Comparing ultrasound-guided serratus anterior plane block with erector spinae plane block for postoperative analgesia in thoracic and breast surgery: A systematic review and meta-analysis

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Research Article

Keywords: serratus anterior plane block, erector spinae plane block, postoperative analgesia, thoracic surgery, breast surgery, meta-analysis

Posted Date: January 3rd, 2023

DOI: https://doi.org/10.21203/rs.3.rs-2213462/v1

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Abstract

**Background:** Serratus anterior plane block (SAPB) was first proposed in 2013 as a new method for regional nerve block, while erector spinae plane block (ESPB) was first proposed in 2016. Both regional nerve block techniques can be used for analgesia in thoracic and breast surgery, but the debate about their actual effects continues. The purpose of this systematic review was to compare the analgesic effects of these two nerve block techniques after thoracic and breast surgery.

**Methods:** We systematically searched the PubMed, Embase, Web of Science and Cochrane Library databases up to August 2022. We performed a meta-analysis of clinical randomized controlled trials (RCTs) comparing the effects of SAPB and ESPB on postoperative analgesia in patients undergoing thoracic and breast surgery.

**Results:** A total of 11 RCTs were included. Meta-analysis revealed that compared with the SAPB group, patients in the ESPB group had significantly reduced 24-hour postoperative opioid consumption (standardized mean difference [SMD]: -0.76; 95% confidence interval [CI]: -1.29 to -0.24; \( P < 0.01; I^2=88\% \)). Rest or movement pain scores were significantly lower at various time points postoperatively. In addition, ESPB-group patients had significantly reduced intraoperative opioid consumption (SMD: -0.43; 95% CI: -0.64 to -0.23; \( P<0.001; I^2=35\% \)). In terms of time to first use of analgesics, ESPB significantly prolonged the time to first analgesic use (SMD: 3.53; 95% CI: 1.62 to 5.44; \( P < 0.001; I^2 = 97\% \)).

**Conclusions:** Compared with SAPB, ESPB is more effective in analgesia after thoracic and breast surgery, especially in thoracic surgery.

Introduction

Thoracic and breast surgery usually lead to different degrees of pain in patients. If postoperative pain is not well controlled, it can not only increase the morbidity and mortality of patients during the postoperative period but also increase the incidence of chronic pain [1, 2]. This may have a negative impact on patient psychology and life. Therefore, it is necessary to apply appropriate pain management after thoracic and breast surgery. Although conventional intravenous analgesics (such as opioids) are widely used, opioids also have some known complications, such as respiratory depression, sedation, pruritus and constipation [3]. Therefore, opioids alone are clearly insufficient to provide adequate pain relief.

In addition to routine opioid administration for pain relief, local anaesthesia can reduce the stress response caused by surgical trauma [4]. In recent years, with the development of enhanced recovery after thoracic surgery (ERATS) and multimodal analgesia, regional anaesthesia technology has played an increasingly important role, as it can provide good postoperative analgesia while reducing opioid use and associated risks [5]. However, as a nonvisual operation, regional anaesthesia requires anaesthesiologists' skillful mastery of anatomy and technique, has limitations, and can cause serious complications, such as pneumothorax, accidental dural puncture, local anaesthetic poisoning and epidural haematoma [6]. In response, there has been growing interest in developing alternatives to traditional regional anaesthesia.

Ultrasound-guided nerve block techniques have become increasingly popular in treating postoperative pain compared with traditional regional anaesthesia due to their effectiveness, feasibility, low incidence of complications and high satisfaction rating from patients postoperatively as well as physician [7]. In recent years, due to the widespread use of ultrasound technology, two newly described ultrasound-guided nerve block techniques have gained wide popularity among thoracic and breast surgery patients [8, 9]. Serratus anterior plane block (SAPB) is a fascial plane block technique first described by Blanco et al. in 2013 [10], while erector spinae plane block (ESPB) was first proposed by Forero et al. in 2016 [11]. Current studies believe that SAPB mainly blocks the long thoracic, medial thoracic, and thoracodorsal nerves, and the lateral cutaneous branch of the intercostal nerve that runs in the plane of the serratus anterior [12]. ESPB, on the other hand, exerts analgesic effects through the paraspinal space or the posterior branch of the spinal nerve, involving the paravertebral space, the epidural space and even the intercostal space [13]. An autopsy study showed [14] that ESPB is similar to paravertebral block, but ESPB has a wider diffusion range and stronger analgesic effect, these observations still need to be confirmed by more clinical studies. Although both nerve block techniques appear to be clinically safe, the debate about their actual effects continues. Therefore, we decided to conduct a systematic review and meta-analysis to determine the analgesic effects of ESPB and SAPB during adult thoracic and breast surgery. We identified randomized controlled trials (RCTs) comparing ESPB with SAPB and endeavoured to evaluate the analgesic effects of perioperative ultrasound-guided ESPB and SAPB in patients undergoing thoracic and breast surgery.

Methods

This systematic review and meta-analysis was conducted according to the criteria of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement [15]. This meta-analysis has been prospectively registered in the PROSPERO database (registration number: CRD42022351781).

Search Strategy

We conducted a comprehensive database search of PubMed, Embase, Web of Science, and the Cochrane Library for RCTs that met the listed inclusion criteria. The search strategy combined terms detailed in the supplementary material (Table S1). We also searched the grey literature by supplementary hand searching because ESPB is a new regional anaesthesia technique first introduced in 2016 [11].

Study Selection Criteria

Two authors (WFZ and YTW) independently read the titles and abstracts of the retrieved articles to screen and select relevant studies. They then reviewed the full text of relevant studies and selected studies based on predetermined inclusion criteria. The inclusion criteria were as follows: (1) RCTs, (2) adult patients undergoing thoracic or breast surgery, and (3) postoperative pain-related data. In contrast, exclusion criteria were as follows: retrospective studies,
observational cohort studies, case reports, letters to the editor, review articles, animal studies, and non-full-text articles (e.g., abstracts or protocols). Because ES PB was first proposed in 2016, publication date was limited to years after 2016, but there were no restrictions on language or region of publication. If there were any differences in the included studies between the two authors, the third author (WDL) was involved in the selection of studies and made the final decision.

**Data Extraction**

EndNote X9 was used to select trials from replicate trials that fit the study. Two researchers independently organized the literature and extracted the data, and the extracted contents were as follows: first author, publication year, publication area, number of participants, type, concentration and dose of local anaesthetic, time required to complete the block procedure, operation time, intraoperative and postoperative opioid consumption and associated side effects, postoperative pain scores, number of people requiring urgent additional analgesics, time to first need for analgesics, and incidence of overall postoperative pulmonary complications. The primary outcome was opioid consumption at 24 h postoperatively. To facilitate meta-analysis, we approximated the median, interquartile range (IQR), and range values as their means and their corresponding standard deviations using the method described by Hozo et al [16]. According to a previous meta-analysis [17], the mean standard deviation of the values at the same time point in other RCTs using the same intervention was used as the missing standard deviation. If the results were only plotted as a graph, the graph data were digitized and extracted using GetData Graph Digitizer 2.26 (http://www.getdata-graph-digitizer.com) [18]. All reported perioperative opioid consumption was converted to intravenous morphine equivalents using a standardized conversion calculator [19]. The included studies assessed pain scores using a visual analogue scale (VAS), numerical rating scale (NRS) or verbal rating scale (VRS), and the results were transposed to a 0–10 scale for statistical evaluation.

**Quality Assessment**

Methodological quality assessments were assessed independently by two authors, and any disagreements were resolved by a third author using the Cochrane risk of bias tool and Jadad scores [20, 21]. The Cochrane risk of bias tool provides descriptions, comments, and an assessment of ‘high’, ‘unclear’ or ‘low’ risk of bias for each included study: random sequence generation; allocation concealment; double-blind, outcome-assessed blinding; incomplete outcome data; selective outcome reporting; and other biases. Each study was analysed independently by two reviewers and was divided into three groups: low risk, unclear risk, and high risk. Studies with a high risk of bias in any one or more key areas were considered to be at high risk of bias. Studies with a low risk of bias in all key areas were considered to have a low risk of bias. Otherwise, they were considered to have unclear bias risks. The Jadad score (total 7 points) uses a score based on appropriate randomization (0–2), allocation concealment (0–2), double-blinding (0–2), and possible withdrawal (0–1) standards. We considered studies to be moderate to high quality if they scored 3 or higher according to these criteria. Finally, the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach was used to evaluate the overall quality of evidence and recommendation for each outcome. The quality of the evidence for the outcomes was rated as very low, low, moderate, or high using the GRADEpro software [22].

**Statistical analysis**

We performed meta-analysis using Review Manager (version 5.3; the Nordic Cochrane Centre, the Cochrane Collaboration, Copenhagen, Denmark, 2014) and Stata 14.0. Standardized mean differences (SMDs) and corresponding 95% confidence intervals (CIs) were calculated for continuous data using a random-effects model, while odds ratios (ORs) for dichotomous data were analysed using the Mantel–Haenszel method with 95% confidence intervals. We calculated the $I^2$ statistic to assess heterogeneity, and an $I^2$ value > 50% was considered the cutoff point for significant heterogeneity. Where significant heterogeneity was observed, a random-effects model was used; otherwise, a fixed-effects model was used. Sensitivity analyses were performed by the leave-one-out method to assess whether the results varied significantly. If possible, subgroup analyses were also used to assess heterogeneity, mainly by surgical type and type of local anaesthetic. Potential publication bias was evaluated using the funnel plot and Egger’s regression, and funnel plots were not used for asymmetry detection if fewer than 10 studies were included in each analysis. A $P$ value < 0.05 with 95% CI was considered statistically significant.

**Results**

**Results of the literature search**

Our study selection process is shown in the PRISMA flow chart (Fig. 1). The literature search initially retrieved 1105 articles. Finally, after review and exclusion, 11 randomized controlled trials [23–33] met our inclusion criteria. The selected studies were published between 2019 and 2022 and were conducted in different countries, such as China, India, Turkey, Egypt and Ireland. Eight studies involved patients undergoing breast surgery [23–26, 28, 29, 31, 33], and another three studies were performed on adult women undergoing breast surgery [27, 30, 32]. Of the included studies, eight studies used bupivacaine or levobupivacaine for nerve block [24–26, 28–31, 33], and the remaining three used ropivacaine [23, 27, 32]. Regarding the pain scale, most studies used the VAS, 4 studies used the NRS, and only one study used the VRS. Among the included studies, the maximum sample size was 50 and the minimum was 17. The research details contained in this review are shown in Table 1.
<table>
<thead>
<tr>
<th>Author/Year</th>
<th>Country</th>
<th>Jadad Score</th>
<th>Number (S:E)</th>
<th>Type of surgery</th>
<th>postoperative analgesia</th>
<th>Pain measurement</th>
<th>Duration of surgery (S:E) (min)</th>
<th>SAPB group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhang 2022</td>
<td>China</td>
<td>7</td>
<td>29:28</td>
<td>VATS</td>
<td>PCIA; parecoxib sodium</td>
<td>NRS</td>
<td>$104 \pm 28.8/109.9 \pm 37.2$</td>
<td>Level of injection: T4–5; between the serratus anterior muscle and external intercostal muscles</td>
</tr>
<tr>
<td>Zengin 2022</td>
<td>Turkey</td>
<td>7</td>
<td>30:30</td>
<td>VATS</td>
<td>PCIA; paracetamol; dexketoprofen; tramadol</td>
<td>VAS</td>
<td>-</td>
<td>Level of injection: reaching the fourth rib, beneath the serratus anterior muscle, and then above the serratus anterior muscle</td>
</tr>
<tr>
<td>Hassan 2022</td>
<td>Egypt</td>
<td>7</td>
<td>28:27</td>
<td>thoracotomy</td>
<td>PCIA</td>
<td>NRS</td>
<td>$275.9 \pm 72.3/271.1 \pm 57.1$</td>
<td>Level of injection: serratus anterior muscle plane and over the 5th rib</td>
</tr>
<tr>
<td>El Malla 2022</td>
<td>Egypt</td>
<td>6</td>
<td>25:25</td>
<td>Multiple Rib Fractures</td>
<td>Paracetamol; ketorolac; tramadol</td>
<td>NRS</td>
<td>-</td>
<td>Level of injection: between latissimus dorsi and serratus anterior muscles</td>
</tr>
<tr>
<td>Jiang 2021</td>
<td>China</td>
<td>7</td>
<td>30:30</td>
<td>MRM</td>
<td>tramadol</td>
<td>NRS</td>
<td>$100.96 \pm 29.3/97 \pm 21.77$</td>
<td>Level of injection: fascia plane of the anterior serratus muscle and the external intercostal muscle</td>
</tr>
<tr>
<td>Elsabeeny 2021</td>
<td>Egypt</td>
<td>7</td>
<td>17:17</td>
<td>thoracotomy</td>
<td>0.125% bupivacaine; acetaminophen</td>
<td>VAS</td>
<td>$127.06 \pm 24.94/216.18 \pm 26.01$</td>
<td>Level of injection: between the serratus anterior muscle and the fifth rib</td>
</tr>
<tr>
<td>Finnerty 2020</td>
<td>Ireland</td>
<td>7</td>
<td>30:30</td>
<td>thoracic surgery</td>
<td>Paracetamol; buprofen; oxycodone</td>
<td>VRS</td>
<td>$100 \pm 50/94 \pm 46$</td>
<td>Level of injection: deep to the serratus anterior muscle.</td>
</tr>
</tbody>
</table>

Abbreviations: (S:E): Serratus anterior plane block group: erector spinae plane block group; SAPB: Serratus anterior plane blocks; ESPB: erector spinae plane block group; intravenous analgesia; MRM: Modified Radical Mastectomy; VATS: video-assisted thoracoscopic surgery; VAS: visual analog scale; NRS: numeric rating score.
### Assessment Of Methodological Quality

All studies were identified as moderate to high quality according to the Jadad score (Table 1). The risk assessment of the included studies is shown in Fig. 2. Among the included articles, five studies were judged as having a low risk of bias [23–26, 27]. Two studies were judged as having an unclear risk of bias [29, 30], and four studies were judged as having a high risk of bias [28, 31–33]. Overall, the quality of the included studies was credible.

### Study Outcome

#### 24-hour postoperative opioid consumption

Ten studies reported opioid consumption 24 h postoperatively in patients undergoing thoracic or breast surgery with ESPB and SAPB. Meta-analysis revealed that ESPB significantly reduced 24-hour opioid consumption compared with SAPB (SMD: -0.76; 95% CI: -1.29 to -0.24; P < 0.01; $I^2 = 88\%$) (Fig. 3). We then performed subgroup analyses. Compared with the SAPB group, patients in the ESPB group had significantly reduced 24-hour opioid consumption after thoracic surgery (SMD: -1.20; 95% CI: -1.82 to -0.58; P < 0.01; $I^2 = 87\%$), but there was no significant difference in breast surgery between patients in the meta-analysis (SMD: -0.31; 95% CI: -1.29 to 0.68; P = 0.54; $I^2 = 91\%$) (Figure S1 A). In addition, we also performed subgroup analysis of local anaesthetics, and the results revealed that after studies by Wang et al. [32] was removed from the subgroup analysis of ropivacaine, the ESPB group also revealed significant differences in the selection of local anaesthetics compared with the SAPB group (Figure S1 B).

#### Postoperative pain scores at 2 h, 4 h, 6 h, 8 h, 12 h and 24 h

Eleven studies and ten studies respectively reported resting and movement pain scores after the use of ESPB and SAPB in patients within 24 hours following thoracic or breast surgery. For patients at rest, the combined analysis of the random effects model revealed that those in the ESPB group had lower pain scores at 6 hours postoperatively (SMD: -0.56; 95% CI: -0.99 to -0.12; P = 0.01; $I^2 = 68\%$) and 12 hours postoperatively (SMD: -0.23; 95% CI: -0.41 to -0.05; P = 0.01; $I^2 = 21\%$) than those in the SAPB group, and the difference between both groups was statistically significant. At 2 h, 4 h, 8 h and 24 h postoperatively, there was no significant difference in pain scores between the groups (Fig. 4). Considering the high heterogeneity between both groups, we performed subgroup analysis and sensitivity analysis. Subgroup analysis revealed that ESPB significantly reduced the pain score after thoracic surgery at 6 hours postoperatively (SMD: -0.73; 95% CI: -1.41 to -0.06; P = 0.03; $I^2 = 78\%$) and 12 hours postoperatively (SMD: -0.26; 95% CI: -0.41 to -0.11; P < 0.01; $I^2 = 28\%$), but there was no significant difference after breast surgery (see Table S2 for specific values). Sensitivity analysis after eliminating a study by El Malla et al. [26] found that the heterogeneity at 6 h postoperatively was significantly reduced, and there was a statistically significant difference between both groups. Similarly, at 2 h, 4 h and 24 h postoperatively, after eliminating a study by Zengin et al. [24], we got the same results (Figure S2; see Table S2 for specific values). Therefore, heterogeneity was derived from these studies.

 Similarly, for movement pain, the combined analysis of random effects models revealed that patients in the ESPB group had lower pain scores at 6, 8, and 12 hours after surgery than those in the SAPB group, with statistically significant differences between both groups (Fig. 5). Because the included studies did not,
meet the subgroup analysis, sensitivity analyses were performed and revealed that after the studies of Zengin et al. [24], Wang et al. [32], and Zengin et al. [24] were removed, the pain scores in the ESPB group were lower than those in the SAPB group at 2 h, 4 h, and 24 h postoperatively. The differences between the groups were statistically significant, and the heterogeneity decreased though still high. In addition, after removing the studies of Hassan et al. [25] and Wang et al. [32] at 8 h and 12 h postoperatively, respectively, the heterogeneity was significantly reduced, indicating that the source of heterogeneity at these two time points was these two studies (Figure S3; see Table S3 for specific values).

Intraoperative Opioid Consumption

Six studies reported intraoperative opioid consumption after the use of ESPB and SAPB in patients receiving thoracic or breast surgery [23, 25, 27, 30–32]. Meta-analysis revealed that compared with the SAPB group, patients in the ESPB group had significantly reduced intraoperative opioid consumption (SMD: -0.43; 95% CI: -0.64 to -0.23; P < 0.001; I² = 35%) (Fig. 6A). Subsequently, subgroup analyses revealed that ESPB-group patients had significantly reduced intraoperative opioid consumption during thoracic surgery (SMD: -0.68; 95% CI: -0.99 to -0.37; P < 0.001; I² = 12%), but there was no significant difference between the groups during breast surgery (SMD: -0.24; 95% CI: -0.51 to 0.03; P = 0.09; I² = 0) (Fig. 6B). In addition, a subgroup analysis of local anaesthetics revealed a significant difference in the choice of bupivacaine and ropivacaine in the ESPB group compared with the SAPB group (Fig. 6C).

Number Of Patients Requiring Urgent Additional Analgesics After Surgery

Four studies that included 204 patients [24, 28, 30, 31] reported the number of patients requiring urgent additional analgesics after use of the ESPB and SAPB in thoracic or breast surgery. Meta-analysis revealed that there was no significant difference between the groups (OR: 0.57; 95% CI: 0.16 to 2.041; P = 0.39; I² = 77%) (Figure S4 A). Then, sensitivity analysis after eliminating a study by Zengin et al. [24] found that the heterogeneity was significantly reduced, and there was a statistically significant difference between both groups (OR: 0.32; 95% CI: 0.16 to 0.66; P = 0.002; I² = 25%) (Figure S4 B). Therefore, heterogeneity was derived from this study.

Time To First Use Of Analgesics

Five studies that included 261 patients [23, 27, 28, 30, 33] reported the time to first analgesic use after use of the ESPB and SAPB in patients receiving thoracic or breast surgery. Meta-analysis revealed that ESPB significantly prolonged the time to first analgesic use compared with SAPB (SMD: 3.53; 95% CI: 1.62 to 5.44; P < 0.001; I² = 97%) (Fig. 7).

Opioid-related Side Effects And The Incidence Of Overall Postoperative Pulmonary Complications

Seven studies, including 426 patients, reported the number of patients suffering opioid-related side effects with the use of ESPB and SAPB after thoracic or breast surgery, referring in particular to postoperative nausea and vomiting (PONV) [23–25, 27, 28, 31, 32]. Meta-analysis revealed that there was no significant difference between the groups (OR: 1.02; 95% CI: 0.63 to 1.67; P = 0.93; I² = 0) (Figure S5 A). However, the finding was consistent in the subgroup analysis between thoracic surgery (OR: 1.25; 95% CI: 0.63 to 2.45; P = 0.52; I² = 0) and breast surgery (OR: 0.82; 95% CI: 0.40 to 1.68; P = 0.58; I² = 25%) (Figure S5 B). No side effects associated with other opioids were found in this systematic review. Two studies reported the incidence of overall postoperative pulmonary complications after thoracic surgery [23, 29], and meta-analysis revealed that compared with the SAPB group, the ESPB group had a significantly reduced incidence of overall postoperative pulmonary complications (OR: 0.37; 95% CI: 0.14 to 0.97; P = 0.04; I² = 0) (Figure S6).

Block Time And Block-related Complications

In addition, three studies including 170 patients [24, 30, 31] reported the time required to complete the block procedure after use of the ESPB and SAPB in patients receiving thoracic and breast surgery. Meta-analysis revealed that there was no significant difference in the time required to complete the blocking procedure between the two blocking methods (SMD: 1.26; 95% CI: -1.59 to 4.11; P = 0.39; I² = 98%) (Figure S7). This systematic review revealed that ESPB and SAPB had no major side effects or complications, such as local anaesthetic systemic toxicity, pneumothorax, pleural puncture, or puncture site infection.

Publication Bias

For the analysis of opioid consumption at 24 h postoperatively, because the results revealed a high degree of heterogeneity, a sensitivity analysis by the leave-one-out method was performed and revealed no significant change in pooled effect size. The funnel plot showed some asymmetry from 24-hour postoperative opioid consumption. Egger's regression showed some publication bias (p = 0.002). Egger's tests for other results are presented in Table S4 in the Supplementary Material. Overall, this systematic review had a few publication biases, but they were not significant. Finally, using the GRADE grading approach, we assessed the evidence for the primary data, with the quality of the evidence for the primary results ranging from low to moderate to high (Table 2).
<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Illustrative comparative risks* (95% CI)</th>
<th>No of Participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>SMD or OR and (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 opioid consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumed risk</td>
<td>Corresponding risk</td>
<td>With SAPB</td>
<td>With ESPB</td>
<td></td>
</tr>
<tr>
<td>No of</td>
<td>(studies)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participants</td>
<td></td>
<td></td>
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<tr>
<td>586</td>
<td>(10 studies)</td>
<td>☐ ☐ ☐ ☐</td>
<td>low</td>
<td>SMD - 0.93 (-1.49 to -0.37)</td>
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<tr>
<td>Intraoperative opioid consumption</td>
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<td></td>
</tr>
<tr>
<td>382</td>
<td>(6 studies)</td>
<td>☐ ☐ ☐ ☐ ☐ ☐</td>
<td>high</td>
<td>SMD - 0.43 (-0.64 to -0.23)</td>
</tr>
<tr>
<td>Pain scores at rest in ESPB patients versus SAPB</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2h</td>
<td></td>
<td>469</td>
<td>☐ ☐ ☐ ☐</td>
<td>SMD - 0.26 (-0.45 to -0.08)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(8 studies)</td>
<td>high</td>
<td></td>
</tr>
<tr>
<td>4h</td>
<td></td>
<td>419</td>
<td>☐ ☐ ☐ ☐</td>
<td>SMD - 0.04 (-0.74 to 0.66)</td>
</tr>
<tr>
<td></td>
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<td>(7 studies)</td>
<td>high</td>
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<tr>
<td>6h</td>
<td></td>
<td>277</td>
<td>☐ ☐ ☐ ☐</td>
<td>SMD - 0.54 (-0.78 to -0.30)</td>
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<td>(5 studies)</td>
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</tr>
<tr>
<td>8h</td>
<td></td>
<td>369</td>
<td>☐ ☐ ☐ ☐ ☐</td>
<td>SMD - 0.49 (-0.99 to -0.01)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6 studies)</td>
<td>high</td>
<td></td>
</tr>
<tr>
<td>12h</td>
<td></td>
<td>8</td>
<td>☐ ☐ ☐ ☐</td>
<td>SMD - 0.23 (-0.41 to 0.05)</td>
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<tr>
<td></td>
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<td>(492 studies)</td>
<td>high</td>
<td></td>
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<tr>
<td>24h</td>
<td></td>
<td>646</td>
<td>☐ ☐ ☐ ☐</td>
<td>SMD - 0.12 (-0.58 to 0.34)</td>
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<td></td>
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<tr>
<td>Pain scores at movement in ESPB patients versus SAPB</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2h</td>
<td></td>
<td>419</td>
<td>☐ ☐ ☐ ☐ ☐</td>
<td>SMD - 0.31 (-0.77 to 0.16)</td>
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<td>(7 studies)</td>
<td>high</td>
<td></td>
</tr>
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<td>4h</td>
<td></td>
<td>369</td>
<td>☐ ☐ ☐ ☐ ☐</td>
<td>SMD - 0.29 (-0.93 to 0.34)</td>
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<td></td>
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<td>(6 studies)</td>
<td>moderate</td>
<td></td>
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<tr>
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<td></td>
<td>226</td>
<td>☐ ☐ ☐ ☐ ☐</td>
<td>SMD - 0.95 (-1.23 to -0.68)</td>
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<td></td>
<td>(4 studies)</td>
<td>high</td>
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</tr>
<tr>
<td>8h</td>
<td></td>
<td>369</td>
<td>☐ ☐ ☐ ☐ ☐</td>
<td>SMD - 0.36 (-0.57 to -0.15)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6 studies)</td>
<td>moderate</td>
<td></td>
</tr>
<tr>
<td>12h</td>
<td></td>
<td>442</td>
<td>☐ ☐ ☐ ☐ ☐</td>
<td>SMD - 0.62 (-0.81 to -0.43)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(7 studies)</td>
<td>moderate</td>
<td></td>
</tr>
<tr>
<td>24h</td>
<td></td>
<td>596</td>
<td>☐ ☐ ☐ ☐</td>
<td>SMD - 0.46 (-1.05 to 0.13)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(10 studies)</td>
<td>moderate</td>
<td></td>
</tr>
</tbody>
</table>

1 Very high statistical heterogeneity, this downgraded the quality of evidence by one level.

2 Egger's test, P < 0.05, this downgraded the quality of evidence by one level

**Abbreviations: SMD:** Standardized mean difference; **OR:** odds ratios; **CI:** Confidence interval; **SD:** standard deviation; **ESPB:** Erector spinae plane block; **SAPB:** Serratus anterior plane block; **PONV:** postoperative nausea and vomiting; **GRADE:** Grades of Recommendation, Assessment, Development, and Evaluation

**GRADE Working Group grades of evidence**
### Outcomes

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Illustrative comparative risks* (95% CI)</th>
<th>No of Participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>SMD or OR and (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time to first use of analgesics</strong></td>
<td></td>
<td>261</td>
<td>⨁⨁⊖⊖ low</td>
<td>SMD 3.53 (1.62 to 5.44)</td>
</tr>
<tr>
<td><strong>Number of patients requiring rescue analgesia</strong></td>
<td></td>
<td>204 (4 studies)</td>
<td>⨁⨁⨁⊖ moderate</td>
<td>OR 0.57 (0.16 to 2.04)</td>
</tr>
<tr>
<td>Study population</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>461 per 1000</td>
<td>328 per 1000</td>
<td>(120 to 635)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>467 per 1000</td>
<td>333 per 1000</td>
<td>(123 to 641)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PONV</strong></td>
<td></td>
<td>426 (7 studies)</td>
<td>⨁⨁⨁⨁ high</td>
<td>OR 1.02 (0.63 to 1.67)</td>
</tr>
<tr>
<td>Study population</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>193 per 1000</td>
<td>197 per 1000</td>
<td>(131 to 286)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>133 per 1000</td>
<td>135 per 1000</td>
<td>(88 to 204)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Very high statistical heterogeneity, this downgraded the quality of evidence by one level.

2 Egger's test, P < 0.05, this downgraded the quality of evidence by one level

**Abbreviations:** SMD: Standardized mean difference; OR: odds ratios; CI: Confidence interval; SD: standard deviation; ESPB: Erector spinae plane block; SAPB: Serratus anterior plane block; PONV: postoperative nausea and vomiting; GRADE: Grades of Recommendation, Assessment, Development, and Evaluation

**GRADE Working Group grades of evidence**

### Discussion

To the authors' knowledge, this is the first meta-analysis comparing ESPB and SAPB in patients receiving thoracic and breast surgery. This systematic review and meta-analysis confirms the potential advantages of ESPB for postoperative analgesia in patients receiving thoracic and breast surgery. Specifically, our meta-analysis yielded the following results: Compared with SAPB, ESPB not only reduced opioid consumption at 24 h postoperatively but also further reduced resting pain scores and movement pain scores at different time points up to 24 h postoperatively. In addition, ESPB reduced intraoperative opioid consumption, prolonged the time to first use of analgesics, decreased the incidence of overall postoperative pulmonary complications, and reduced the number of patients requiring urgent additional analgesia after surgery. The incidence of PONV were not significantly different between the groups, and there was no significant difference in the time required to complete the block procedure between the two block methods. The quality of evidence for this systematic review was mostly moderate to high quality, and the results of the included studies were highly reliable.

Postoperative pain is a significant challenge for anaesthesiologists with the increasing number of patients undergoing thoracic and breast surgery around the world in recent years. Therefore, there is an urgent need to determine the most effective analgesic modality for reducing postoperative pain. Ultrasound-guided nerve block has been recognized as a novel approach to the management of postoperative pain after thoracic and breast surgery because of its ease of use, low incidence of side effects, and high postoperative patient and physician satisfaction [34, 35]. This is also one of the most important components of ERATS.
ERATS aims to achieve optimal pain control earlier and achieve discharge criteria sooner [36]. Currently, thoracic paravertebral block, intercostal block, ESPB, and SAPB are the most commonly used nerve blocks for thoracic or breast surgery [37, 38]. The difference in postoperative analgesia between these blocks is still a matter of debate. However, ESPB and SAPB are more popular at present. Since SAPB was first proposed in 2013, it has attracted unprecedented attention from researchers and has stimulated researchers' interest in fascial plane blocks [39–41]. Subsequently, after ESPB was first described by Forero in 2016, an increasing number of studies focused on these two novel fascial plane blocks [23, 39]. Both SAPB and ESPB blocks aim to produce local anaesthesia at the interface plane through which peripheral nerves pass [27]. Despite the limited evidence base, both ESPB and SAPB appear to be clinically safe.

In a study comparing ESPB and SAPB in patients undergoing video-assisted thoracoscopic surgery [33], ESPB provided better quality of recovery and analgesia with fewer postoperative complications than SAPB. ESPB seems to have advantages in thoracic surgery. Zhang et al. [23] and Elsabeeny et al. [28] also found that the analgesic effect of ESPB was better than that of SAPB, and the consumption of opioids was lower. Mechanistically, it has been suggested that ESPB is considered to be similar to paravertebral block, achieving a multilaminar range of sensory block in the posterior, lateral and anterior walls of the chest, and ESPB blocks the thoracic spine dorsal and ventral branches of spinal nerves, causing some degree of sympathetic blockade. Thus, ESPB provides a broader sensory block to the anterior and posterior hemithorax. In contrast, SAPB blocked the lateral cutaneous branch of the intercostal nerve, excluding the anterior cutaneous and posterior main branches. Consequently, it is less effective in controlling visceral pleural pain, leading to analgesia in the anterolateral portion of the chest wall only [9, 12]. This is consistent with our findings that in intraoperative opioid consumption, subgroup analysis revealed that thoracic surgery required less opioids, but there was no significant difference in breast surgery. At the same time, in terms of opioid consumption 24 hours after surgery, subgroup analysis revealed that ESPB further reduced the consumption of opioids after thoracic surgery, but there was no significant difference between the groups after breast surgery. In time of first use of analgesics, ESPB also showed an advantage, time of first use of analgesics was extended.

Regarding postoperative pain scores, a retrospective study [42] showed that the VAS score of the ESPB group was significantly lower than that of the SAPB group. Likewise, in a study of patients undergoing thoracotomy [27], ESPB was found to provide better pain relief and lower postoperative dynamic NRS scores. In addition, a meta-analysis in thoracic surgery also demonstrated that the analgesic effect of ESPB was superior to that of SAPB [17]. Our meta-analysis showed that patients in the ESPB group had reduced at-rest pain scores, in addition, the ESPB group showed also reduced pain scores at all time points when coughing or exercising. As discussed above, this may be related to the wider range of ESPB blocks and the ability to control visceral pleural pain.

In addition, our meta-analysis revealed that there were no significant differences between the groups in the incidence of PONV. This may be related to both preuse of antiemetics and preanalgesia with operations in some studies. In addition, there was no significant difference in the time required to complete the block procedure between the two blocking techniques. Ultrasound-guided ESPB has similar advantages to SAPB. In addition to accurate positioning and convenient operation, the puncture point of ESPB is far away from the spinal cord and pleura; at the same time, there is no close distribution of important blood vessels, nerves and other organs, which leads to the risk of neurospinal injury, pneumothorax and haematoma being very small [13]. In our meta-analysis, we found no complications related to the block technique. However, we also found that ESPB was able to significantly reduce the incidence of overall postoperative pulmonary complications. This may be related to the better analgesic effect of ESPB, with patients coughing consciously and getting out of bed earlier, resulting in reduced pulmonary-related complications. Therefore, the above results provide new evidence to support ESPB as a viable alternative to SAPB.

However, with ultrasound-guided ESPB in clinical use for 7 years and SAPB in clinical use for barely 10 years, several important issues have not yet been resolved. For example, there is a lack of uniform evaluation criteria for the optimal concentration, volume, and type of local anaesthetics in ESPB and SAPB. Some studies recommend the use of 20 ml and 30 ml of 0.25% or 0.5% robivacaine [43, 44]. Shi et al. [45] revealed that in SAPB receiving different doses of ropivacaine for breast surgery, 0.5% ropivacaine 20 ml and 0.5% ropivacaine 30 ml could both meet the needs of postoperative analgesia after breast surgery, but 0.5% ropivacaine 10 ml could not provide sufficient analgesia. In addition, Kunigo et al. [46] revealed that 0.375% robivacaine 40 mL was more extensive than 20 mL. Larger doses did not prolong the time to first analgesic use after surgery. Of all the RCTs in this meta-analysis, the vast majority used 0.25–0.5% robivacaine for breast surgery, 0.5% ropivacaine 20 ml and 0.5% ropivacaine 30 ml could both meet the needs of postoperative analgesia after breast surgery.

The results revealed that both ropivacaine and bupivacaine showed stronger analgesic effects in ESPB. Therefore, more RCTs are needed in the future to clarify the analgesic effect of the two block techniques when different concentrations, volumes and types of local anaesthetics are used.

Although strict inclusion and exclusion criteria standardized the included studies, this meta-analysis was still certain heterogeneous. Sensitivity analyses and subgroup analyses were performed, and the results showed that the heterogeneity was significantly reduced in most of the studies. In addition, the main reasons for the high heterogeneity are as follows. First, intraoperative opioids (remifentanil, fentanyl, or sufentanil) and postoperative opioids (fentanyl, morphine, tramadol, sufentanil, or ibuprofen) are different. Although opioids were switched to equivalent doses as in other studies [29, 47], additional analgesics such as tramadol and ibuprofen were used in some trials, which made comparing opioids across trials more difficult. Second, differences in anaesthesiologists' proficiencies in performing nerve blocks can also affect heterogeneity. All interfascial blocks depend on the spread of local anaesthetic within the tissue plane, the extent of which will vary from patient to patient as well as with the anaesthesiologist's expertise and depends on a variety of factors [14]. Third, heterogeneity may stem from differences in pain rating scales and the possible influence of perioperative opioid use on pain scores. Fourth, heterogeneity was also based on the nature of the surgery (type of surgery, different levels, modalities, and extent of surgery) and differences in the choice, dose, and concentration of local anaesthetic used in each study. Finally, some studies did not use double-blinding and adequate allocation concealment, which may have contributed to heterogeneity. However, despite these high levels of heterogeneity, ESPB showed consistently better results than SAPB for analgesic outcomes in thoracic and breast surgery. In addition, the GRADE evidence quality ratings were mostly moderate to high quality, with moderate quality being due to a high degree of heterogeneity among the results, which reduces one level of evidence quality. Egger's bias test found no publication bias among the majority of studies. This is more favourable for our results.
Our results suggest that ESPB reveals better analgesic efficacy than SAPB in thoracic and breast surgery, especially in thoracic surgery. However, there are several notable limitations that we should consider when interpreting the results. First, the small sample size of the included studies may have masked the true treatment effect. Second, the results of postoperative opioid use indicated potential publication bias, whereas the PONV results indicated no publication bias, which may be related to the small number of included studies and the small sample size of the literature review. Third, data on patient satisfaction, length of PACU and hospital stay and comprehensive opioid-related side effects were not well represented in the included sample. Fourth, rare complications including pneumothorax or large vessel injury could not be assessed, and larger sample sizes could be required to analyse rare incidents. Finally, ESPB and SAPB may play a significant role in avoiding postoperative chronic pain [48, 49]. However, none of the included studies evaluated the efficacy of ESPB and SAPB for chronic pain, and more RCTs and longer follow-up are needed to assess the long-term efficacy of both.

Conclusion

In conclusion, our results suggest that since ultrasound-guided ESPB exhibits superior postoperative analgesic efficacy relative to SAPB, it may be a better treatment for postoperative pain during thoracic and breast surgery in the future and can be used as an alternative to SAPB. However, due to the certain degree of heterogeneity among studies as well as some publication bias, more multicentre, double-blind and well-designed RCTs that are also larger in sample size should be conducted in the future to clarify these conclusions.

Declarations

Acknowledgements

We would like to thank American Journal Experts (AJE) for his help with language-editing

Authors’ contributions

WFZ helped design and conduct the study, analyze the data, and write the manuscript. YTW, KH, MWZ, CY, YFW helped design and conduct the study. LFW, HYX, MLZ and YFY participated in the analysis of data and critical review of the manuscript. WDL contributed to the design of the study, collection and analysis of data, and revise the manuscript.

Funding

This work was supported by the Science and Technology Project of Jiangxi Provincial Health Commission, No.202210876.

Availability of data and materials

All data generated or analyzed during this study are included in this published article and its supplementary information files.

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Competing interests

The authors declare no competing financial interests.

References


**Figures**

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**Figure 1**

Flow chart of study retrieval
Figure 2

Risk of bias summary: authors' assessments about risk of bias for each included study. Green, red, and yellow circles indicate low, high, and unclear risk of bias, respectively.

Figure 3

Forest plot for the comparison of intravenous morphine equivalents (mg) in the first 24 h after surgery. Abbreviations: ESPB: erector spinae plane block; SAPB: serratus anterior plane block.
Figure 4

Forest plot of pain scores at rest for the erector spinae plane block group versus the serratus anterior plane block group. Abbreviations: ESPB: erector spinae plane block; SAPB: serratus anterior plane block.
Figure 5

Forest plot of pain scores at movement or coughing for the erector spinae plane block group versus the serratus anterior plane block group. Abbreviations: ESPB: erector spinae plane block; SAPB: serratus anterior plane block
Figure 6

Forest plot for the comparison of intravenous morphine equivalents (mg) in the intraoperative opioid consumption. (A): Analysis of all data in the associated studies; (B): Subgroup analysis by differentiating thoracic surgery or breast surgery; (C): Subgroup analysis by differentiating bupivacaine and ropivacaine. Abbreviations: ESPB: erector spinae plane block; SAPB: serratus anterior plane block

Figure 7

Forest plot of time to first use of analgesics for the erector spinae plane block group versus the serratus anterior plane block group. Abbreviation: ESPB: erector spinae plane block; SAPB: serratus anterior plane block

Supplementary Files
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- Additionalfile.zip