Systematic Review

Postoperative Analgesic Effects of Serratus Anterior Plane Block for Thoracic and Breast Surgery: A Meta-analysis of Randomized Controlled Trials

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Background: Postoperative pain is a concern after thoracic and breast surgeries. Recent studies have demonstrated that ultrasound-guided serratus anterior plane block (SAPB) could provide postoperative analgesia.

Objective: The objective of this systematic review and meta-analysis was to examine the effects of SAPB on postoperative analgesia in thoracic and breast surgery.

Study Design: A systematic review and meta-analysis of randomized control trials (RCTs).

Methods: We systematically queried the PubMed, Embase, Web of Science, and Cochrane Library online databases from their establishment through Mar 31, 2022. Eligible RCTs were selected for the purpose of conducting the meta-analysis. The risk of bias of the included trials was assessed by Cochrane Review Manager. The level of certainty was examined utilizing the GRADE (Grade of Recommendations Assessment, Development, and Evaluation) scale to determine whether the evidence was of high quality or not.

Results: During the process of the meta-analysis, a total of 27 pieces of literature was included in the present research. SAPB significantly reduced the intraoperative opioid consumption (mean difference [MD] = -9.52 mg of morphine equivalent, 95% CI, -15.50 to -3.54; $P < 0.01$, $I^2 = 98\%$) and postoperative pain opioid consumption (MD = -23.12 mg of morphine equivalent, 95% CI, -30.59 to -15.65; $P < 0.01$, $I^2 = 100\%$. Also, patients in the SAPB group had lower pain scores during the first postoperative 24 hours. Furthermore, SAPB attenuated the occurrence of postsurgical nausea and vomiting, as well as chronic postsurgical pain.

Limitations: Double-blinding was not performed in some trials, also some assessors were not blinded; the included sample sizes of eligible trials which reported the incidence of chronic postsurgical pain were relatively small; the comparisons between SAPB and other types of blocks were not performed in our meta-analysis.

Conclusion: Our findings suggest that SAPB not only relieves acute pain after thoracic and breast surgery, but also reduces the incidence of chronic postsurgical pain.

Key words: Thoracic and breast surgery, serratus anterior plane block, meta-analysis

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For patients undergoing thoracic or breast surgeries, the adverse experience caused by pain during the postoperative period affects recovery. Serious postoperative pain is correlated with a greater risk of anxiety, hemodynamic disturbances, and increased myocardial oxygen consumption (1-3). In addition, approximately 20% to 60% of the occurrence of chronic pain is associated with poor postoperative acute pain control (4-6). Traditional postoperative analgesia methods include epidural analgesia (7), intravenous patient-controlled analgesia, intercostal block (8), paravertebral block (9), and local anesthetics infiltration (10). Among these, paravertebral block and intercostal nerve block carry a risk of pneumothorax (11). patient-controlled analgesia has the shortcoming of high opioid dosages. Epidural analgesia has the shortcoming of nerve injury, and the duration of wound infiltration is short.

Ultrasound-guided serratus anterior plane block (SAPB) is a relatively new reported interfascial plane block technique (12). Local anesthetic is injected into the plane between the latissimus dorsi muscle and serratus anterior muscle to provide thoracic analgesia. A number of studies have reported that SAPB could effectively relieve postoperative pain in thoracic or breast surgeries (13-15). However, a high-quality randomized controlled trial (RCT) had a different result (16). Previous meta-analyses have been conducted to explore the effectiveness of SAPB for thoracic or breast surgeries (17,18), but the sample size was small. Furthermore, the incidence of chronic postsurgical pain has not been evaluated.

Thus, we conducted this systemic review and meta-analysis to examine the effects of SAPB on postoperative analgesia in thoracic and breast surgery.

Methods

We performed this systematic review and meta-analysis in accordance with the guidelines detailed in Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA). The PROSPERO registration number is CRD42021278361.

Systematic Literature Search

Several online databases, including Embase, Web of Science, the Cochrane Library, and PubMed were systematically queried. Trials that had been conducted from the inception of the databases through Mar 31, 2022, were retrieved. There were no language limitations imposed. The search terms included the following: "serratus anterior plane block," "SAP block," "SAPB," "thoracic surgery," "thoracoscopic surgery," "thoracotomy," "modified radical mastectomy," "mastectomy," and "breast surgery." Furthermore, references contained in the eligible studies were also searched systematically. Our Supplementary material contains a full description of database search techniques.

Criteria for Selection and Extraction of Data

The following were the eligibility requirements for inclusion: 1) adult patients receiving thoracic or breast surgery under the administration of general anesthesia; 2) trials reporting SAPB as an analgesic technique; 3) a control group without intervention, with sham block, or wound infiltration; 4) outcomes including intraoperative and postoperative opioid consumption, postoperative pain scores, nausea and vomiting, and chronic pain; 5) RCTs.

The following were the exclusion criteria for the present research: 1) nonrandomized trials, including case reports, letters to the editor, or reviews; 2) animal studies;. 3) incomplete studies, such as conference abstracts.

First, 2 authors independently used EndNote to exclude duplicates. Next, they checked whether the trials met the conditions according to the title and abstract. Finally, a careful evaluation of full texts of the screened studies was performed to evaluate if they fulfilled all of the eligibility requirements for inclusion for the present research in their original form. Each of the 2 authors independently retrieved and cross-checked the following information using the data from the included studies: year of publication, first author's name, type of surgery, sample size, SAPB technique used, general anesthesia technique used, comparison, intraoperative and postoperative opioid consumption, pain scores during the first postoperative 24 hours, incidence of chronic postsurgical pain, and occurrence of complications (postoperative nausea and vomiting [PONV], and block-related complications). For studies that recorded different types of opioid consumptions, we converted the values to an equal dosage of intravenous morphine using the online calculator at www.globalrph.com/narcotic.

Quality and Risk Evaluation

With the aid of RevMan 5.3 (The Nordic Cochrane Centre for The Cochrane Collaboration), the researchers assessed the potential bias for all the studies. Each of the included studies was reviewed by 2 independent authors based on the criteria listed below: selective reporting, missing data on outcomes, blinding of outcome evaluators, concealing allocations, generation of random sequences, patient blinding, and other biases. The risk of bias value was categorized into 3 groups according to their values as follows: low group, unclear group, or high group.

The degree of confidence was assessed utilizing

GRADE (Grading of Recommendations Assessment, Development, and Evaluation). Accordingly, the level of certainty was categorized as very low, low, moderate, or high.

Statistical Analysis

Utilizing RevMan 5.3, the meta-analysis was carried out. With regard to dichotomous outcomes, the pooled risk ratio (RR) and 95% CIs were calculated. For continuous data, the mean differences (MD) and 95% CIs were evaluated. In the case where continuous data were defined as median (interquartile ranges) or median (min-max), we transformed the values to corresponding mean and standard deviation to adhere to the earlier discussed methods (19,20). Statistical significance was considered to have been achieved when the *P* value was < 0.05. Heterogeneity in trials was examined utilizing the I^2 statistic, wherein $I^2 > 50\%$ was defined as "highly heterogeneous." Clinical and methodological issues were shown to be the primary causes of high clinical heterogeneity. As a consequence, a random-effects model was utilized even in studies with low I^2 values.

Results

Search Results

According to the retrieval strategy, a total of 865 related studies were initially obtained from the databases. Next, 221 duplicates were excluded, following which 610 studies were removed once their titles and abstracts were reviewed. The full texts for the remaining 34 studies were thoroughly examined to assess if they fulfilled the eligibility requirements for inclusion. Notably, an additional 7 trials were omitted due to these reasons: pediatric patients (n = 1) (21), continuous SAPB technique (n = 1) (22), comparisons with other types of blocks (n = 4) (23-26), and meta-analysis (n = 1) (27). Finally, 27 trials (13-16,28-50) that satisfied the eligibility requirement were selected for inclusion in the meta-analysis. The schematic of the literature screening process is depicted in Fig. 1.

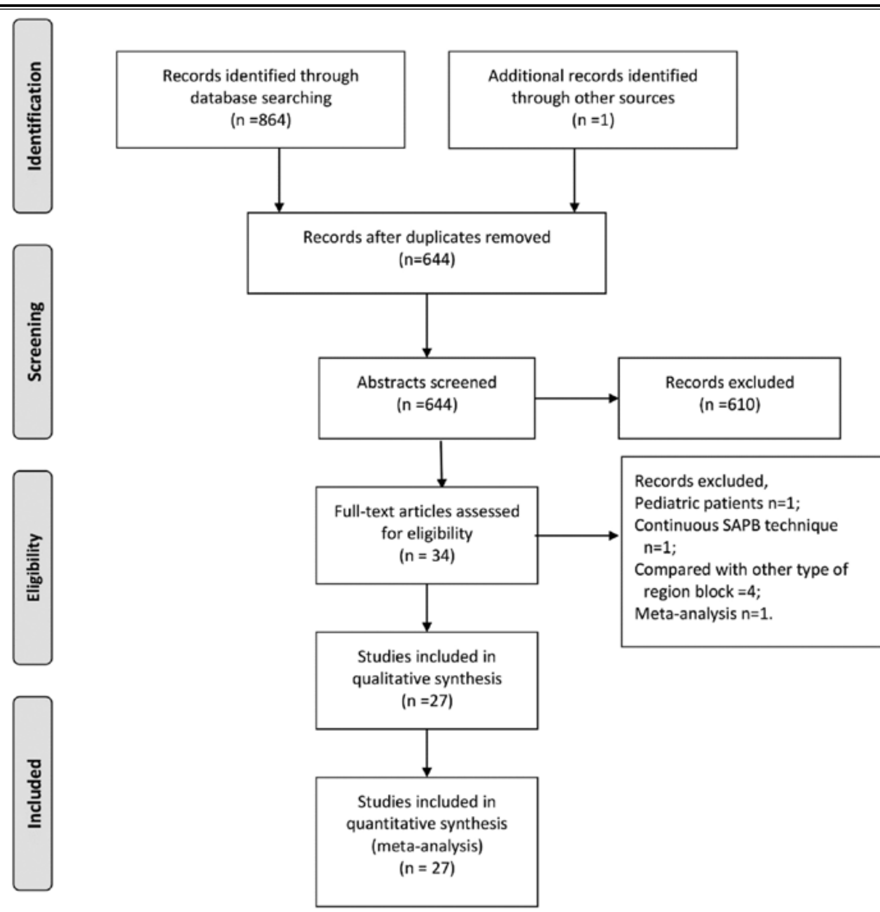

Fig. 1. *Flow chart of studies retrieved.*

Study Characteristics

A total of 27 RCTs comprising of 1,892 patients (1,153 patients underwent breast surgery and 739 patients underwent thoracic surgery) were analyzed. The publication years for these studies were from 2016 through 2022. The sizes of the samples were within a range of 40 to 189. Bupivacaine was used as the local anesthetic in 11 trials, while ropivacaine was administered in the remaining trials. The comparison groups in 18 trials did not have an intervention; the comparison group in 6 trials received a sham block; the comparison group in 3 trials received an infiltration block Table 1 lists detailed data on the specific features of the included studies.

Assessment of Bias

Twenty-two studies discussed their approaches to generating random sequences; 7 trials did not report the allocation concealment. Fifteen trials explicitly described their process of double-blinding. The assessors were blinded in a total of 21 studies (51-58). No selective reporting was reported. Five studies did not calculate the sample size, which might lead to other biases. Figure 2 depicts an overview of the evaluation of risk bias.

Meta-analysis

Intraoperative opioid consumption

A total of 8 trials reported intraoperative opioid consumption. The result showed that SAPB substantially attenuated opioid consumption during the surgery compared to the control group (MD= -9.52 mg of morphine equivalent, (95% CI, -15.50 to -3.54; $P < 0.01$, $I^2 = 98\%$, Fig. 3).

Postoperative Opioid Consumption

Nineteen trials recorded postoperative opioid consumption. A Forest plot demonstrates that SAPB significantly reduced opioid consumption during the first postoperative 24 hours (MD= -23.12 mg of morphine equivalent, 95% CI, -30.59 to -15.65]; $P < 0.01$, $I^2 = 100\%$, Fig. 4).

Postoperative Pain Score

Postoperative pain scores were assessed at different time points during the first postoperative 24 hours. As shown in Fig. 5, patients treated with SAPB had lower pain scores at 2, 4, 6, 8, 12, and 24 hours postsurgery.

Chronic Postsurgical Pain

Three trials reported chronic postsurgical pain. Our meta-analysis showed that SAPB significantly reduced the occurrence of chronic postsurgical pain (RR = 0.44, 95% CI, 0.29 - 0.68, $P < 0.01$, $I^2 = 0\%$, Figure 6)

Complications

The incidence of PONV was evaluated in 20 trials. A Forest plot demonstrates that SAPB significantly reduced the occurrence of PONV. (RR = 0.47, 95% CI, 0.37 - 0.61, $P < 0.01$, $I^2 = 22\%$, Fig. 7).

In all the studies that were included, there were no reports of other complications associated with the block.

Publication Bias

The symmetrical distribution of funnel plots for intraoperative and postoperative opioid consumption indicates that there was no obvious publication bias. (Supplement Figs. 1,2)

GRADE Evaluation

All studies considered in this review used the randomized trial "study design" type. The I^2 values of most reports were high to a relative extent, while the "inconsistency" was graded as serious. Pain ratings, as well as opioid use, were reported as the median (interquartile range) in some of these studies. Herein, the "indirectness" was categorized as serious. The GRADE levels for the outcomes were from low to high. The overall GRADE results are summarized in Table 2.

Discussion

This systematic review and meta-analysis demonstrates that ultrasound-guided SAPB could significantly reduce opioid consumption and relieve pain in patients after thoracic and breast surgery. Additionally, SAPB could decrease the incidences of chronic postsurgical pain and PONV.

Poor pain control is a significant risk factor for postoperative readmission (59). Opioids have long been used for treating acute postsurgical pain after thoracic and breast surgery. A recent large-scale clinical retrospective study (60) shows that approximately 10% of adult patients who were administered opioids after surgical procedures or endoscopic surgeries experience opioid-related adverse events, which are further associated with increased mortality and a longer hospital stay. Therefore, while effectively managing postoperative pain, it is particularly important to minimize the use of opioids. Presently, multi-modal analgesia has

Table 1. ***Included studies details.***

	Surgery type	Sample size	General anesthesia	SAPB technique	Control group
Abdallah 2021	Breast surgery	SAPB: 20 Control: 20	Induction: fentanyl 1–3 μg/kg, propofol 2–4 mg/kg, and rocuronium 0.6 mg/kg; Maintenance: desflurane 2–6% in a 50:50 mixture of oxygen and air.	Position: lateral decubitus Local anesthetics: 20 mL of 0.5% ropivacaine Timing: before the general anesthesia	Sham block
Ahiskalioglu 2020	Breast surgery	SAPB: 20 Control: 20	Induction: fentanyl 1–2 μg/kg, propofol 2 mg/kg, and rocuronium 0.6 mg/kg; Maintenance: sevoflurane 1–2% in a 50:50 mixture of oxygen and N_2O.	Position: lateral decubitus Local anesthetics: 30 mL of 0.25% bupivacaine Timing: before the general anesthesia	Sham block
Aslan 2020	Breast surgery	SAPB: 20 Control: 20	Induction: fentanyl 1 μg/kg, propofol 2-3 mg/kg, and rocuronium 0.6 mg/kg; Maintenance: 48% nitrogen oxide, 2% sevoflurane, 50% oxygen.	Position: supine Local anesthetics: 40 mL of 0.25% bupivacaine Timing: after the general anesthesia	No block
Bakeer 2020	Breast surgery	SAPB: 58 Control: 58	Induction: fentanyl 1 μg/kg, propofol 2 mg/kg, and cisatracurium 0.15 mg/kg; Maintenance: sevoflurane 2% in 50% mixture of oxygen and air.	Position: lateral Local anesthetics: 30 mL of 0.25% bupivacaine Timing: before the general anesthesia	No block
Bhan 2021	Breast surgery	SAPB: 50 Control: 50	Induction: fentanyl 2 μg/kg, propofol 1-2 mg/kg, and vecuronium 0.1 mg/kg; Maintenance: 1 minimum alveolar concentration desflurane in oxygen and air.	Position: supine Local anesthetics: 0.4 mL /kg of 0.375% ropivacaine Timing: before the general anesthesia	No block
Chai 2022	Breast surgery	SAPB: 32 Control: 33	Induction: midazolam 0.05 mg/kg, sufentanil 0.4 μg/kg, propofol 2 mg/kg, and cisatracurium 0.2 mg/kg; Maintenance: propofol 4-12 mg/kg/h, remifentanil 0.05-0.2 μg/kg/min	Position: lateral Local anesthetics: 30 mL 0.375% ropivacaine Timing: before the general anesthesia	No block
Chen 2019	Thoracic surgery	SAPB: 20 Control: 20	Induction: propofol 2.5 mg/kg, midazolam 0.05 mg/kg, sufentanil 0.6 μg/ kg, and rocuronium 1 mg/kg; Maintenance: NR.	Position: lateral Local anesthetics: 0.4 mL/kg of 0.25% ropivacaine Timing: after the general anesthesia	Infiltration block
Dikici 2020	Thoracic surgery	SAPB: 20 Control: 20	Induction: propofol 2–3 mg/kg, fentanyl 1–2 μ/kg, and rocuronium 0.6 mg/kg; Maintenance: sevoflurane at a rate of 2 L/min with a minimum alveolar concentration of 1 in a mixture of 50% air+50% O_2.	Position: lateral Local anesthetics: 0.25 mL/kg of 0.25% bupivacaine Timing: after the general anesthesia	Infiltration block
Elsabeeny 2020	Breast surgery	SAPB: 25 Control: 25	Induction: propofol 2 mg/kg, fentanyl 2 μg/kg and rocuronium 0.6 mg/kg; Maintenance: sevoflurane and rocuronium.	Position: lateral Local anesthetics: 25 mL of 0.25% bupivacaine Timing: after the general anesthesia	No block
Er 2021	Thoracic surgery	SAPB: 39 Control: 38	Induction: midazolam 0.5–1.0 mg/kg, sufentanil 0.5–1.0 μg/kg, etomidate 0.2–0.3 mg/kg, and cisatracurium 0.3 mg/kg; Maintenance: propofol and cisatracurium.	Position: lateral Local anesthetics: 15 mL of 0.375% ropivacaine Timing: after the general anesthesia	No block
Goel 2020	Breast surgery	SAPB: 30 Control: 30	Induction: propofol 2 mg/kg, morphine 0.1 mg/kg, and vecuronium 0.1 mg/kg; Maintenance: NR.	Position: NR Local anesthetics: 20 mL of 0.2% ropivacaine Timing: after the general anesthesia	No block
Kim 2018	Thoracic surgery	SAPB: 42 Control: 43	Induction: propofol 1.5–2.0 mg/kg, remifentanil 1 μg/kg, rocuronium 0.9 mg/kg; Maintenance: sevoflurane at a 0.7–1.5 age-adjusted minimal alveolar concentration and remifentanil 0.05–0.2 μg/kg/min.	Position: lateral Local anesthetics: 0.4 mL/kg of 0.375% ropivacaine Timing: after the general anesthesia	Sham block
Liu 2022	Thoracic surgery	SAPB: 30 Control: 30	Induction: midazolam 0.08 mg/kg, sufentanil 0.4 μg/ kg, etomidate 0.3 mg/kg, vecuronium 0.1 mg/kg, Maintenance: propofol 6 mg/kg/h, remifentanil 8 μg/kg/h,	Position: NR Local anesthetics: NR Timing: after the general anesthesia	No block
Mazzinari 2019	Breast surgery	SAPB: 28 Control: 30	Induction: midazolam 0.01–0.03 mg/kg, fentanyl 1 μg/kg, propofol 2 mg/kg, and rocuronium bromide 0.6 mg/kg; Maintenance: propofol.	Position: NR Local anesthetics: 30 mL of 0.25% levobupivacaine Timing: after the general anesthesia	No block

Table 1 (continued). ***Included studies details.***

	Surgery type	Sample size	General anesthesia	SAPB technique	Control group
Ökmen 2018	Thoracic surgery	SAPB: 20 Control: 20	Induction: propofol 2–2.5 mg/kg, fentanyl 1 μg/kg. and rocuronium bromide 0.6 mg/kg; Maintenance: sevoflurane at 1 to 2.5% concentration and flow of 3 L/min air mixture.	Position: supine Local anesthetics: 20 mL of 0.25% bupivacaine Timing: after the general anesthesia	No block
Park 2018	Thoracic surgery	SAPB: 42 Control: 42	Induction: NR; Maintenance: sevoflurane and a remifentanil infusion (0–0.2 μg/kg/min).	Position: lateral Local anesthetics: 15 mL of 0.375% ropivacaine Timing: before the general anesthesia	No block
Qian 2021	Breast surgery	SAPB: 90 Control: 89	Induction: sufentanil 0.5 μg/kg, propofol 2.0 mg/kg, and rocuronium 0.6 mg/kg; Maintenance: sevoflurane.	Position: lateral Local anesthetics: 30 mL of 0.5% ropivacaine Timing: before the general anesthesia	Sham block
Qiu 2021	Thoracic surgery	SAPB: 29 Control: 30	Induction: sufentanil 0.6 μg/kg, propofol set to a plasma concentration of 4 μg/mL, and cisatracurium 0.15 mg/kg; Maintenance: propofol.	Position: lateral Local anesthetics: 30 mL of 0.375% ropivacaine Timing: after the general anesthesia	No block
Saad 2018	Thoracic surgery	SAPB: 30 Control: 30	Induction: fentanyl 1–2 μg/kg, propofol 2–3 mg/kg, and rocuronium 0.5–0.8 mg/kg; Maintenance: sevoflurane 1 minimum alveolar concentration inhalation.	Position: lateral Local anesthetics: 30 mL of 0.5% bupivacaine Timing: after the general anesthesia	No block
Sernyonov 2019	Thoracic surgery	SAPB: 47 Control: 57	Induction: fentanyl 2–3 μg/kg, isoflurane (minimum alveolar concentration 1–2) and rocuronium bromide; Maintenance: NR.	Position: lateral Local anesthetics: 0.25% bupivacaine hydrochloride 2 mg/kg Timing: after the general anesthesia	No block
Shokri 2016	Breast surgery	SAPB: 23 Control: 23	Induction: fentanyl 2 μg/kg, thiopentone sodium 3–5 mg/kg, and atracurium 0.5 mg/kg; Maintenance: isoflurane and atracurium.	Position: supine Local anesthetics: 0.4 mL/kg of 0.25% bupivacaine Timing: before the general anesthesia	Infiltration block
Tang 2021	Breast surgery	SAPB: 43 Control: 44	Induction: dezocine 0.1 mg/kg, midazolam 0.02 mg/ kg, sufentanil 0.4 μg/kg, etomidate 0.3 mg/kg, and cisatracurium 0.2–0.4 mg/kg; Maintenance: propofol 4-6 mg/kg/h.	Position: supine Local anesthetics: 20 mL of 0.5% ropivacaine Timing: after the general anesthesia	No block
Viti 2020	Thoracic surgery	SAPB: 46 Control: 44	Induction: NR; Maintenance: NR.	Position: lateral Local anesthetics: 20 mL of 0.375% ropivacaine Timing: before the general anesthesia.	No block
Wang 2019	Breast surgery	SAPB: 50 Control: 50	Induction: midazolam 0.02 mg/kg, sufentanil 0.4 μg/kg, propofol 2 mg/kg, and cisatracurium 0.2 mg/kg; Maintenance: propofol and remifentanil.	Position: lateral Local anesthetics: 30 mL of 0.3% ropivacaine Timing: after the general anesthesia.	No block
Xiao 2021	Breast surgery	SAPB: 28 Control: 28	Induction: propofol l.5 mg/kg, sufentanil 0.4 μg/kg, rocuronium 0.9 mg/kg; Maintenance: propofol 2.5 mg/kg/h and target-controlled infusion of 1.0–2.0 μg/kg/h remifentanil.	Position: lateral Local anesthetics: 30 mL of 0.33% ropivacaine Timing: before the general anesthesia	No block
Yao 2019	Breast surgery	SAPB: 34 Control: 34	Induction: sufentanil 0.5 μg/kg, propofol 2 mg/kg, and cisatracurium 0.15 mg/kg; Maintenance: sevoflurane.	Position: lateral Local anesthetics: 25 mL of 0.5% ropivacaine Timing: before the general anesthesia	Sham block
Yayik 2019	Breast surgery	SAPB: 24 Control: 24	Induction: fentanyl 1-2 μg/kg, propofol 2 mg/kg, and rocuronium 0.6 mg/kg; Maintenance: sevoflurane 1–2% in a 50:50 mixture of oxygen and N_2O.	Position: lateral Local anesthetics: 20 mL of 0.25% bupivacaine Timing: before the general anesthesia	Sham block

Abbreviation: SAPB, serratus anterior plane block; NR, not reported.

emerged as a new option for postoperative analgesic treatment; it is associated with a decrease in the occurrence of opioid-related adverse effects (61).

Our meta-analysis illustrates that the SAPB group patients exhibited substantially attenuated postsurgical opioid consumption and pain scores, which indicates its effectiveness in controlling pain in patients after thoracic and breast surgery. As an essential component of enhanced recovery after surgery, effective relief of postsurgical pain needs to be addressed. In addition, SAPB was associated with a reduction in the occurrence of PONV, which may underlie the benefits of decreased opioid consumption.

Chronic postsurgical pain represents a frequent and important complication in thoracic and breast surgery. It can occur in 20% to 60% of patients who have thoracic surgery. The pain decreases patients' quality of life, and hampers their activities of daily living (30,34). Our meta-analysis indicates that SAPB could significantly reduce these occurrences. However, the sample size of included studies was small. In addition, the quality of the evidence was low. Further high-quality, larger sample-size clinical trials are required to confirm this result.

The levels of evidence certainty ranged from low to high, which might be the result of these factors: first, continuous data were used for the vast majority of the outcomes, and the trials revealed significant heterogeneity; secondly, opioid consumption and pain levels did not follow normal distributions and need to be converted into corresponding values of mean and standard deviation, so the evidence was indirect. Finally, variations in the choice of medications and the anesthetic were not standardized, which further contributed to the high clinical heterogeneity. Thus, we utilized a random-effects model for this meta-analysis and downgraded the level of certainty on the GRADE scale.

The findings of the current meta-analysis need to be explained taking into account the existing research limitations. First, double-blinding was not performed in some trials; also some assessors were not blinded, which could affect the quality of the included studies. Sec-

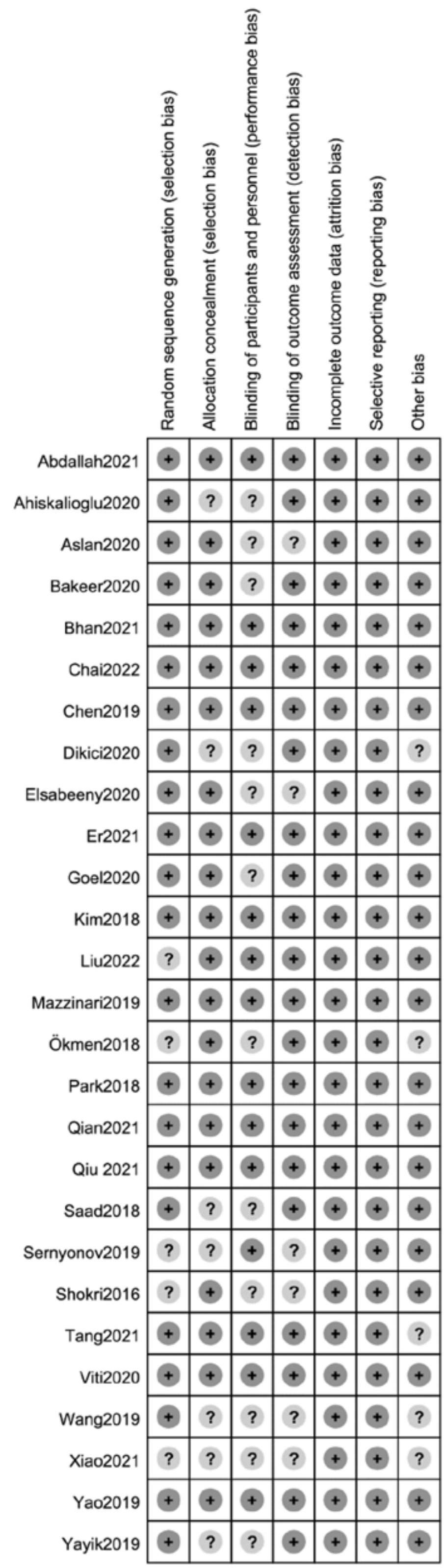

Fig. 2. *Risk of bias assessment of included studies.*

Study or Subgroup	SAPB Mean	SAPB SD	SAPB Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Abdallah2021	42	18	20	45	17.1	20	9.8%	-3.00 [-13.88, 7.88]
Bakeer2020	20.3	5.1	58	46.5	9.3	58	14.1%	-26.20 [-28.93, -23.47]
Dikici2020	0.8	1.9	30	1.5	2.33	30	14.4%	-0.70 [-1.78, 0.38]
Elsabeeny2020	4.02	6.62	25	2.58	5.77	25	13.8%	1.44 [-2.00, 4.88]
Mazzinari2019	50.4	34.2	28	70.07	29.42	30	6.9%	-19.67 [-36.14, -3.20]
Qian2021	29.35	2.26	90	36.35	4.52	89	14.4%	-7.00 [-8.05, -5.95]
Qiu 2021	37.6	6.9	29	48	7.3	30	13.8%	-10.40 [-14.02, -6.78]
Wang2019	86.4	14.1	50	100.8	15.6	50	12.7%	-14.40 [-20.23, -8.57]
Total (95% CI)			**330**			**332**	**100.0%**	**-9.52 [-15.50, -3.54]**

Heterogeneity: Tau² = 64.25; Chi² = 339.87, df = 7 (P < 0.00001); I² = 98%
Test for overall effect: Z = 3.12 (P = 0.002)

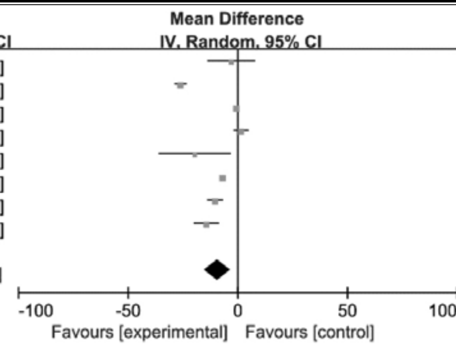

Fig. 3. *Forest plot of pooled analysis showing intraoperative opioid consumption.*

Study or Subgroup	SAPB Mean	SAPB SD	SAPB Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Abdallah2021	12.7	13	20	15	15.7	20	5.4%	-2.30 [-11.23, 6.63]
Ahiskalioglu2020	88.8	17.42	20	111.75	11.89	20	5.4%	-22.95 [-32.19, -13.71]
Aslan2020	28.44	7.41	20	42.69	11.28	20	5.7%	-14.25 [-20.16, -8.34]
Chai2022	78.9	5.7	32	90.6	11.7	33	5.8%	-11.70 [-16.15, -7.25]
Chen2019	435	52	20	440	66	20	2.4%	-5.00 [-41.82, 31.82]
Dikici2020	11	5.9	30	20.9	5.6	30	5.8%	-9.90 [-12.81, -6.99]
Elsabeeny2020	12	4.65	25	27.57	6.96	25	5.8%	-15.57 [-18.85, -12.29]
Er2021	124.4	3.2	39	165.2	6.5	38	5.8%	-40.80 [-43.10, -38.50]
Goel2020	2.31	2.19	30	30.51	8.7	30	5.8%	-28.20 [-31.41, -24.99]
Kim2018	41.8	11.9	42	52	17.9	43	5.6%	-10.20 [-16.65, -3.75]
Mazzinari2019	8.13	4.68	28	15.87	9.33	30	5.8%	-7.74 [-11.50, -3.98]
Ökmen2018	4.36	0.82	20	7.56	0.68	20	5.9%	-3.20 [-3.67, -2.73]
Qian2021	6	3.01	90	29.35	2.26	89	5.9%	-23.35 [-24.13, -22.57]
Qiu 2021	78	71	29	103	68	30	2.5%	-25.00 [-60.49, 10.49]
Sernyonov2019	12.87	5.13	47	20.37	6.03	57	5.8%	-7.50 [-9.65, -5.35]
Shokri2016	25.78	5.73	23	93.34	7.88	23	5.8%	-67.56 [-71.54, -63.58]
Wang2019	57	9	50	84	12	50	5.8%	-27.00 [-31.16, -22.84]
Yao2019	150.3	8.4	34	209.4	21	34	5.5%	-59.10 [-66.70, -51.50]
Yayik2019	37.19	21.61	24	103.79	62.25	24	3.4%	-66.60 [-92.96, -40.24]
Total (95% CI)			**623**			**636**	**100.0%**	**-23.12 [-30.59, -15.65]**

Heterogeneity: Tau² = 247.04; Chi² = 3824.02, df = 18 (P < 0.00001); I² = 100%
Test for overall effect: Z = 6.07 (P < 0.00001)

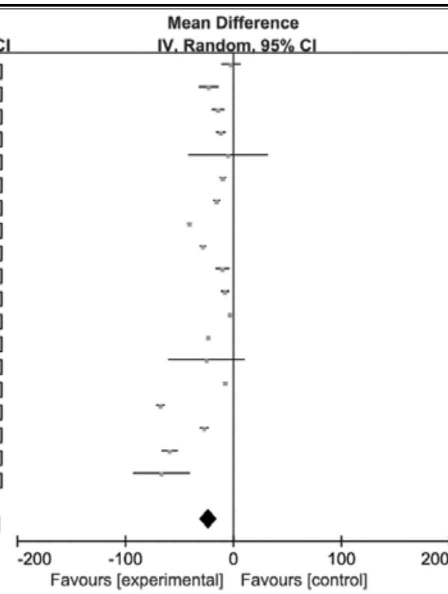

Fig. 4. *Forest plot of pooled analysis showing postoperative opioid consumption.*

ond, although we systematically queried the databases, the included sample sizes of eligible trials which reported the incidence of chronic postsurgical pain were relatively small. Third, although we found that SAPB could provide effective postoperative analgesia in thoracic and breast surgery, the comparisons between SAPB and other types of blocks were not performed in our meta-analysis.

Conclusion

In summary, the findings of this review illustrate that SAPB may be recommended as an analgesic method for reducing postsurgical opioid consumption and pain levels in patients who have undergone thoracic and breast surgery. In addition, SAPB might reduce the incidence of chronic postsurgical pain.

Authorship

All named authors meet the International Committee of Medical Journal Editors (ICMJE) criteria for authorship for this article, take responsibility for the integrity of the work as a whole, and have given their approval for this version to be published.

Compliance with Ethics Guidelines

This article is based on previously conducted studies and does not contain any new studies with human patients or animals performed by any of the authors.

Data Availability

All data relevant to the study are included in the article or uploaded as supplementary information.

Study or Subgroup	SAPB Mean	SAPB SD	SAPB Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
1.3.1 2H								
Abdallah2021	0.1	0.2	20	0.4	0.8	20	10.6%	-0.30 [-0.66, 0.06]
Bhan2021	2.43	0.86	50	2.65	0.71	50	14.6%	-0.22 [-0.53, 0.09]
Chai2022	1.2	0.8	32	3.1	0.8	33	9.2%	-1.90 [-2.29, -1.51]
Chen2019	1.53	0.39	20	3.2	0.96	20	6.7%	-1.67 [-2.12, -1.22]
Dikici2020	3.1	1.6	30	5.5	1.1	30	2.9%	-2.40 [-3.09, -1.71]
Er2021	1.8	0.6	39	3.1	0.7	38	16.4%	-1.30 [-1.59, -1.01]
Ökmen2018	3.1	0.91	20	4.2	1.1	20	3.6%	-1.10 [-1.73, -0.47]
Qiu 2021	0.1	0.3	29	3.2	1.8	30	3.3%	-3.10 [-3.75, -2.45]
Shokri2016	2.72	1.58	23	2.72	1.58	23	1.7%	0.00 [-0.91, 0.91]
Wang2019	2.2	0.7	50	2.9	0.9	50	13.9%	-0.70 [-1.02, -0.38]
Xiao2021	0.59	0.21	28	1.21	0.76	28	16.3%	-0.62 [-0.91, -0.33]
Yayik2019	2.83	1.6	24	5.29	2.64	24	0.9%	-2.46 [-3.70, -1.22]
Subtotal (95% CI)			**365**			**366**	**100.0%**	**-0.99 [-1.11, -0.88]**
Heterogeneity: Chi² = 147.18, df = 11 (P < 0.00001); I² = 93%								
Test for overall effect: Z = 16.52 (P < 0.00001)								
1.3.2 4H								
Bakeer2020	1	1.52	58	3.35	3.8	58	2.3%	-2.35 [-3.40, -1.30]
Chai2022	1.3	0.9	32	3	0.7	33	16.5%	-1.70 [-2.09, -1.31]
Dikici2020	3.3	1.3	30	5.1	1.3	30	5.9%	-1.80 [-2.46, -1.14]
Goel2020	1.22	0.67	30	3.53	0.68	30	21.8%	-2.31 [-2.65, -1.97]
Saad2018	1.36	2.34	30	5.07	5.45	30	0.6%	-3.71 [-5.83, -1.59]
Sernyonov2019	3.04	2.13	47	5.05	2.43	57	3.3%	-2.01 [-2.89, -1.13]
Wang2019	3.3	1	50	3.9	1.2	50	13.6%	-0.60 [-1.03, -0.17]
Xiao2021	2.17	0.45	28	2.93	0.56	28	36.0%	-0.76 [-1.03, -0.49]
Subtotal (95% CI)			**305**			**316**	**100.0%**	**-1.39 [-1.55, -1.23]**
Heterogeneity: Chi² = 75.77, df = 7 (P < 0.00001); I² = 91%								
Test for overall effect: Z = 17.04 (P < 0.00001)								
1.3.3 6H								
Aslan2020	2.35	0.67	20	3.5	0.69	20	12.3%	-1.15 [-1.57, -0.73]
Bakeer2020	2.43	0.86	50	2.65	0.71	50	22.9%	-0.22 [-0.53, 0.09]
Er2021	2.1	0.5	39	4.1	0.5	38	43.8%	-2.00 [-2.22, -1.78]
Kim2018	4.5	1.9	42	6.4	1.6	43	3.9%	-1.90 [-2.65, -1.15]
Ökmen2018	2.75	0.71	20	3.65	1.03	20	7.3%	-0.90 [-1.45, -0.35]
Park2018	4.5	1.9	42	6.1	1.6	42	3.9%	-1.60 [-2.35, -0.85]
Saad2018	1.36	2.33	30	4	3.11	30	1.1%	-2.64 [-4.03, -1.25]
Shokri2016	2.36	0.79	23	8.36	2.37	23	2.1%	-6.00 [-7.02, -4.98]
Tang2021	0	0	43	2.35	0.76	44		Not estimable
Viti2020	1.7	1.8	46	3.5	2.4	44	2.8%	-1.80 [-2.68, -0.92]
Subtotal (95% CI)			**355**			**354**	**100.0%**	**-1.47 [-1.62, -1.33]**
Heterogeneity: Chi² = 171.08, df = 8 (P < 0.00001); I² = 95%								
Test for overall effect: Z = 19.56 (P < 0.00001)								
1.3.4 8H								
Bakeer2020	1.35	2.28	58	3	4.56	58	1.9%	-1.65 [-2.96, -0.34]
Chai2022	1.6	0.9	32	3	0.7	33	21.7%	-1.40 [-1.79, -1.01]
Chen2019	1.94	0.56	20	4.38	1.36	20	8.1%	-2.44 [-3.08, -1.80]
Dikici2020	3.3	1.2	30	5	1	30	10.7%	-1.70 [-2.26, -1.14]
Goel2020	1.35	0.9	30	3.7	0.65	30	21.2%	-2.35 [-2.75, -1.95]
Sernyonov2019	3.32	1.88	47	4.47	2	57	6.0%	-1.15 [-1.90, -0.40]
Wang2019	3.8	1.2	50	4.6	1.3	50	13.9%	-0.80 [-1.29, -0.31]
Xiao2021	4.02	0.82	28	5.08	1.07	28	13.4%	-1.06 [-1.56, -0.56]
Yayik2019	3.04	1.48	24	4.25	2.13	24	3.1%	-1.21 [-2.25, -0.17]
Subtotal (95% CI)			**319**			**330**	**100.0%**	**-1.57 [-1.75, -1.39]**
Heterogeneity: Chi² = 37.90, df = 8 (P < 0.00001); I² = 79%								
Test for overall effect: Z = 16.85 (P < 0.00001)								
1.3.5 12H								
Aslan2020	1.6	0.5	20	1.6	0.6	20	7.8%	0.00 [-0.34, 0.34]
Bakeer2020	1.35	2.28	58	4.06	3.8	58	0.7%	-2.71 [-3.85, -1.57]
Chai2022	2.43	0.86	50	2.65	0.71	50	9.6%	-0.22 [-0.53, 0.09]
Dikici2020	2.4	0.6	32	2.6	0.5	33	12.7%	-0.20 [-0.47, 0.07]
Er2021	3.2	1.2	30	4.3	0.9	30	3.2%	-1.10 [-1.64, -0.56]
Goel2020	2.7	0.6	39	4.5	0.5	38	15.1%	-1.80 [-2.05, -1.55]
Ökmen2018	1.53	0.84	30	3.73	0.79	30	5.4%	-2.20 [-2.61, -1.79]
Park2018	2.3	1.03	20	3.6	0.67	20	3.2%	-1.30 [-1.84, -0.76]
Saad2018	4.5	0.5	42	6	0.61	42	16.2%	-1.50 [-1.74, -1.26]
Sernyonov2019	2.64	2.33	30	2.36	3.89	30	0.3%	0.28 [-1.34, 1.90]
Shokri2016	3.83	2.58	47	4.77	2.32	57	1.0%	-0.94 [-1.89, 0.01]
Tang2021	3.64	0.79	23	6.64	0.53	23	6.1%	-3.00 [-3.39, -2.61]
Viti2020	2.64	0.76	43	2.65	0.76	44	9.0%	-0.01 [-0.33, 0.31]
Wang2019	1.2	1.3	46	2.8	2.4	44	1.4%	-1.60 [-2.40, -0.80]
Xiao2021	3.9	1.3	50	4.6	1.4	50	3.3%	-0.70 [-1.23, -0.17]
Yayik2019	4.41	0.87	28	5.31	0.79	28	4.9%	-0.90 [-1.34, -0.46]
Subtotal (95% CI)			**588**			**597**	**100.0%**	**-1.06 [-1.15, -0.96]**
Heterogeneity: Chi² = 334.22, df = 15 (P < 0.00001); I² = 96%								
Test for overall effect: Z = 21.61 (P < 0.00001)								
1.3.6 24H								
Abdallah2021	2.6	1.9	20	2.6	1.9	20	0.7%	0.00 [-1.18, 1.18]
Bakeer2020	1.35	2.28	58	4.06	3.8	58	0.7%	-2.71 [-3.85, -1.57]
Bhan2021	2.65	0.71	50	2.71	0.65	50	13.4%	-0.06 [-0.33, 0.21]
Chai2022	2.3	0.6	32	2.5	0.6	33	11.2%	-0.20 [-0.49, 0.09]
Dikici2020	3.7	1.2	30	4.2	0.8	30	3.6%	-0.50 [-1.02, 0.02]
Er2021	2.5	0.5	39	3.6	0.4	38	23.4%	-1.10 [-1.30, -0.90]
Goel2020	1.77	0.75	30	3.73	0.79	30	6.3%	-1.96 [-2.35, -1.57]
Ökmen2018	2	0.85	20	3.35	0.93	20	3.1%	-1.35 [-1.90, -0.80]
Park2018	5	1.17	42	6	0.61	42	6.0%	-1.00 [-1.40, -0.60]
Qiu 2021	3.6	1.4	29	4.7	1.6	30	1.6%	-1.10 [-1.87, -0.33]
Saad2018	2.64	3.89	30	2.64	3.89	30	0.2%	0.00 [-1.97, 1.97]
Sernyonov2019	3.53	2.18	47	3.77	1.58	57	1.7%	-0.24 [-0.99, 0.51]
Shokri2016	5.36	0.79	23	5.36	0.79	23	4.6%	0.00 [-0.46, 0.46]
Tang2021	2.35	0.77	43	2.35	0.77	44	9.1%	0.00 [-0.32, 0.32]
Viti2020	1.5	1.6	46	2.7	2.3	44	1.4%	-1.20 [-2.02, -0.38]
Wang2019	3.9	1.5	50	4.9	1.3	50	3.1%	-1.00 [-1.55, -0.45]
Xiao2021	3.51	0.52	28	4.92	0.71	28	9.0%	-1.41 [-1.74, -1.08]
Yayik2019	1.46	1.5	24	3.33	2.06	24	0.9%	-1.87 [-2.89, -0.85]
Subtotal (95% CI)			**641**			**651**	**100.0%**	**-0.76 [-0.86, -0.67]**
Heterogeneity: Chi² = 164.14, df = 17 (P < 0.00001); I² = 90%								
Test for overall effect: Z = 15.34 (P < 0.00001)								

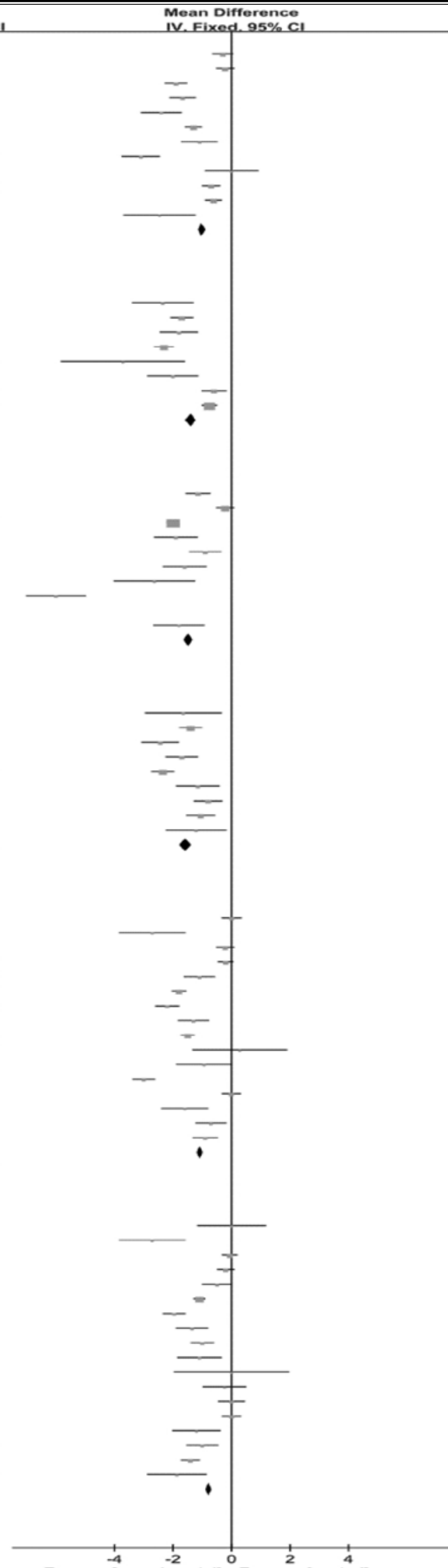

Fig. 5. *Forest plot of pooled analysis showing postoperative pain scores.*

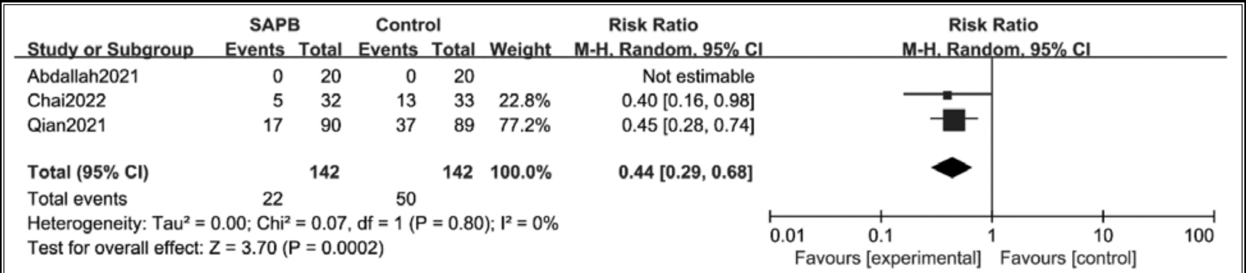

Fig. 6. *Forest plot of pooled analysis showing the incidence of chronic postsurgical pain.*

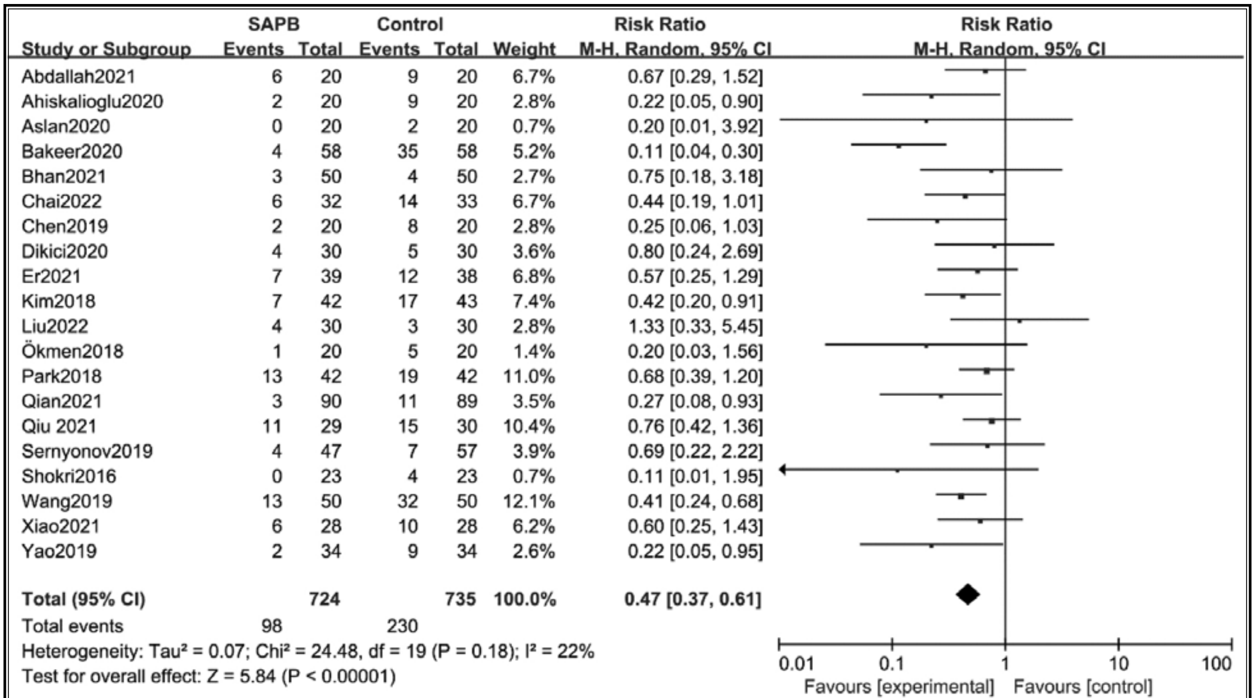

Fig. 7. *Forest plot of pooled analysis showing the incidence of complications.*

Table 2. *GRADE evaluation.*

Outcome	MD/RR (95%CI)	Level of certainty	Reasons
Intraoperative opioid consumption	-6.27 (-8.01 to -4.53)	⊕⊕○○ LOW	Indirectness was "serious" Inconsistency was "serious"
Postoperative opioid consumption	-1.20 (-1.63 to -0.77)	⊕⊕○○ LOW	Indirectness was "serious" Inconsistency was "serious"
Postoperative pain score			
2 h postoperative	-0.86 (-1.03 to -0.70)	⊕⊕⊕○ MODERATE	Indirectness was "serious"
4 h postoperative	-0.47 (-0.87 to -0.07)	⊕⊕○○ LOW	Indirectness was "serious" Inconsistency was "serious"
6 h postoperative	0.48 (0.30 - 0.77)	⊕⊕⊕⊕ HIGH	None
8 h postoperative	0.49 (0.27 - 0.89)	⊕⊕⊕⊕ HIGH	None
12 h postoperative	-8.63 (-14.08 to -3.19)	⊕⊕○○ LOW	Indirectness was "serious" Inconsistency was "serious"
24 h postoperative	-0.42 (-0.72 to -0.13)	⊕⊕○○ LOW	Indirectness was "serious" Inconsistency was "serious"
Chronic postsurgical pain	-0.47 (-0.55 to -0.39)	⊕⊕⊕○ MODERATE	Indirectness was "serious"
Incidence of PONV	0.70 (0.30 - 1.64)	⊕⊕⊕⊕ HIGH	None

MD, mean difference; RR, risk ratio; h, hours; PONV, postoperative nausea and vomiting.

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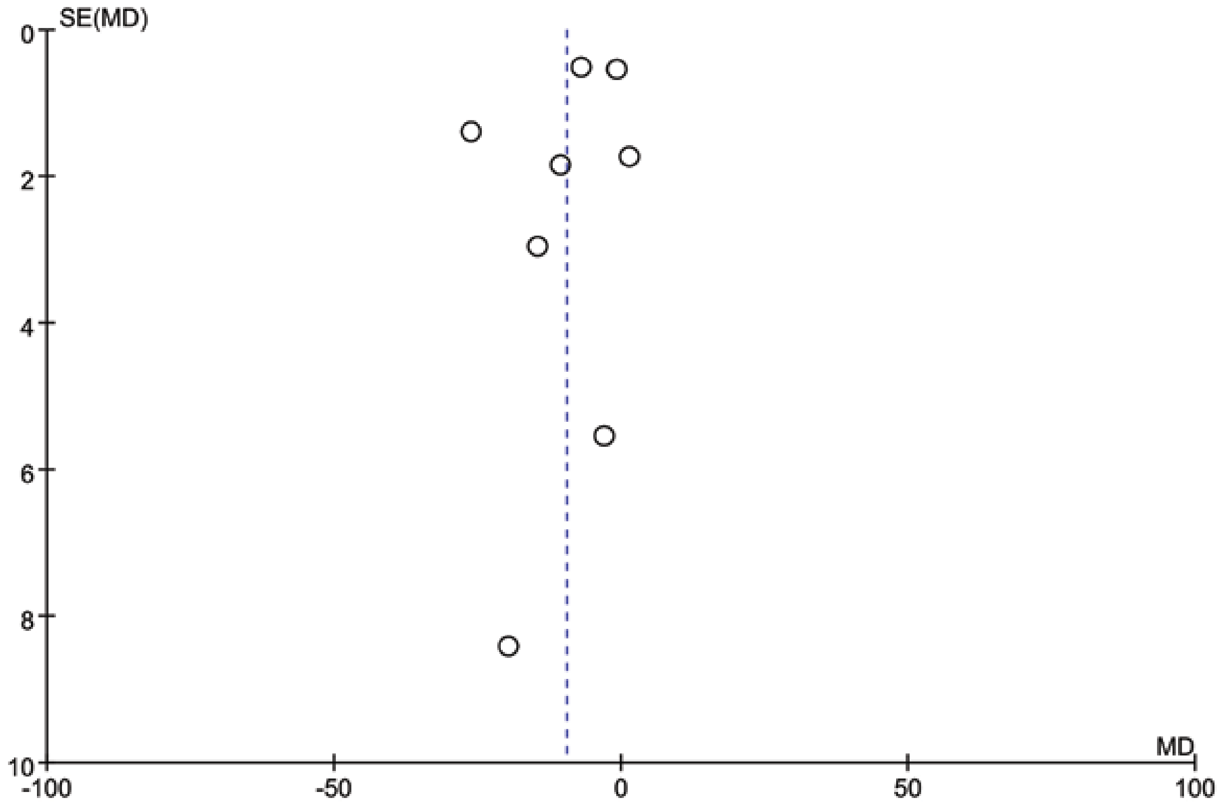
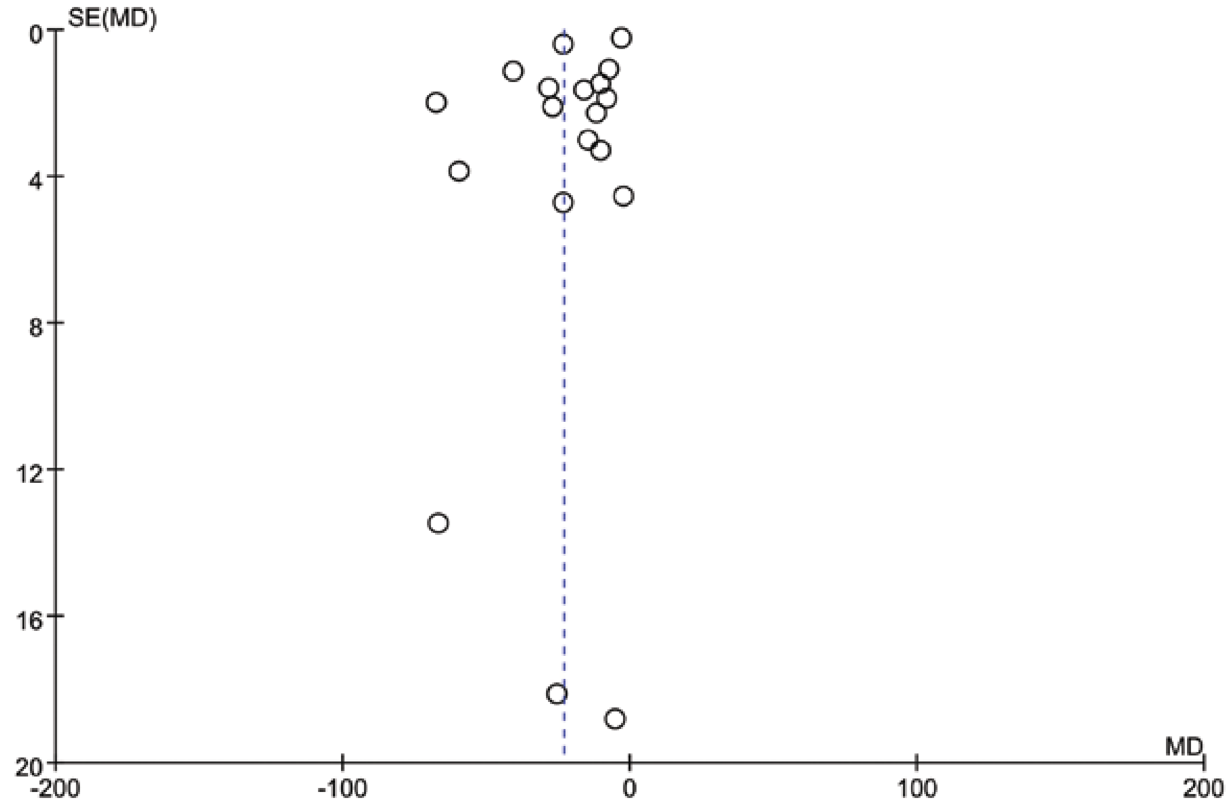


Supplementary Fig. 1. *The funnel plot for intraoperative opioid consumption*.



Supplementary Fig. 2. *The funnel plot for postoperative opioid consumption*.

Supplementary digital. *The full description of search techniques for databases.*

PUBMED

(("serratus"[All Fields] AND ("anterior"[All Fields] OR "anteriores"[All Fields] OR "anteriorization"[All Fields] OR "anteriorized"[All Fields] OR "anteriors"[All Fields]) AND ("aircraft"[MeSH Terms] OR "aircraft"[All Fields] OR "plane"[All Fields] OR "planes"[All Fields]) AND ("block"[All Fields] OR "blocked"[All Fields] OR "blocking"[All Fields] OR "blockings"[All Fields] OR "blocks"[All Fields])) OR ("SAP"[All Fields] AND ("block"[All Fields] OR "blocked"[All Fields] OR "blocking"[All Fields] OR "blockings"[All Fields] OR "blocks"[All Fields])) OR "SAPB"[All Fields]) AND ("thoracic surgical procedures"[MeSH Terms] OR ("thoracic"[All Fields] AND "surgical"[All Fields] AND "procedures"[All Fields]) OR "thoracic surgical procedures"[All Fields] OR ("thoracic"[All Fields] AND "surgery"[All Fields]) OR "thoracic surgery"[All Fields] OR "thoracic surgery"[MeSH Terms] OR ("thoracic"[All Fields] AND "surgery"[All Fields]) OR ("thoracoscopy"[MeSH Terms] OR "thoracoscopy"[All Fields] OR ("thoracoscopic"[All Fields] AND "surgery"[All Fields]) OR "thoracoscopic surgery"[All Fields]) OR ("thoracotomy"[MeSH Terms] OR "thoracotomy"[All Fields] OR "thoracotomies"[All Fields]) OR ("mastectomy, modified radical"[MeSH Terms] OR ("mastectomy"[All Fields] AND "modified"[All Fields] AND "radical"[All Fields]) OR "modified radical mastectomy"[All Fields] OR ("modified"[All Fields] AND "radical"[All Fields] AND "mastectomy"[All Fields])) OR ("mastectomy"[MeSH Terms] OR "mastectomy"[All Fields] OR "mastectomies"[All Fields] OR "mastectomy, simple"[MeSH Terms] OR ("mastectomy"[All Fields] AND "simple"[All Fields]) OR "simple mastectomy"[All Fields]) OR (("breast"[MeSH Terms] OR "breast"[All Fields] OR "breasts"[All Fields] OR "breast s"[All Fields]) AND ("surgery"[MeSH Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields]) OR "operative surgical procedures"[All Fields] OR "general surgery"[MeSH Terms] OR ("general"[All Fields] AND "surgery"[All Fields]) OR "general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgerys"[All Fields] OR "surgeries"[All Fields])))

EMBASE

#1 'serratus anterior plane block'/exp OR 'serratus anterior plane block' OR (serratus AND anterior AND plane AND block)

#2 'sap block' OR (sap AND block)

#3 sapb

#4 #1 OR #2 OR #3

#5 'thoracic surgery'/exp OR 'thoracic surgery' OR (thoracic AND ('surgery'/exp OR surgery))

#6 'thoracoscopic surgery'/exp OR 'thoracoscopic surgery' OR (thoracoscopic AND ('surgery'/exp OR surgery))

#7 'thoracotomy'/exp OR thoracotomy

#8 'modified radical mastectomy'/exp OR 'modified radical mastectomy' OR (modified AND ('radical'/exp OR radical) AND ('mastectomy'/exp OR mastectomy))

#9 'mastectomy'/exp OR mastectomy

#10 breast AND surgery

#11 #5 OR #6 OR #7 OR #8 OR #9 OR #10

#12 #4 AND #11

Web of science

#1 ALL=(serratus anterior plane block) OR ALL=(SAP block) OR ALL=(SAPB)

#2 ALL=(thoracic surgery) OR ALL=(thoracoscopic surgery) OR ALL=(thoracotomy) OR ALL=(modified radical mastectomy) OR ALL=(mastectomy) AND ALL=(breast surgery)

#3= #1 AND #2

Cochrane library

#1 (serratus anterior plane block) OR (SAP block) OR (SAPB) (Word variations have been searched)

#2 (thoracic surgery) OR (thoracoscopic surgery) OR (modified radical mastectomy) OR (mastectomy) OR (breast surgery) (Word variations have been searched) 26705

#3 #1 AND #2