Meta-Analysis

Erector Spinae Plane Block Similar to Paravertebral Block for Perioperative Pain Control in Breast Surgery: A Meta-Analysis Study

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Background: Erector spinae plane block could be a potential alternative to paravertebral block or other analgesic techniques for breast surgery, but the current evidence on erector spinae plane block in breast surgery is conflicting.

Objective: To compare the analgesic effectiveness between erector spinae plane block, systemic analgesic, and paravertebral block for breast surgery.

Study Design: Meta-analysis.

Setting: The literature search was performed from 2016 to August 2020 using the MEDLINE, EMBASE, Cochrane library, and ClinicalTrials.gov databases.

Methods: Clinical trials comparing erector spinae plane block to systemic analgesic and paravertebral block were included from the aforementioned databases. Primary outcomes were 24-hour postoperative opioid administration and postoperative pain score. Secondary outcomes were patient satisfaction levels, post-anesthesia care unit and hospital stay, block-related side effects, and opioid-related side effects. Systematic search, critical appraisal, and pooled analysis were performed according to the PRISMA statement.

Results: We analyzed 495 cases in 8 randomized controlled trials. Compared with a systemic analgesic, the use of erector spinae plane block resulted in a reduced 24-hour postoperative intravenous morphine equivalent dose by a mean difference of 7.59 mg ($P < 0.00001$). Compared with paravertebral block, no statistical difference was found in opioid administration. No differences were observed in pain score, opioid-related side effects, or analgesic technique-related complications. Between the trials, heterogeneity existed and could not be evaluated using meta-regression owing to inadequate reported data.

Limitations: Moderate heterogeneity among the included trials could not be assessed by potential covariates owing to the limited reported data in each trial.

Conclusion: Erector spinae plane block is superior to systemic analgesic within 24 hours after breast surgery and can serve as an alternative to paravertebral block with similar analgesic effects.

Key words: Erector spinae plane block, paravertebral block, breast surgery, perioperative analgesia, randomized controlled trial, meta-analysis

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Breast cancer has a high incidence and prevalence worldwide (1) with a high proportion of affected women undergoing breast surgery (2,3). The postoperative pain of breast surgery is difficult to manage owing to the complexity of the surgery and nerve innervation (4) and deserves to be minimized for better functional outcomes and a reduced hospital stays (5,6).

Thoracic paravertebral block (PVB) is considered the gold standard for managing breast surgical pain (7,8). However, its invasiveness and potential complications such as pleural penetrating and pneumothorax hinder its use (9).

Erector spinae plane block (ESPB) is a myofascial plane block first described in 2016 by Forero et al (10). Clinical studies on analgesia in breast surgery have been conducted in recent years (4,11), and ESPB was considered an alternative to PVB owing to its less invasiveness and possible wider spreading of local anesthetics (10).

Existing evidence has suggested modest effectiveness of ESPB when compared with systemic analgesics alone in breast surgery (12-19), whereas controversial results have been reported when compared with PVB (13,20-22). Previous systematic reviews and meta-analyses reported the efficacy of ESPB in some specific surgery (23-26), but trials of surgeries other than breast surgery were included in these meta-analyses. To differentiate these equivocal results from clinical trials with small sample sizes, a comprehensive investigation is needed.

Objectives

This study was a meta-analysis to identify the clinical efficacy of ESPB in adult women undergoing breast surgery. Its purpose was to quantify ESPB's analgesic benefits by comparison with a systemic analgesic alone and PVB. The primary outcomes were 24-hour postoperative equivalent opioid administration and postoperative pain scores at specific time intervals. The secondary outcomes were patient satisfaction levels, post-anesthesia care unit (PACU) and hospital stay, block-related side effects, and opioid-related side effects.

Methods

Protocol and Registration

We followed the guideline of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Data on randomized control trials of ESPB as an analgesic technique for patients undergoing breast surgeries were collected. A specified protocol was designed for the process of systematic review and meta-analysis, but the protocol was not registered.

Eligibility Criteria

Randomized control trials comparing ESPB with systemic analgesia and PVB in patients undergoing breast surgery were included. The minimum patient age was 18 years. Breast surgeries included elective simple mastectomy, lumpectomy, and modified radical mastectomy with or without axillary lymph nodes dissection except for emergent surgery or cosmetic mammoplasty owing to variable surgical techniques. No language restriction was applied to study inclusion.

Information Sources and Search Strategy

A systematic search strategy was applied to the search process. MEDLINE, EMBASE, Cochrane Database of Systematic Reviews, and ClinicalTrials.gov were searched from September 2016, first ESPB description by Forero et al (10), to August 2020. The search used pre-specified medical subject headings and key words. The key words were ESPB, erector spinae, nerve block, breast surgery, breast, mastectomy, lumpectomy, postoperative pain, pain control, and postoperative analgesia.

Study Selection

Types of the article searched were not restricted to randomized control trials for risk of missing studies. All selected databases were systematically searched. The citations and related studies of eligible articles were also reviewed to identify relevant trials. The clinical trial registry at ClinicalTrials.gov was reviewed for potentially relevant ongoing or completed studies.

Data Collection Process and Data Items

Data were extracted from articles' context, figures, tables, flow diagram, and supplement sections of the selected trials. If data could not be found in the published text, additional supplements or appendices were searched. Data collected included the year of publication, patient number, intervention and comparison, average age, technique and assessment of success, postoperative analgesic administration, interval postoperative pain scores, level of patient satisfaction, PACU and hospital stay, block-related-side effects, and opioid-related side effects.

Risk of Bias in Individual Studies

The methodological quality of the included studies was assessed using the Cochrane Collaboration tool for risk of bias assessment (27). The tool included 5 domains and an overall result to evaluate the risk of bias of each trial. The 5 domains were randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and

selection of the reported result. Three risk levels in the 5 domains and overall result were rated, low, some concern, and high. Two independent investigators would assess the risk of bias of all selected trials before data extraction, and the unweighted kappa was calculated to evaluate the inter-rater reliability of the 2 independent investigators using the SPSS software (version 20; SPSS Inc.). If there was a disagreement between the 2 reviewers, a discussion on the eligibility of the studies would take place.

Summary Measures

The 2 primary outcomes were the 24-hour cumulative postoperative administration of the equivalent intravenous morphine dose and difference in the area under the curve of weighted pain score at the first, sixth, twelfth, and twenty-fourth hour. The measurement of the area under the curve for pain assessment originated from a previous meta-analysis (28), which conducted a systematic review of pectoralis myofascial plane II block with another analgesic strategy. The area under the curve analysis presented both the severity and duration of postoperative pain. The secondary outcomes were patient satisfaction level; PACU and hospital stay; block-related side effects including hematoma, injection pain, pneumothorax, and local anesthetic systemic toxicity (LAST); and opioid-related side effects including respiratory depression, sedation, pruritus, constipation, or urinary retention, nausea, and vomiting. Postoperative surgical pain assessment included the visual analog scale, numeric rating scale, and verbal rating scale scores (29-31). For data synthesis, all pain scores were converted to the equivalent visual analog scale score of 0 – 10 cm (29). All opioid doses were converted to equivalent intravenous morphine doses (mg) for synthesis and comparison (32,33).

For continuous outcomes, the mean and standard deviation (SD) were extracted. If the mean and SD were absent, the median and interquartile range were used to estimate the mean and SD. The mean and 95% confidence interval were used to estimate the SD if not present in the reported data. For dichotomous outcomes, data were converted to incidence. If data from 3 or more studies were available, studies were pooled. If the data reported on less than 3 studies, evidence was qualitatively summarized.

Synthesis of Results

Continuous data were pooled using the inverse variance method with the random-effects model and dichotomous data were pooled using the random-effects Mantel–Haenszel model. We calculated the 99% confidence intervals of mean differences and odds ratios, and $P < 0.01$ was designated as the threshold of statistical significance to reduce the risk of type I error. I^2 statistics were calculated for all pooled outcome variables to evaluate heterogeneity. Significant heterogeneity was demonstrated if $I^2 > 50\%$. If significant heterogeneity was detected, a meta-regression analysis using the mixed-effect model was conducted to identify any clinical predictors of treatment effects. R2 values were calculated to quantify the extent of the covariates explaining the variability of results of the pooled studies. The following covariates were considered for meta-regression analysis: surgery invasiveness (with or without axillary dissection), surgery duration, the dose of local anesthetics for nerve block, localization for the technique of nerve blocks, and adjuvant therapy or medication for nerve block or pain. Meta-regression analysis was performed only when the covariates were extracted from more than 3 studies.

Risk of Bias across Studies

The risk of publication bias was assessed by visual inspection of the funnel plot. An inverted and symmetrically shaped funnel was considered low risk (34). If the pooled studies for each outcome were < 10, the Egger's regression test was conducted (35).

Forest trees and publication bias graphs were created and evaluated using the Review Manager Software (RevMan version 5.3; Nordic Cochrane Center, Cochrane Collaboration). Comprehensive Meta-Analysis 3.0 was used for additional meta-regression. Inter-rater reliability between reviewers for trials eligibility was assessed using unweighted kappa and calculated using the SPSS software (version 20; SPSS Inc.).

Results

Study Selection

After conducting the systematic search strategy, 347 studies related to ESPB and breast surgery were identified. Two hundred and seventy-one studies remained after excluding duplicates. Only 18 randomized control trials were extracted, 7 of which were excluded. In the 7 excluded studies, 3 compared the efficacy of ESPB with pectoralis myofascial plane block (36-38), one compared the efficacy of ESPB with Tumescent anesthesia (39), one investigated the effect of different local anesthetic concentrations (40), one clarified

the simplicity of nerve block techniques (41), and the population studied in the last excluded trial comprised patients undergoing breast/thoracic surgery (42). The study flow diagram is shown in Fig. 1.
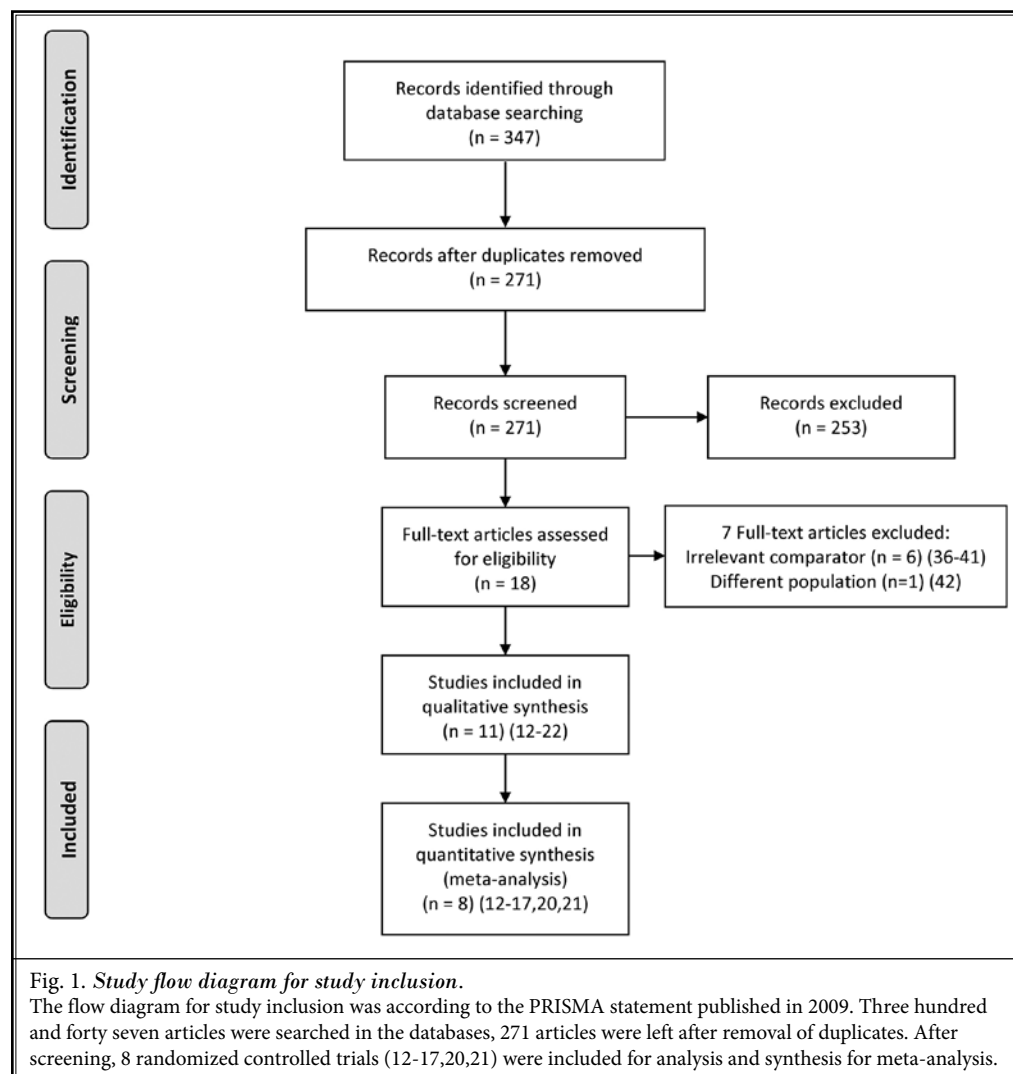
Study Characteristics

The characteristics of the included studies are presented in Table 1. Surgical procedures performed in these studies included mammoplasty (22), modified radical mastectomy (12-21), simple mastectomy, and lumpectomy (12-14,22) with or without additional axillary sentinel lymph nodes dissection (12-14,21). The 11 randomized control trials involved 837 patients, of which 392 received ESPB before surgery, 133 received PVBs, and the remaining 235 received general anesthe-

sia alone (control group). Of these 11 studies, 8 compared ESPB with general anesthesia alone (12-19) and 4 with PVB (13,20-22) The included patients were all ASA I or II, and none of them had chronic pain, long-term opioid use, secondary surgery, or contraindication to regional analgesia.

All included studies reported cumulative 24-hour opioid administration but reported pain severity as a visual analog scale score or numeric analog scale score at different time intervals. Opioid-related side effects such as postoperative nausea and vomiting (PONV) were reported in 10 studies (12-18,20,22). Complications of regional analgesics were reported in 7 studies, and only 4 cases with pneumothorax were recorded in the PVB group (12,14,16,17,21). Two studies mentioned the time in the PACU and the time to hospital discharge (17,22), and only 2 studies reported patients' satisfaction (16,17).

The techniques of regional analgesia and block related regimen, dosage, and injected level of vertebrae are shown in Table 2. All 11 studies cited ESPB as described by Forero et al (10). The procedures of regional analgesia were all performed preoperatively with 20 ~ 30 mL of 0.2 ~ 0.5% bupivacaine or ropivacaine at the level of T2 to T5 under ultrasonography, but one study performed the procedure with articaine (21). No adjuvant agent was added in the

Fig. 1. *Study flow diagram for study inclusion.*
The flow diagram for study inclusion was according to the PRISMA statement published in 2009. Three hundred and forty seven articles were searched in the databases, 271 articles were left after removal of duplicates. After screening, 8 randomized controlled trials (12-17,20,21) were included for analysis and synthesis for meta-analysis.

Table 1. *Characteristics of included trials.*

No.	Author/Year	Surgery	n	Groups (n)	Surgical anesthesia	Primary outcome	Time of nerve block
1	Gurkan et al/2018 (14)	Elective breast cancer surgery	50	1.ESPB+GA (25) 2.GA (25)	GA	Time period NRS Morphine consumption	Before surgery
2	Aksu et al/2019 (12)	Elective breast surgery	50	1.ESPB+GA (25) 2.GA (25)	GA	Time period NRS Morphine consumption	Before surgery
3	Eldemrdash et al/2019 (21)	MRM with axillary dissection	75	1.ESPB+GA (23) 2.PVB+GA (23) 3.SAP+GA (24)	GA	Time period VAS 24hr morphine	Before surgery
4	Ghamry et al/2019 (20)	Unilateral MRM	70	1.PVB+GA (35) 2.ESPB+GA (35)	GA	24hrs VAS	Before surgery
5	Singh et al/2019 (16)	MRM	40	1.ESPB+GA (20) 2.GA (20)	GA	24hrs morphine dose	Before surgery
6	Gurkan et al/2020 (13)	Elective unilateral breast surgery	75	1.ESPB+GA (25) 2.PVB+GA (25) 3.GA (25)	GA	Time period NRS Morphine consumption	Before surgery
7	He et al/2020 (18)	Unilateral mastectomy with or without axillary dissection	40	1. ESPB+GA (20) 2. GA (20)	GA	Time period VAS	Before surgery
8	Seelam et al/2020 (19)	Unilateral MRM	100	1. ESPB+GA (250 2. GA (50)	GA	24hr morphine	Before surgery
9	Sharma et al/2020 (15)	Unilateral mastectomy	60	1.ESPB+GA (30) 2.GA (30)	GA	Time period VAS 24hr morphine	Before surgery
10	Swisher et al/2020 (22)	Non-mastectomy breast surgery	100	1.ESPB+GA (50) 2.PVB+GA (50)	GA	PACU+ surgical opioid NRS at PACU	Before surgery
11	Yao et al/2020 (17)	MRM	79	1.ESPB+GA (39) 2.GA (40)	GA	QoR questionnaire	Before surgery

ESPB: erector spinae plane block, GA: general anesthesia, NRS/VAS: numerical rating scale/visual analogue scale, MRM: modified radical mastectomy, Pecs II: pectoralis II plane block, PVB: paravertebral block, SAP: serratus anterior plane block, PACU: post-anesthetic care unit

Table 2. *Techniques and local anesthetic regimen for erecter spinae plane block and paravertebral block of the included trials.*

No.	Author/Year	Pre-incisional analgesia	Surgical analgesia	Aduvant analgesia	Nerve block			
					Localization	Level of block*	LA injectants	Assessment
1	Gurkan et al/2018 (14)	Fentanyl 2mcg/kg	N/S	Tramadol 100mg Paracetamol 1g	USG	uni T4	20mL 0.25% bupivacaine	Visual confirm under USG
2	Aksu et al/2019 (12)	Fentanyl 2mcg/kg	N/S	Tramadol 100mg Paracetamol 1g	USG	bi T2~4	20mL 0.25% bupivacaine	Visual confirm under USG
3	Ghamry et al/2019 (20)	Fentanyl 1mcg/kg	Fentanyl 1mcg/kg bolus	N/S	USG	uni T5	20mL 0.25% bupivacaine	Pinprick test 20min after block
4	Eldemrdash et al/2019 (21)	Fentanyl 2mcg/kg	N/S	Paracetamol 1g	USG	T4 or 5	20mL 2% articaine+epi.	Visual confirm under USG
5	Singh et al/2019 (16)	Morphine 0.1mg/kg	N/S	Diclofenac 1.5mg/kg q8h	USG	T5	20mL 0.25% bupivacaine	Pin prick test till 30min
6	Gurkan et al/2020 (13)	Fentanyl 2mcg/kg	N/S	Tramadol 100mg Paracetamol 1g	USG	uni. T4	20mL 0.25% bupivacaine	Visual confirm under USG
7	He et al/2020 (18)	NA	NA	Flurbiprofen 50mg	USG	T3	20mL of 0.5% ropivacaine	NA
8	Seelam et al/2020 (19)	Fentanyl 1.5mcg/kg	Fentanyl 0.5mcg/kg bolus	Paracetamol 1g	USG	T4	30mL 0.25% bupivacaine	Visual confirm under USG
9	Sharma et al/2020 (15)	Fentanyl 1mcg/kg	Fentanyl 0.5mcg/kg bolus	Diclofenac 1.5mg/kg	USG	T5	0.4mL/kg 0.5%ropivacaine	Pin prick test till 30 min
10	Swisher et al/2020 (22)	Fentanyl	Fentanyl	Acetaminophen	USG	T2~T5	20mL 0.5% ropivacaine	Cold sensation till 30 min
11	Yao et al/2020 (17)	Sufentanil 0.5mcg/kg	N/S	Flurbiprofen 50mg per 8 hours	USG	T4	25mL 0.5% ropivacaine	Visual confirm under USG

*level of block: local anesthetics injection at the level of spine, T: thoracic, LA: local anesthetics, N/S: not specified, USG: ultrasonography, epi: epinephrine

local anesthetics. Four studies confirmed the success of regional analgesia using the pinprick test or loss of cold sensation (15,16,20,22). Data of perioperative opioid use and pain scales at different time points were collected (Supplementary Table 1 and 2), but one study (22) was excluded due to the different outcome measurement.

Risk of Bias within Studies

Figure 2 shows the risk of bias assessment of the 9 individual studies. One study was assessed as low risk overall (16), 7 studies were assessed as showing some concerns (12,14-17,20-22), whereas the other 2 were assessed as with high risk of bias (18,19). Only one study (19) did not present adequate information about the randomization process and was rated high risk. In the domain of deviations from intended interventions, one study was assessed as low risk (16), one was assessed as high risk (18), whereas some studies did not blind the participants to the intervention (12-14,16,20,21), and some studies did not blind those delivering the intervention (12-17,20-22). In the domain of missing outcome data, outcome measurement, and selection of the reported result, the assessed ratings were all low risk. Patient loss was not reported in these 11 studies. Two trials (18,19) were not incorporated into the calculation of meta-analyses owing to high risks of bias. The unweighted kappa for agreement on full text eligibility between the 2 independent reviewers was 0.67. The discussion of eligibility was initiated for 4 studies.

Results of Individual Studies and Synthesis of Results (Supplementary Tables 1 and 2)

ESPB versus Control

The patients of the 6 studies (12-17) pooled as groups receiving ESPB versus control were 164 versus 165. All 6 studies reported 24-hour cumulative opioid dose administration. Analysis of these data showed a significantly lower administration of intravenous morphine equivalent dose by a mean difference (95% confidence interval) of 7.59 mg (4.29 ~ 10.89), ($P < 0.00001$, $I^2 = 94\%$) overall in the ESPB group than in the control group (Fig. 3). This outcome was characterized by high heterogeneity; however, the risk of publication bias was low with $P < 0.05$ in the Egger's regression test.

For analyzing the outcome of pain scores, 250 patients were pooled (ESPB 125, control 125). The mean differences (95% confidence interval) of pain scores between the 2 groups were -1.02 (-1.80 ~ -0.24), -0.88 (-1.75 ~ -0.01), -0.57 (-1.00, -0.13), and -0.24 (-1.06, 0.58) at the first, sixth, twelfth, and twenty-fourth hours (Fig. 4).

Three hundred and twenty-nine patients were pooled for the PONV outcome (ESPB 164, control 165). Patients who received ESPB had less
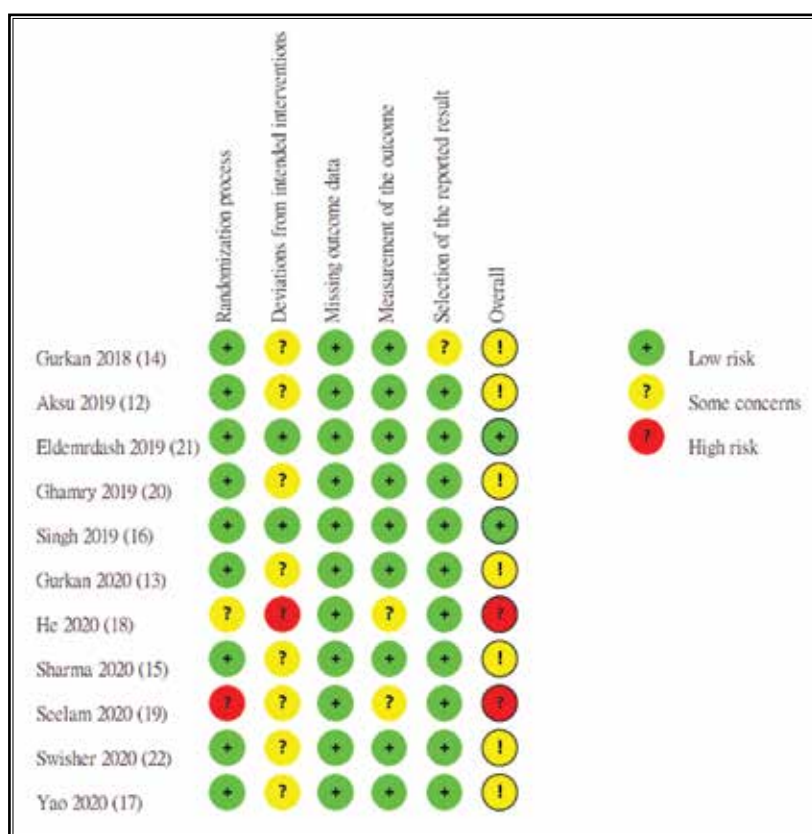

Fig. 2. *Cochrane risk of bias assessment of randomized control trial for each individual study.*
The risk of bias assessment was according to the Cochrane Collaboration's tool for assessing risk of bias in randomized trials published on BMJ in 2011. The assessment was conducted by 2 independent assessors. In the 11 trials, 2 trials were rated as low risk (16,21), 2 trials were rated as high risk (18,19), and the remaining 7 trials were rated as some concern (12-15,17,20,22).
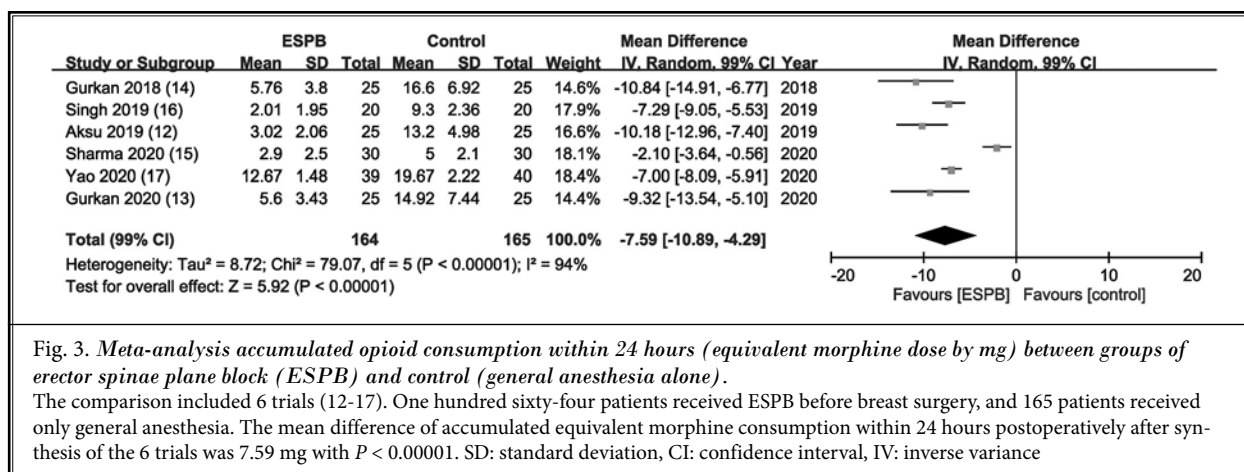
Fig. 3. *Meta-analysis accumulated opioid consumption within 24 hours (equivalent morphine dose by mg) between groups of erector spinae plane block (ESPB) and control (general anesthesia alone).*
The comparison included 6 trials (12-17). One hundred sixty-four patients received ESPB before breast surgery, and 165 patients received only general anesthesia. The mean difference of accumulated equivalent morphine consumption within 24 hours postoperatively after synthesis of the 6 trials was 7.59 mg with *P* < 0.00001. SD: standard deviation, CI: confidence interval, IV: inverse variance

PONV events with an odds ratio (99% confidence interval) of 0.5 (0.25 ~ 1.02) and a low level of publication bias (Egger's test, *P* < 0.05). No study in the 2 groups reported on complications related to the performance of regional analgesia.

ESPB versus PVB

For the comparison of ESPB versus PVB, 83 versus 83 patients were pooled from 3 studies (13,20,21). The administration of equivalent intravenous morphine dose was not different between the 2 groups, with a mean difference (95% confidence interval) of 1.05 mg (-2.55 ~ 0.46) (*P* = 0.14, I^2 = 50%) (Fig. 5). This outcome was characterized by moderate heterogeneity; however, the risk of publication bias was low with *P* = 0.57619 in the Egger's regression test.

For analyzing the outcome of pain scores, 166 patients (ESPB 83, PVB 83) were included for pooling at each time interval (first, sixth, twelfth, and twenty-fourth hour). The mean differences between the 2 groups were calculated and found to be not statistically significant (Fig. 6).

Only 2 studies in these groups reported PONV events, and therefore a meta-analysis could not be performed. The 2 studies reported opposing results of postoperative events, though no significance between the 2 groups was observed. In the pooled data, only 4 patients developed pneumothorax after receiving PVBs.

Meta-regression

In the 6 trials (12-17) comparing ESPB with control and 3 trials (13,20,21) comparing ESPB with PVB, a meta-regression could not be conducted owing to inadequately reported data of pre-specified covariates.
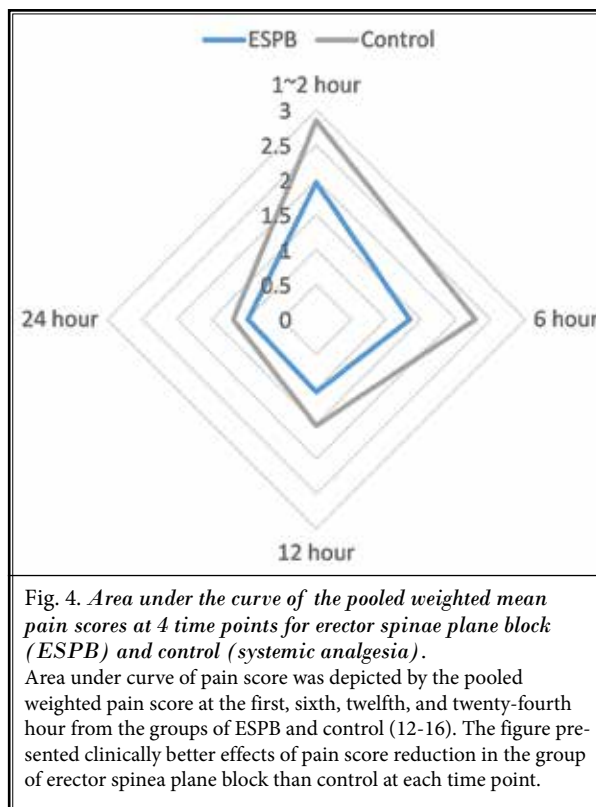

Fig. 4. *Area under the curve of the pooled weighted mean pain scores at 4 time points for erector spinae plane block (ESPB) and control (systemic analgesia).*
Area under curve of pain score was depicted by the pooled weighted pain score at the first, sixth, twelfth, and twenty-fourth hour from the groups of ESPB and control (12-16). The figure presented clinically better effects of pain score reduction in the group of erector spinea plane block than control at each time point.

The pooled data of individual trials could not be differentiated whether the patients underwent axillary dissection or not. Only one trial (17) used 25 mL of local anesthetics for nerve block, whereas others used 20 mL. All trials localized the injection target under ultrasonography. In the covariate of adjuvant therapy or medication for nerve block or pain, 6 trials comprising the ESPB group versus general anesthesia alone
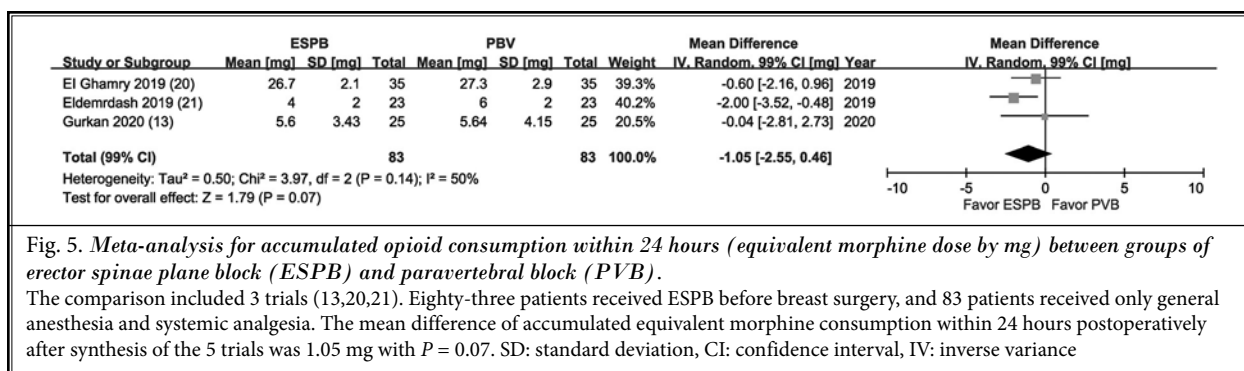
Fig. 5. *Meta-analysis for accumulated opioid consumption within 24 hours (equivalent morphine dose by mg) between groups of erector spinae plane block (ESPB) and paravertebral block (PVB).*
The comparison included 3 trials (13,20,21). Eighty-three patients received ESPB before breast surgery, and 83 patients received only general anesthesia and systemic analgesia. The mean difference of accumulated equivalent morphine consumption within 24 hours postoperatively after synthesis of the 5 trials was 1.05 mg with *P* = 0.07. SD: standard deviation, CI: confidence interval, IV: inverse variance
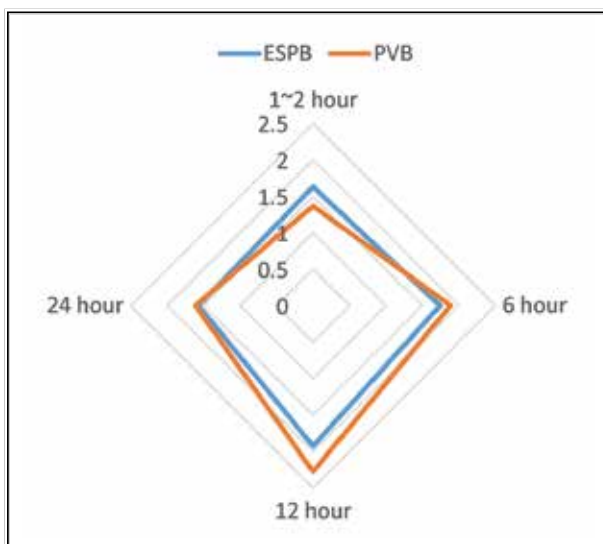

Fig. 6. *Area under the curve of the pooled weighted mean pain scores at 4 time points for erector spinae plane block (ESPB) and paravertebral block (PVB)*
Area under curve of pain score was depicted by the pooled weighted pain score at 1st, 6th, 12th, 24th hour from the groups of ESPB and PVB. (13,20,21) The figure presented no significant difference between the groups of ESPB and PVB clinically.

group administered patients an additional adjuvant paracetamol or non-steroidal anti-inflammatory drug. In the comparison of ESPB versus PVB, only one trial (13) of the 3 administered paracetamol as well. Other trials did not mention the prescription of adjuvant medication or therapy.

Surgical duration could be a factor of heterogeneity. In the comparison of ESPB and control, one trial (17) reported longer surgical duration (110 ~ 113 minutes) with higher 24-hour opioid demand of the patients; whereas other trials reported surgical duration of about 80 ~ 90 minutes. In the comparison of ESPB and PVB, longer surgical duration, 160 ~ 180 minutes (20) compared to 70 ~ 100 minutes (13), implicated higher patients' 24-hour opioid prescription.

Additional Analysis

Only one study (17) reported the time in the PACU and patient satisfaction, which showed that ESPB was associated with a shorter time in the PACU and higher satisfaction than the control group.

Discussion

Summary of Evidence

The current study presented the first meta-analysis of ESPB applied to patients undergoing breast surgery. The results demonstrated that ESPB could be an alternative analgesic technique to PVB with similar clinical effects. For the primary outcomes, patients receiving ESPB had less opioid administration and less pain at each of the investigated time intervals in 24 hours than patients receiving general anesthesia alone. No current research identified clinically important differences for morphine administration; however, reducing intravenous morphine equivalent dose up to 7 mg could be considered clinically important. Despite lower pain scores in the ESPB group than in the control (Fig. 4), the level of reduction was small. Regarding secondary outcomes, ESPB could reduce PONV more than the control group without severe nerve block related complications. Between ESPB and PVB, there were no statistical differences in opioid administration in 24 hours or pain scores at each time interval tested. There were also no statistical differences in nerve blocks related complications and PONV. These results support the analgesic effects of ESPB and its similar effects to PVB in patients undergoing breast surgery.

The anatomical spreading of local anesthetics after erector spinae plane injection is considered to be extensively cephalocaudal spreading from the level of injection. As described by Forero et al (10), this spreading could be achieved from T1 to T11 after injection at the level of T5. Some studies reported paravertebral and epidural infiltration of radiocontrast or dye under radial images or cadaveric examination (43,44). Although other cadaveric studies identified a limited spreading of the dye from the dorsal to the costotransverse foramen and the sparing of the paravertebral space, the analgesic effects of ESPB could also be explained by the extensive lateral spreading and the involvement of the lateral cutaneous branch of the intercostal nerve (45,46). In this study, the effects of postoperative analgesia were similar to PVB. Although the paravertebral injection could precisely block the ventral and dorsal rami of the spinal nerve, ESPB achieved the same clinical effects by involving the lateral cutaneous branch of the intercostal nerve in patients undergoing breast surgery.

The results of this study are consistent with the results of previous systematic review and meta-analysis. ESPB could be an effective analgesic technique for the patients undergoing some surgeries including breast surgery (24-26). The pain score and opioid prescription reduced in ESPB group comparing to systemic analgesia in these studies. Furthermore, ESPB could be an alternative analgesic technique to PVB, which was considered a gold standard technique in breast surgery (23). Although previous meta-analyses demonstrated similar results, one meta-analysis did not assess the quality of individual trials (47), and another one incorporated trials with high risk of bias or different outcomes measurement into meta-analyses (48).

However, despite the clinical effects of ESPB and PVB in breast surgery being similar, the probability of complications related to nerve blocks was different. In the current studies, 4 patients developed pneumothorax after PVB, but none after ESPB. The level of practitioner skill and experience should be high for safety in PVB because of the vicinity of the pleura, neural axis, and great vessels (49-51). However, the associated risks of vascular puncture, neuraxial spread with symptomatic hypotension, and pleural puncture are not insignificant and can be up to 5.4%, 4.6%, and 1.1%, respectively (49,51,52). Additionally, PVB is contraindicated for patients with coagulopathy due to injection depth (53). For these reasons and its similar clinical analgesic effects, ESPB could be superior to PVB for patients undergoing breast surgery.

We attempted to perform meta-regression analysis to explain the high heterogeneity of opioid administration and pain scales among trials, but the absence of the reported covariates impeded it. Surgical duration could be a factor of heterogeneity, because the results implicated that longer surgical duration correlated with higher 24 hours opioid prescription. According to a previous meta-analysis of analgesia for breast surgery, invasiveness and postoperative analgesic modality could be the covariates responsible for the heterogeneity (28).

Limitations

There are some limitations to the current study. First, the high level of heterogeneity among the included studies in the outcome analysis could not be explained by meta-regression or sensitivity analysis. Probable reasons might be attributable to surgical duration or the variation in surgical or anesthetic techniques, which could not be quantified for analysis. Second, this study was limited to ESPB and restricted the inclusion of studies of other novel fascial plane blocks (36-38,54-58). Local infiltration, with its rising popularity in perioperative analgesia, was not included in the study. Third, only 3 of the 8 studies incorporated into meta-analyses confirmed the success of nerve blocks. Bias could have occurred owing to potential failure of local anesthetics deposition. Fourth, axillary dissection could be an important variable. The subgroup analysis of the presence/absence of additional axillary dissection could not be conducted because of limited data. Fifth, only PONV could be analyzed as secondary outcomes. Limited data on patient satisfaction levels, PACU and hospital stay, and other opioid-related side effects precluded evaluation. Sixth, rare complications including pneumothorax or large vessels injury could not be evaluated. A larger sample size was required to analyze the rare incidence. Seventh, the current study presented moderate quality of evidence owing to the low statistical power of the meta-analysis and moderate heterogeneity among included trials.

Conclusions

ESPB is a simple analgesic technique superior to general anesthesia alone 24 hours after breast surgery and can thus serve as an alternative to PVB with similar analgesic effects.

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