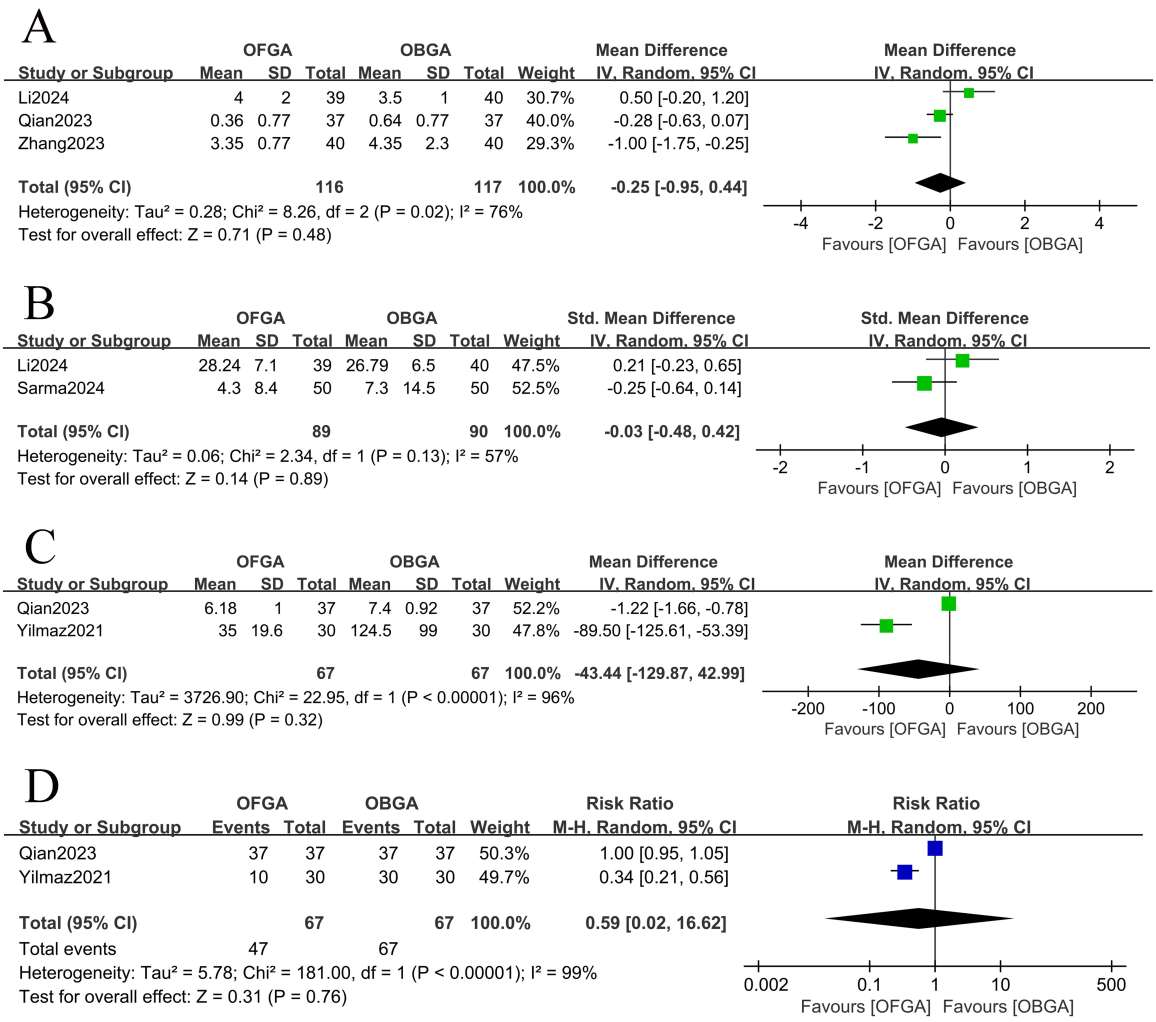

FIGURE 5. Meta-analytic evaluation of postoperative pain management outcomes. (A) 24-hour postoperative pain scores. (B) Opioid consumption. (C) Time to first rescue analgesia. (D) Frequency of rescue analgesia administration. Forest plots compare outcomes between opioid-free general anesthesia (OFGA) and opioid-based general anesthesia (OBGA) cohorts. CI, confidence interval; SD, standard deviation; M-H, mantel–haenszel; IV, inverse variance.

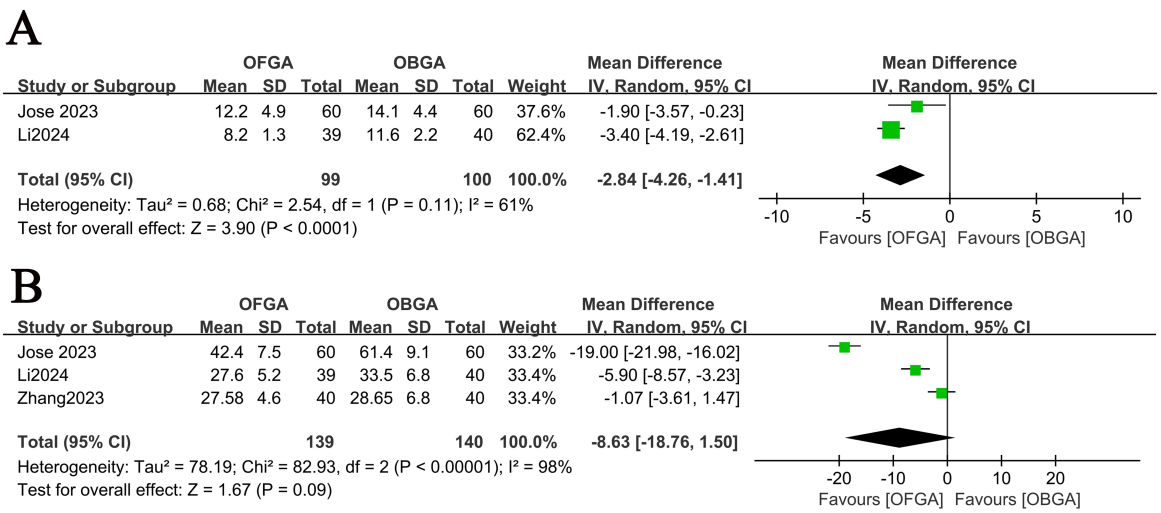

FIGURE 6. Meta-analysis of postoperative recovery metrics. (A) Tracheal extubation time. (B) Post-anesthesia care unit (PACU) duration. Forest plots compare opioid-free general anesthesia (OFGA) and opioid-based general anesthesia (OBGA) cohorts, presenting pooled mean differences (MD) with 95% confidence intervals. CI, confidence interval; SD, standard deviation; IV, inverse variance.

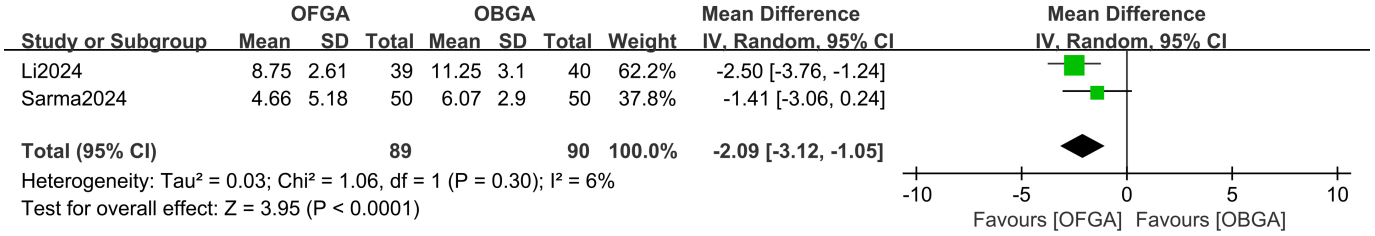

FIGURE 7. Meta-analytic comparison of neutrophil-lymphocyte ratio (NLR) between opioid-free (OFGA) and opioid-based general anesthesia (OBGA) cohorts. CI, confidence interval; SD, standard deviation; IV, inverse variance.

TABLE 2. Summary of GRADE for included studies.

Outcome	Included studies (n)	Patients (n)	Quality of evidence	Reasons
Incidence of PONV	6	493	⊕⊕⊕◯ MODERATE	"Risk of bias" was downgraded to "serious".
Incidence of bradycardia	4	294	⊕⊕⊕⊕ HIGH	NONE.
Incidence of hypotension	4	294	⊕⊕⊕⊕ HIGH	NONE.
Incidence of hypertension	2	154	⊕⊕⊕⊕ HIGH	NONE.
Pain score at postoperative 24 hour	3	233	⊕⊕◯◯ LOW	"Risk of bias" and "Imprecision" were downgraded to "serious".
Postoperative opioid consumption	2	179	⊕⊕◯◯ LOW	"Imprecision" and "Inconsistency" were downgraded to "serious".
Time to first rescue analgesia	2	134	⊕⊕⊕◯ MODERATE	"Imprecision" was downgraded to "serious".
Number of patients in need of rescue analgesia	2	114	⊕⊕⊕⊕ HIGH	NONE.
Extubation time	2	199	⊕⊕⊕◯ MODERATE	"Imprecision" was downgraded to "serious".
Post-anesthesia care unit stay	3	279	⊕⊕⊕◯ MODERATE	"Imprecision" was downgraded to "serious".
Neutrophil-lymphocyte ratio	2	179	⊕⊕⊕◯ MODERATE	"Risk of bias" was downgraded to "serious".

PONV, postoperative nausea and vomiting.

the two groups. However, these inconsistencies may be explained by differences in study protocols. Specifically, Qian *et al.* [35] did not specify whether pain scores were assessed at rest or during movement, whereas both Li *et al.* [34] and Sarma *et al.* [15] clearly reported pain scores during movement. In addition, opioid consumption differed in definition and administration: Li *et al.* [34] utilized patient-controlled intravenous analgesia with sufentanil, while Sarma *et al.* [15] employed patient-controlled intravenous analgesia with morphine postoperatively. These disparate approaches to rescue analgesia and variation in surgery type (lumpectomy *vs.* broader breast cancer surgery) likely contributed to the observed heterogeneity in analgesic outcomes. These findings also require validation through further standardized research. Hyperalgesia is an important reason for poor postoperative pain control after opioid use [45]. After infusion of remifentanil at a rate of 0.05–0.3 μg/kg/min for 60–90 minutes, the degree and range of postoperative incision pain increase, and the incidence of hyperalgesia is much higher than with other opioid analgesics [46, 47]. In contrast, our study revealed that OFGA techniques frequently utilized long-acting local anesthetics such as ropivacaine in conjunction with regional nerve blocks (*e.g.*, erector spinae, pectoral, or paravertebral blocks), enhancing analgesic effects without opioid-related risk.

Although our meta-analysis demonstrated a statistically significant decrease in extubation time with OFGA (MD = −2.84 minutes), the clinical importance of this reduction remains uncertain. A time difference of less than 3 minutes may lack practical relevance in routine clinical settings. Notably, Zhang *et al.* [48] reported comparable extubation times between OFGA and OBGA groups. Conversely, a separate RCT observed a marginal prolongation of tracheal extubation in patients receiving OFGA [49]. These conflicting findings

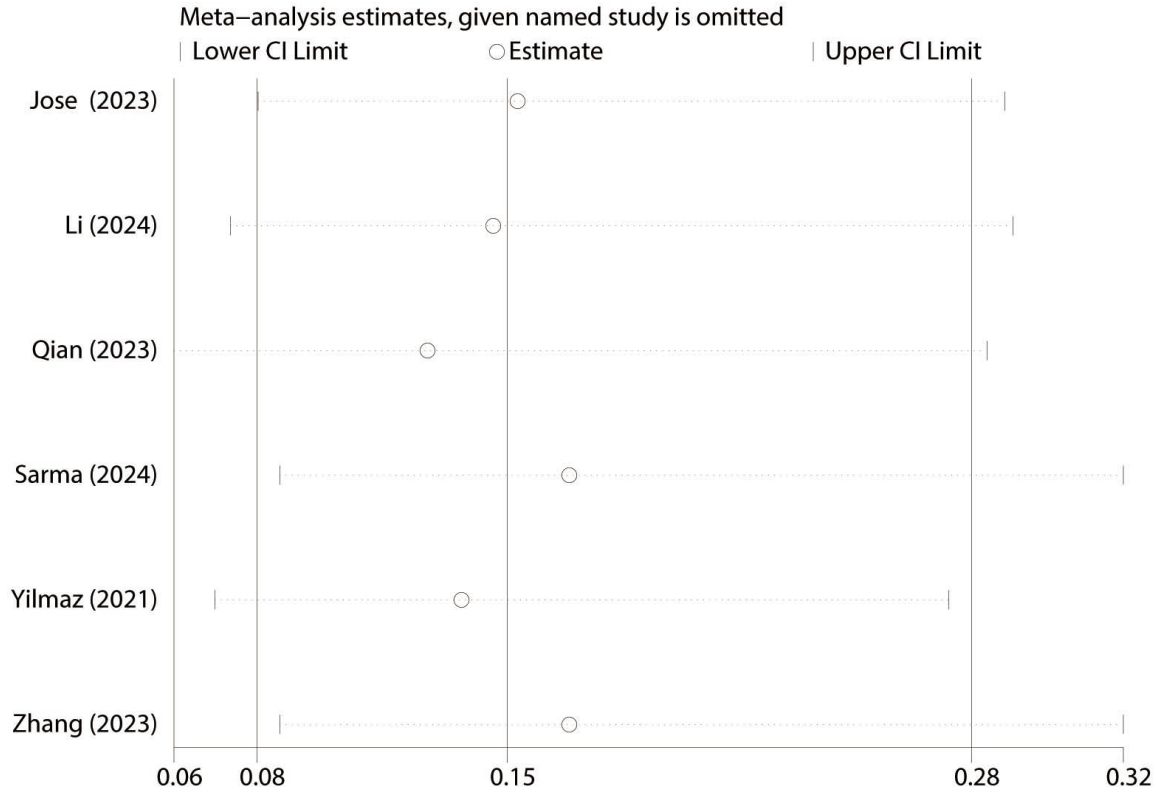

FIGURE 8. Sensitivity analysis for the incidence of PONV. A leave-one-out sensitivity analysis was conducted to assess the influence of individual studies on the pooled effect size and test result robustness. PONV, postoperative nausea and vomiting; CI, confidence interval.

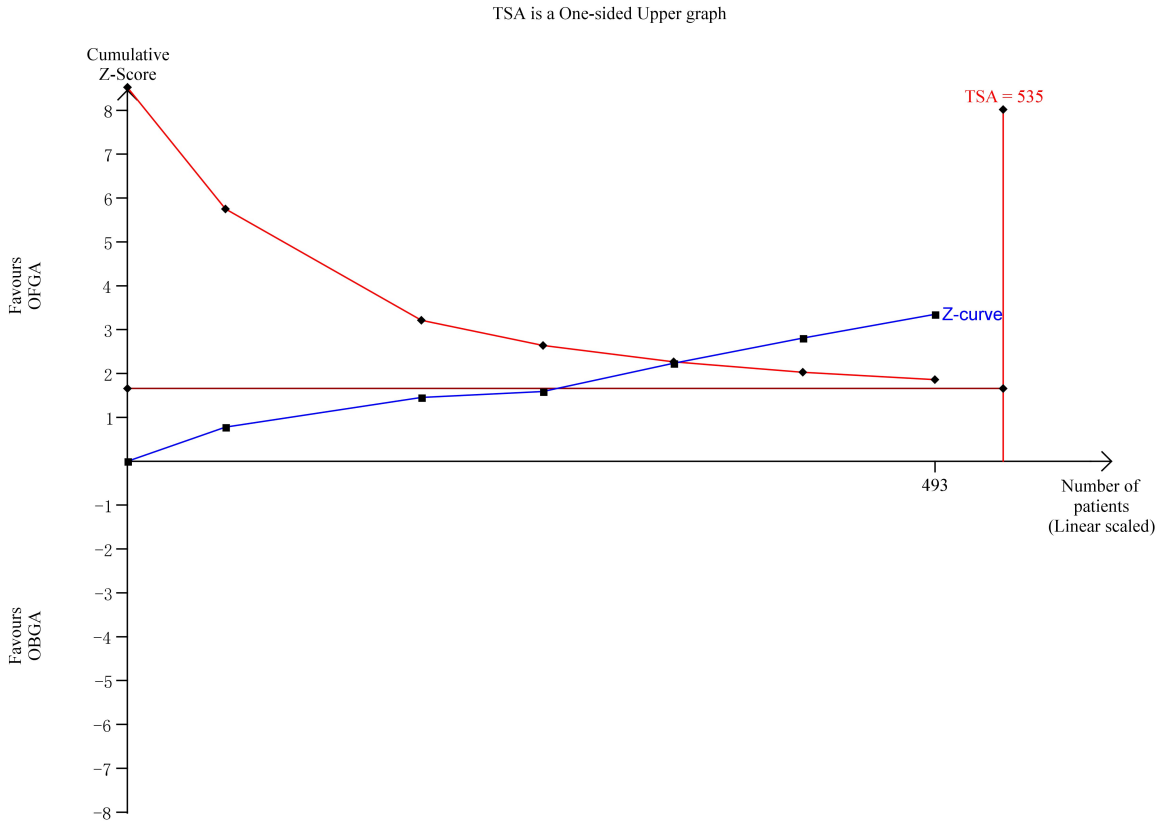

FIGURE 9. TSA for the incidence of PONV. TSA, trial sequential analysis; PONV, postoperative nausea and vomiting; OFGA, opioid-free general anesthesia; OBGA, opioid-based general anesthesia.

underscore the need for larger, standardized trials to clarify the impact of OFGA on postoperative recovery metrics. In addition, we found that OFGA decreased the NLR, which indicated less inflammation or improved cell-mediated immunity [50]. A systematic review demonstrated that an NLR exceeding 5 holds significant prognostic value in clinical oncology, and elevated preoperative NLR levels are independently associated with increased postoperative recurrence risk [51]. Previous studies have shown that opioids may suppress immune function [52, 53]. A retrospective study found that, compared with inhalational agent-opioid anesthesia, propofol-paravertebral block anesthesia attenuated the postoperative increase in the NLR after breast surgery [54]. Our study only evaluated the NLR as an immune marker. To fully assess the impact of OFGA on immune function, future research should incorporate broader biomarkers.

Several limitations of this meta-analysis should be acknowledged. First, although we conducted a comprehensive search, the sample size included in this meta-analysis was relatively small. Second, most of the included studies were conducted in China and India, which may affect generalizability. Third, the OFGA techniques included in the study exhibited significant heterogeneity, which may lead to potential biases. Fourth, the surgical procedures included in the analysis also varied widely; this broad clinical spectrum adds further heterogeneity and may limit the generalizability of the findings. Despite applying a random-effects model, the variability in anaesthetic approaches and surgical types necessitates cautious interpretation of the findings.

5. Conclusions

Our study suggests that OFGA is a promising alternative to OBGA in breast surgery, offering effective pain relief, reduced adverse effects, and benefits for postoperative NLR. However, to establish its role definitively, future research should focus on standardized OFGA protocols applied in specific surgical contexts to validate and optimize its clinical application.

AVAILABILITY OF DATA AND MATERIALS

The datasets supporting the conclusions of this article are supplemented along with the article.

AUTHOR CONTRIBUTIONS

LX—conceptualization, methodology, writing–original draft. YZL and YFS—project administration, resources, supervision. LX and QHS—formal analysis, investigation, validation. QHS—project administration.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/2019691504757293056/attachment/Supplementary%20material.zip.

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