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The opioid sparing effect of erector spinae plane block for various surgeries: a meta-analysis of randomized-controlled trials

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ABSTRACT

INTRODUCTION: The erector spinae plane block (ESPB) is a newer fascial plane block which has been broadly applied for postoperative analgesia after various surgeries, but the effectiveness in these populations is not well established.

EVIDENCE ACQUISITION: A systematic database search was conducted in PubMed, PMC, Embase, and Scopus for randomized controlled trials (RCTs) comparing ESPB with control, placebo, or other blocks. The primary outcome was intravenous opioid consumption in milligram morphine equivalents 24 h after surgery. Standardized mean differences (SMDs) with 95% confidence intervals (CI) were calculated using a random-effects model.

EVIDENCE SYNTHESIS: A total of 29 RCTs were included. An analysis was conducted by subgroups differentiated by surgery type, 'no block' vs. ESPB, and other blocks vs. ESPB. ESPB was effective in reducing opioid consumption against no block for breast surgery (SMD -1.13; CI 95%), thoracic surgery (SMD -3.00; CI 95%), and vertebral surgery (SMD -1.78; CI 95%). ESPB was effective against alternative blocks for breast surgery (vs. paravertebral, SMD -1.07; CI 95%) and abdominal surgery (SMD -1.77; CI 95%). ESPB showed moderate effect in thoracic surgery against paravertebral (SMD 0.58; CI 95%) and against no block in abdominal surgery (SMD 0.80; CI 95%). In only one case did ESPB perform worse than another block: vs. PECS block for breast surgery (SMD 1.66; CI 95%).

CONCLUSIONS: ESPB may be a useful addition to the multimodal analgesic regimen for a variety of surgeries especially when the alternative is no block. Unanswered questions include determining of the mechanism of action, refining of the EPSB technique, and establishing recommended local anesthetic dose and volume.

Key Words: regional anaesthesia; acute pain; postoperative pain; erector spinae plane block; opioid

HIGHLIGHTS

- The erector spinae plane block is newer fascial plane block that is being increasingly used in a variety of surgical settings
- In this meta-analysis, we aimed to evaluate the erector spinae plane block for multiple surgical indications by assessing its effectiveness against no block and alternative blocks currently offered in clinical practice
- ESPB results in an opioid-sparing effect in major breast, minor thoracic, minor abdominal, and vertebral surgery compared to no block at all.
- Alternative blocks may offer similar benefits to ESPB for thoracic, breast, and abdominal surgery.

INTRODUCTION

The erector spinae plane block (ESPB) is a technique originally described by Forero et al. in 2016 for chronic chest wall pain but has been rapidly and widely adopted in the perioperative setting for patients undergoing various types of surgery.¹ The goal of the ESPB is to inject local anaesthetic under ultrasound guidance into the fascial plane anterior to the erector spinae muscle (ESM) with spread to the branches of the spinal nerves in this region.¹

Because of its simplicity and few reported adverse effects, ESPB has quickly become popular and has been described in hundreds of case reports.² However, the exact mechanism of action for the ESPB is still not well understood. In addition, the indications, technique, and dosing regimen are not yet standardized. These issues create confusion for anesthesiologists, surgeons, and patients and represent barriers to ongoing clinical and research efforts aimed at improving postoperative pain management.

Therefore, we designed this meta-analysis to summarize the evidence to date for the ESPB for a specific set of surgical procedures: breast surgery, thoracic surgery, abdominal surgery, vertebral, and hip arthroplasty. We tested the hypothesis that ESPB will result in decreased 24-hour opioid consumption in milligram morphine equivalents (MME) when compared to no block (i.e., systemic analgesia accompanied by no block, placebo, sham, or local anesthetic infiltration) and to other blocks for each of these surgeries. We also explored, merely for descriptive purposes, variations in ESPB block technique such as local anesthetic used, volume injected, the spine level where the block is performed, and the type of surgery.

METHODS

The following systematic review and meta-analysis was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocols (PRISMA-P). This protocol was registered prospectively with PROSPERO on the 08/13/2020 (ID: CRD42020198441).

Information sources, search strategy, and study records

The systematic literature search was established a priori by the research team and was performed utilizing the following databases: PubMed, MEDLINE, Embase, and Scopus. The initial search queried each database from 30 of May through the end of June 2020 using the string "erector spinae plane block" and was deliberately broad to avoid missing any relevant articles (Supplementary Table). . Inclusion criteria for research articles were: focus on perioperative pain treatment with ESPB, English language, randomized-controlled trials (RCTs) involving human adult participants, and reporting of postoperative pain outcomes including 24-hour opioid consumption. Articles that did not meet these criteria were excluded. Final results were exported to Zotero, a free, open source platform for researchers available online (<https://www.zotero.org/>), and duplicates were removed manually.³ Two reviewers (AF and EB) independently evaluated the articles then discussed their assessments together to determine inclusion in this meta-analysis.

Data items

We extracted contextual data such as surgical procedure, type of control group (e.g., no block or alternative block), details related to the ESPB technique (e.g., level, type of local anaesthetic used, volume of injectate), and outcome measurement (e.g., amount of opioid consumed within 24 hours).

Outcomes and prioritization

The data were then evaluated within each type of surgery (breast, thoracic, abdominal, vertebral, and hip), stratifying the cohorts into groups (e.g., ESPB versus no block and/or other blocks). No block was defined as systemic analgesia accompanied by no block, sham block, or local anesthetic infiltration. The primary outcome was 24-h opioid consumption in MME. We chose this primary outcome because subjective metrics such as the Numerical Rating Scale or Visual Analog Scale were considered less effective in objectively identifying severe pain which, according to the protocol defined by the World Health Organization, could require opioids for analgesia. If the opioid used was not morphine, we used established tables to convert the drug and dose to 24-h MME.^{4,5} If data were originally reported as median and interquartile range, estimates of mean and standard deviation were calculated using published conversions.^{6,7}

For descriptive purposes, we also reported the local anesthetic used, its volume injected, the spine level where the block is performed, and the type of surgery.

Risk of bias in individual studies

Risk of bias was evaluated according to the Cochrane Handbook for Systematic Reviews of Interventions.⁶ In order to minimize the risk of residual confounders, only RCTs were included. To assess sequence generation biases, we reviewed selected RCTs to ensure cohorts had nearly equal numbers of patients. Two reviewers (AF and EB) independently assessed the risk of bias for each individual study and discussed it to the research team. The biases assessed were: random sequence generation (selection bias); allocation concealment (selection bias); blinding of participants and personnel (performance bias); blinding of outcome assessment (detection bias); incomplete outcome data (attrition bias); and selective reporting (reporting bias).⁸ Risk of bias was reported next to the respective forest plot for individual studies.

Meta-bias

We recognized that our opioid conversions, although based on equianalgesia tables,^{4,5} and data conversions from median to mean, when applicable,^{6,7} potentially exposed our study to additional bias. This was necessary because of the wide heterogeneity in reporting opioid data in the literature within RCTs. For RCTs that included more than two arms (i.e., ESPB versus two other groups), we considered ESPB in two separate comparisons: first against one cohort and then against the other.

Data synthesis

Estimates of effect were derived from quantitative analysis utilizing Review Manager 5.4.⁹ The primary outcome was the 24 h opioid consumption in MME. Subgroups were created to explore and resolve potential heterogeneity within intervention and control groups based on procedural variations. The analysis model chosen was random effects and the effect measure selected was the standardized mean difference (SMD). The confidence interval set was 95%.

Confidence in cumulative evidence

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) methodology to assess the quality evidence for each outcome individually. MME mean scores were utilized (with standard deviations or standard errors) to estimate SMDs with 95% confidence interval (95%CI). Statistical significance was set at $p < 0.05$. Subgroup analysis was performed based on procedural differences. To evaluate the size of effect of the standardized mean difference (SMD) we established the levels of 0.2, 0.5, 0.8 as small, medium, and large effects, respectively. Heterogeneity was estimated using the I^2 index,

with values of 25%, 50%, and 75%, taken to indicate low, moderate, and high levels of heterogeneity, respectively.¹⁰

RESULTS

Selection of Sources of Evidence

A flow chart describing the complete literature search process is depicted in Figure 1. After deduplication, abstracts from 975 studies were evaluated. As required, each step was performed independently by two reviewers. In case of a disagreement, a third reviewer was consulted for resolution. After the title and abstract screening, an additional screening of the references was conducted, and two recent relevant studies were included in the full text evaluation.^{11,12} Of the 53 full text studies evaluated, 23 were excluded because they did not meet the inclusion criteria; in particular, three full text studies were excluded because they did not report opioids consumed in a 24-hour interval.¹³⁻¹⁵ We contacted the authors but were unable to obtain these data. Therefore, the remaining 30 studies were selected for meta-analysis. However, there was only one study reporting ESPB in hip surgery,¹⁶ making it impossible to perform meta-analysis.

Synthesis of Results

In Table 1, we report the descriptive characteristics for each study relative to block execution.

The main results are presented as forest plots (Figure 2) and summary tables (Table 2, 3, 4, and 5).

Table 1. Study characteristics.

	Study	Reference	Control	Local anesthetic	Volume	Spine level	Type of surgery
Breast surgery	<i>Gurkan et al. 2018</i>	17	ESPB vs No block	0.25% bupivacaine	20 ml	T4	Mastectomies, SLNB, axillary dissection
	<i>Aksu et al., 2019</i>	18	ESPB vs No block	0.25 % bupivacaine	10 ml for each level	bi-level (T2-T4)	Mastectomie, SLNB, axillary dissection
	<i>Gurkan et al. 2019</i>	19	ESPB vs No block	0.25 % bupivacaine	10 ml for each level	T4	Mastectomy and conservative approach

	<i>Oksuz et al., 2019</i>	20	ESPB vs No block	0.25 % bupivacaine	20 ml	T4-T5	Reduction Mammoplasty
	<i>Singh et al., 2019</i>	21	ESPB vs No block	0.5% bupivacaine	20 ml	T5	Radical Mastectomy
	<i>Sharma et al., 2020</i>	22	ESPB vs No block	0.5% ropivacaine	0.4 ml/kg	T5	Total Mastectomy and Axillary Clearance
	<i>Seelam et al., 2020</i>	11	ESPB vs No block	0.25% of bupivacaine	30 ml	T3	Mastectomy
	<i>Gad et al. 2018</i>	23	ESPB vs Modified PECS block	0.25% levobupivacaine plus 0.5 µ/kg dexmedetomidine	20 ml	T4	MRM
	<i>Altıparmak et al., 2019</i>	24	ESPB vs Modified PECS block	0.25% bupivacaine	20 ml	T4	Radical mastectomy surgery
	<i>Swisher et al. 2018</i>	25	ESPB vs PVB block	0.5% ropivacaine	20 ml	T3-T4	Lumpectomy with SNLB, breast reconstruction, and breast reduction
	<i>El Ghamry et al., 2019</i>	26	ESPB vs PVB block	0.25 % bupivacaine	20 ml	T5	MRM
	<i>Moustafa et al., 2019</i>	27	ESPB vs PVB block	0.25 % bupivacaine	20 ml	T4	MRM
	<i>Gurkan et al., 2019</i>	19	ESPB vs PVB block	0.25 % bupivacaine	20 ml	T4	MRM, Breast conserving surgery, Simple mastectomy.
	<i>Sinha et al. 2019</i>	28	ESPB vs PECS II	0.2% ropivacaine)	20 ml	T4	Unilateral MRM
Hip surgery	<i>Tulgar et al. 2018</i>	16	No block	0.5% bupivacaine + 2% lidocaine	20 ml + 10 ml	T4	hip and proximal femur surgery
	<i>Tulgar et al. (2) 2018</i>	16	QLB-t	0.5% bupivacaine + 2% lidocaine	20 ml + 10 ml	T4	hip and proximal femur surgery
Vertebral surgery	<i>Singh et al., 2019</i>	40	ESPB vs No block	0.5% bupivacaine	20 ml	T10	lumbar spine surgery
	<i>El Ghamry et al., 2019</i>	41	ESPB vs No block	0.25 % bupivacaine	20 ml	L3	PLIF
	<i>Zhang et al., 2020</i>	42	ESPB vs No block	0.3% ropivacaine	25 ml	T12	open posterior lumbar decompression
	<i>Yayik et al., 2019</i>	43	ESPB vs No block	0.25% bupivacaine	20 ml	L3	Lumbar Spinal Decompression
Abdominal surgery	<i>Kang et al. 2019</i>	33	No block	0.5% ropivacaine	20 ml	NA	Living Donor Laparoscopic Hepatectomy
	<i>Tulgar et al. (1) 2018</i>	34	No block	0.375% bupivacaine	20 ml	T9	laparoscopic cholecystectomy
	<i>Tulgar et al. (2) 2018</i>	35	No block	0.375% bupivacaine	20 ml	T9	laparoscopic cholecystectomy
	<i>Hamed et al. 2019</i>	36	No block	0.5% bupivacaine	20 ml	T9	Abdominal Hysterectomy

Thoracic surgery	<i>Altıparmak et al., 2020</i>	37	OSTAP	0.375% bupivacaine	20 ml	T7	laparoscopic cholecystectomy
	<i>Abu et al. 2019</i>	38	Sham	0.25% bupivacaine	20 ml	T7	Epigastric Hernia Repair
	<i>Selim et al., 2019</i>	39	PVB	0.025% bupivacaine	20 ml	L2	Hysteroscopic Polypectomy
	<i>Tulgar et al. (3) 2018</i>	35	OSTAP	0.375% bupivacaine	20 ml	T9	laparoscopic cholecystectomy
	<i>Chen et al. (1) 2019</i>	29	ICNB at T4-T9	0.375% ropivacaine	20 ml	T5	thoracoscopic surgery
	<i>Cifci et al. 2020</i>	30	Without ESPB	0.25% bupivacaine	20 ml	T5	VATS
	<i>Yao et al. 2020</i>	12	Sham	0.5% ropivacaine	25 ml	T4	VATS
	<i>Chen et al. (2) 2019</i>	29	PVB at T5 level	0.375% ropivacaine	20 ml	T5	thoracoscopic surgery
	<i>Zhao et al. 2020</i>	31	PVB (upper T3 lower T8)	0.4% ropivacaine	30 ml	Upper T3 lower T9	VATS
	<i>Wang et al., 2019</i>	32	Wound infiltration with 20 ml of 0.5% ropivacaine	0.5% ropivacaine	20 ml	T5	Thoracotomy

Abbreviations: ESPB: Erector spinae plane block; PVB: paravertebral block; PECS: Pectoral Block; OSTAP: oblique subcostal transverse abdominis plane block; ICNB: intercostal nerve block; QLB-t: transmuscular quadratus lumborum block; SNLB: Sentinel Lymph Node Biopsy; MRM: Modified radical mastectomy; PLIF: Posterior Lumbar Interbody Fusion; VATS: video-assisted thoracoscopic surgery

Table 2.

Opioid consumption with versus without erector spinae plane block in breast surgery.

Should ESPB be used to lower postoperative 24h morphine consumption following breast surgery?						
Patient or population: Patients undergoing breast surgery Settings: Postoperative Intervention: Erector spinae plane block Comparison: Control group (No block, PVB, PECS block)						
Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	ESPB				
24h Morphine consumption - ESPB vs No Block	The mean 24h Morphine consumption ranged across control groups from 16.6 mg	The mean 24h Morphine consumption in the intervention groups was 12.4 mg	SMD - 1.13 [- 1.75, - 0.50]	343 (6 studies)	⊕⊕⊕⊖ moderate	
24h Morphine consumption - ESPB vs PVB	The mean 24h Morphine ranged across control groups from 20.8 mg	The mean 24h Morphine in the intervention groups was 14.2 mg	SMD - 1.07 [- 2.15, - 0.00]	389 (5 studies)	⊕⊕⊕⊖ moderate	
24h Morphine consumption - ESPB vs PECS Block	The mean 24h Morphine ranged across control groups from 9.9 mg	The mean 24h Morphine in the intervention groups was 14.0 mg	SMD 1.66 [0.67, 2.64]	145 (3 studies)	⊕⊕⊖⊖ low	

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

Abbreviations: CI: Confidence interval; SMD: Standardized Mean Difference, PVB: paravertebral block, PECS: pectoral nerve block.

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

Table 3.

Opioid consumption with versus without erector spinae plane block in thoracic surgery.

Should ESPB be used to lower postoperative 24h morphine consumption following thoracic surgery?

Patient or population: Patients undergoing thoracic surgery

Settings: Postoperative

Intervention: Erector spinae plane block

Comparison: Control group (No block, PVB)

Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
	Assumed risk	Corresponding risk				
	Control	ESPB				
24h Morphine consumption - ESPB vs No Block	The mean 24h Morphine consumption ranged across control groups from 28.3 mg	The mean 24h Morphine consumption in the intervention groups was 18.4 mg	SMD -3.00 [-4.69, -1.31]	195 (3 studies)	⊕⊕⊕⊖ moderate	
24h Morphine consumption - ESPB vs PVB	The mean 24h Morphine consumption ranged across control groups from 11.3 mg	The mean 24h Morphine consumption in the intervention groups was 15.4 mg	SMD 0.58 [0.16, 1.00].]	162 (2 studies)	⊕⊕⊕⊖ Low	

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

Abbreviations: CI: Confidence interval; SMD: Standardized Mean Difference; PVB: paravertebral block.

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

Table 4. Opioid consumption with versus without erector spinae plane block in abdominal surgery.

Should ESPB be used to lower postoperative 24h morphine consumption following abdominal surgery?					
Patient or population: Patients undergoing abdominal surgery Settings: Postoperative Intervention: Erector spinae plane block Comparison: Control group (No block, Other blocks)					
Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)
	Assumed risk	Corresponding risk			
	Control	ESPB			
24h Morphine consumption - ESPB vs No Block	The mean 24h Morphine consumption ranged across control groups from 37.4	The mean 24h Morphine consumption in the intervention groups was 18.1 mg	SMD - 0.80 [- 1.06, - 0.54]	244 (5 studies)	⊕⊕⊕⊖ low
24h Morphine consumption - ESPB vs Other Blocks	The mean 24h Morphine consumption ranged across control groups from 22.1 mg	The mean 24h Morphine consumption in the intervention groups was 16.4 mg	SMD - 1.77 [- 2.19, - 1.35]	174 (3 studies)	⊕⊕⊕⊖ low

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

Abbreviations: **CI:** Confidence interval; **SMD:** Standardized Mean Difference.

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

Table 5. Opioid consumption with versus without erector spinae plane block in vertebral surgery.

Should ESPB be used to lower postoperative 24h morphine consumption following vertebral surgery?					
Patient or population: Patients undergoing vertebral surgery Settings: Postoperative Intervention: Erector spinae plane block Comparison: Control group					
Outcomes	Illustrative comparative risks* (95% CI)		Relative effect (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)
	Assumed risk	Corresponding risk			
	Control	ESPB			
24h Morphine consumption	The mean 24h Morphine consumption ranged across control groups from 23.8 mg	The mean 24h Morphine consumption in the intervention groups was 15.6 mg	SMD - 1.78 [- 2.12, - 1.45]	220 (4 studies)	⊕⊕⊕⊖ moderate

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).

Abbreviations: CI: Confidence interval; : SMD: Standardized Mean Difference.

GRADE Working Group grades of evidence

High quality: Further research is very unlikely to change our confidence in the estimate of effect.

Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

Very low quality: We are very uncertain about the estimate.

Breast surgery

Thirteen RCTs were evaluated.^{11, 17- 28} Of these, six compared ESPB (n=172) to no block (n=171), five compared ESPB (n=194) to paravertebral block (PVB; n=195), and three compared ESPB (n=74) to the pectoral block (PECS; n=71). At 24 hours, the average MME consumed in ESPB patients was 12.4 mg versus 16.6 mg in patients who had no block; SMD -1.13 (95% CI -1.75 to -0.50). Test for overall effect was $Z = 3.52$ ($p < 0.01$), and heterogeneity was $I^2=86\%$.

For the ESPB vs. PVB subgroup, the mean 24-hour MME in patients undergoing ESPB was 14.2 mg vs. 20.8 in patients who had PVB; SMD -1.07 (95% CI -2.15 to -0.00). Test for overall effect was $Z = 1.97$ ($p = 0.05$), and heterogeneity was $I^2=96\%$.

For the ESPB vs. PECS block subgroup, the 24-hour MME in patients undergoing ESPB was 14.0 mg vs. 9.9 in patients who received PECS block; SMD 1.66 (95% CI 0.67 to 2.64). Test for overall effect was $Z = 3.30$ ($p < 0.01$), and heterogeneity was $I^2=84\%$.

Thoracic surgery

Five RCTs were evaluated.^{12, 29-32} Of these, three compared ESPB (n=97) to no block (n=98), and two compared ESPB (n=81) to PVB (n=81). We included within the PVB group patients who underwent an intercostal block for analgesia since the site of local anesthetic action was similar. Hence the study conducted by Chen et al. was counted twice.⁴¹ At 24 hours, the average MME in ESPB patients was 18.4 mg vs. 28.3 mg in patients who had no block; SMD -3.00 (95% CI -4.69 to -1.31). Test for overall effect was $Z = 3.48$ ($p < 0.01$), and heterogeneity was $I^2=94\%$.

Conversely, in the ESPB vs. PVB subgroup, 24-hour MME in patients undergoing PVB was 15.4 mg vs. 11.3 in patients who received PVB; SMD 0.58 (95% CI 0.16 to 1.00). Test for overall effect was $Z = 2.71$ ($p < 0.01$), and heterogeneity was $I^2=42\%$.

Abdominal surgery

Seven studies were evaluated.³³⁻³⁹ Of these, five compared ESPB (n=122) to no block (n=122), and three compared ESPB (n=87) to other blocks such as the oblique subcostal transverse abdominis plane block and PVB (n=87). A total of eight studies were considered instead of the seven mentioned as one study was analyzed twice because it contained both ESPB versus no block and ESPB versus alternative block.³⁵ At 24 hours, the average MME in ESPB patients was 18.1 mg vs. 37.4 mg in patients who had no block; SMD -0.80 (95% CI -1.06 to -0.54). Test for overall effect was $Z = 5.98$ ($p < 0.01$), and heterogeneity was $I^2=0\%$.

In the ESPB vs. alternative blocks block subgroup, the 24-hour MME in patients undergoing ESPB was 16.4 mg versus 21.1 in patients who received an alternative block; SMD -1.77 (95% CI from -2.19 to -1.35). Test for overall effect was $Z = 1.92$ ($p = 0.05$), and heterogeneity was $I^2=98\%$.

Vertebral surgery

Eight RCTs were evaluated.⁴⁰⁻⁴³ They all compared ESPB (n=110) to no block (n=110). At 24 hours, the average MME in ESPB patients was 15.6 mg vs. 23.8 mg in patients who had no block; SMD -1.78 (95% CI -2.12 to -1.45). Test for overall effect was $Z = 3.27$ ($p < 0.01$), and heterogeneity was $I^2=94\%$.

Hip surgery

We only found one randomized controlled trial for hip surgery which compared ESPB with no block or transmuscular quadratus lumborum block (QLB-t).¹⁶ For this reason, we could not perform meta-analysis. However, the results of this study suggest some benefit from ESPB when compared to either no block or QLB-t.

DISCUSSION

Based on the results of our meta-analysis, ESPB provides statistically-significant decreases in 24-hour opioid requirements measured in MME for patients undergoing major breast, minor thoracic, minor abdominal, and vertebral surgery compared to no block at all. This suggests that ESPB can offer added opioid-sparing benefit to multimodal analgesic strategies in the management of postsurgical pain. When compared to alternative blocks, ESPB shows mixed results depending on the type of surgical procedure.

To our knowledge, this is the first meta-analysis to provide a individual evaluation of the opioid-sparing effect of ESPB for a variety of specific surgical procedures. Given the wide range of clinical indications suggested for the ESPB as reported by the large number of case reports and series, this present study offers a concise summary of the quantified postoperative analgesic benefits of ESPB, if any, for selected surgeries.⁴⁴⁻⁴⁶ We believe that given the trend towards evidence-based pain management with emphasis on the development of procedure-specific clinical pathways, the abundance of anecdotal reports constitutes a major bias in the current literature for ESPB and prevents proper clinical contextualization of the block.

Previously-published meta-analyses based on study results available at the time have generally compared ESPB only to systemic analgesia. In our updated meta-analysis, we have been able to compare ESPB to alternative regional anesthesia techniques in addition to no block as these data have become available. This is clinically relevant due to the fact that every block technique offers specific advantages and disadvantages that may differ based on the surgery, and this balance must be considered in the validation process of any new intervention like the ESPB.^{47, 48}

With regard to our results for breast surgery, we recognize that anesthetizing this territory is complex; chest wall and breast innervation is derived from the second through sixth perforating lateral cutaneous branches of the corresponding intercostal nerves.⁴⁹⁻⁵² Once these branches reach the subcutaneous tissue, they split into anterior and posterior divisions. The subclavicular area is innervated separately by the supraclavicular branches (C3-C4) of the superficial cervical plexus.⁴⁶⁻⁴⁹ The parasternal region is innervated by the perforating cutaneous terminal branches of the upper intercostal nerves. The subclavicular area and parasternal region are likely not covered by ESPB.⁴⁹⁻⁵²

Two meta-analyses focusing specifically on breast surgery and the use of ESPB were published in 2020 and reported similar outcomes to ours.^{53, 47} ESPB for patients undergoing breast surgery is consistently shown to be more effective than no block, but it may be more or less effective than other blocks as also shown by Huang et al.⁵⁴ Since ESPB, PVB, and PECS blocks differ greatly in technique and site of injection, these results are not easy to explain. Differences in surgical technique and invasiveness of underlying disease may be factors influencing postoperative pain and opioid consumption. In addition, fascial plane blocks are still relatively new, and there are many variations in technique and dosing regimen which can affect individual study results and subsequent meta-analyses when data are aggregated. For example, the PECS II has been described both as a single fascial plane injection and as a combination of two fascial plane injections (combined with PECS I). The key point from the present study and other recent meta-analyses is that any regional analgesic technique is likely better than no regional analgesic technique, and the one offered to a patient is often influenced by surgical and patient factors as well as the regional anesthesia skills of the anesthesiologist.

Concerning thoracic surgery, we wish to point out that the reported studies involved patients who underwent minor procedures where regional analgesia may be useful but perhaps may

not be necessary when compared to major surgery. Only two studies compared ESPB to other regional anesthesia techniques such as PVB. PVB, which has proven analgesic efficacy in major thoracic surgery, may also be better than ESPB for minor thoracic procedures.⁵⁵ Another meta-analysis of ESPB published in 2020 for chest wall procedures shows superiority of ESPB over no block but slight superiority of PVB over ESPB similar to our meta-analysis.⁵⁴ Unlike our study, however, this study combined data from breast surgery and thoracic surgery patients which complicates the analysis and interpretation.

With regard to abdominal surgery, the mechanism by which ESPB exerts its analgesic effect requires clarification. A similar opioid-sparing effect has been demonstrated by a recently published meta-analysis by Mohamed et al. which compared ESPB to only systemic analgesia as a control group rather than comparing ESPB to other available blocks as in our meta-analysis.⁴⁸ Contrasting perspectives on ESPB mechanism of action emerge from cadaveric model studies with some suggesting injectate spread into the anterior paravertebral space, while others show lack of spread to the paravertebral space and only dorsal rami coverage; therefore, despite data supporting the opioid-sparing benefit in abdominal surgery, the exact mechanism by which this effect is achieved is still not yet understood.⁵⁵

This meta-analysis reports emerging data for vertebral surgery which is a novel application for peripheral regional analgesia. Although an analgesic mechanism has been suggested, it is not fully explored in the literature.⁴¹ Unlike neuraxial blockade, ESPB does not produce lower extremity motor blockade which makes it attractive for musculoskeletal procedures that require early postoperative mobilization. For this reason, ESPB may also be a useful technique to incorporate into the multimodal analgesic regimen for hip arthroplasty. There

is arguably a need for a motor-sparing regional block for this surgical population since commonly-performed alternative blocks produce quadriceps weakness.^{56, 57}

There are important limitations to our study. First, we only included published RCTs aiming to summarize the body of evidence of highest quality that had undergone peer review; therefore, we did not include unpublished results such as data that may be available online. In addition, there remain numerous sources of bias within the original studies due to the many variations in technique that have been previously mentioned. Our own conversions from original opioid type and dosage to MME and summary statistics to conform to the present study's methods and results also represent a source of bias. We wish to emphasize that, although our analysis shows a statistically-significant reduction of 24-hour MME when ESPB is compared to no block, our study is not designed to report on any potential clinically-significant advantages in terms of other patient outcomes such as opioid-related adverse events, healthcare utilization, or persistent postoperative pain. These types of variables were not considered in this meta-analysis because they were not collected in the included RCTs. Based on the present study's findings, it is necessary to point out that ESPB today is not a uniform technique and is in reality a set of heterogeneous procedures in terms of vertebral level, injection site, concentration of local anesthetic used, and volume of injectate. Finally, a further limitation of the present study consists in the high probability of publication bias.

CONCLUSIONS

In conclusion, the scientific literature reviewed in our meta-analysis shows that ESPB offers opioid-sparing benefits when compared to no block after breast and vertebral surgery and minor thoracic and abdominal procedures as part of a multimodal pain management regimen. In order for our experience and understanding of ESPB to continue evolving,

further research is needed to investigate the impact of ESPB on other clinical outcomes and the potential utility of ESPB in other surgical populations.

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AUTHORS' CONTRIBUTION

Conceptualization and methodology AF, VT, EB; investigation and data curation AF, VT, EB; formal analysis; AF, VT, EB; writing—original draft preparation AF, VT, EB, CC, EM; writing—review and editing, AF, VT, EB, CC, EM; visualization AF, VT, EB, CC, EM; supervision EM, CC; project administration AF, VT. All authors have read and agreed to the published version of the manuscript.

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Figure Legends

Figure 1.

PRISMA flow diagram. The diagram shows the study selection process and provides reasons for exclusion for the records screened. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Figure 2.

Forest plot for the comparison of intravenous morphine equivalents (mg) in the first 24 h after surgery. Comparison of results expressed in intravenous morphine equivalents (mg) through SMD between subgroups undergoing various types of surgery.

Risk of bias legend

(A) Random sequence generation (selection bias)

(B) Allocation concealment (selection bias)

(C) Blinding of participants and personnel (performance bias)

(D) Blinding of outcome assessment (detection bias)

(E) Incomplete outcome data (attrition bias)

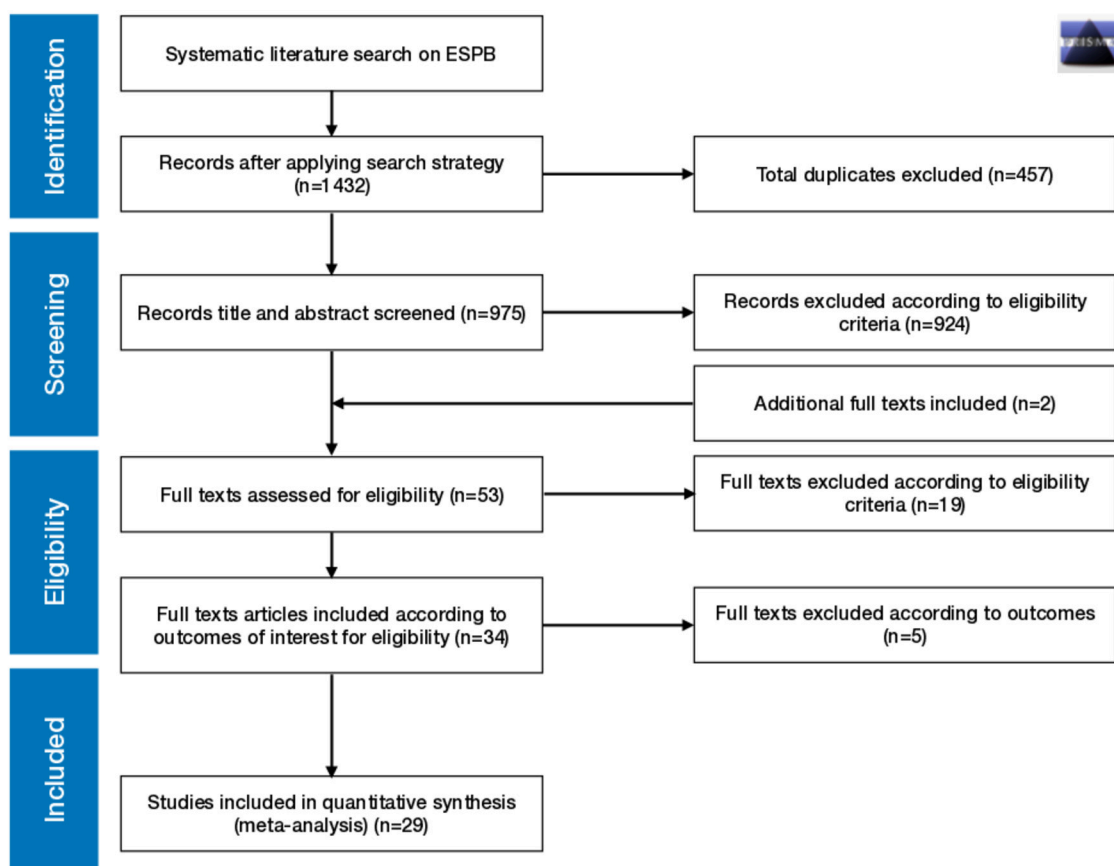
(F) Selection reporting (reporting bias)

ESPB: Erector spinae plane block; CI: Confidence interval; SMD: Standardized Mean Difference, PVB: paravertebral block, PECS: pectoral nerve block.

Supplementary table. Search strategies

PMC erector spinae plane block
Scopus ALL (erector AND spinae AND plane AND block)
Embase 'erector spinae plane block'/exp OR 'erector spinae plane block' OR (erector AND spinae AND plane AND block)
Pubmed Search: erector spinae plane block ("erector"[All Fields] OR "erectores"[All Fields] OR

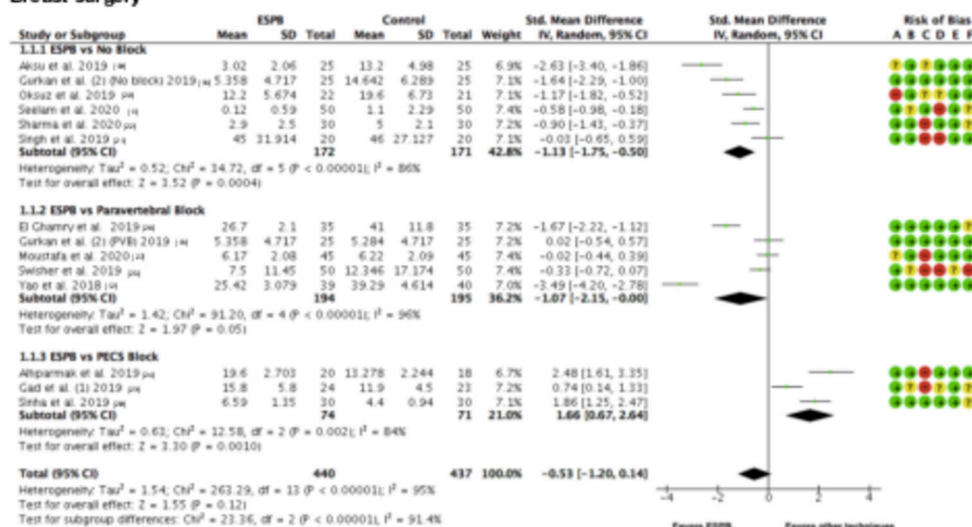
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AND
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AND
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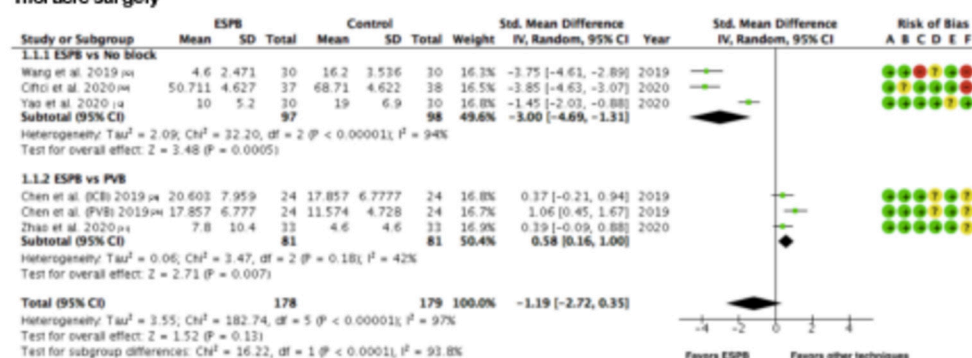
From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed.1000097

For more information, visit www.prisma-statement.org.

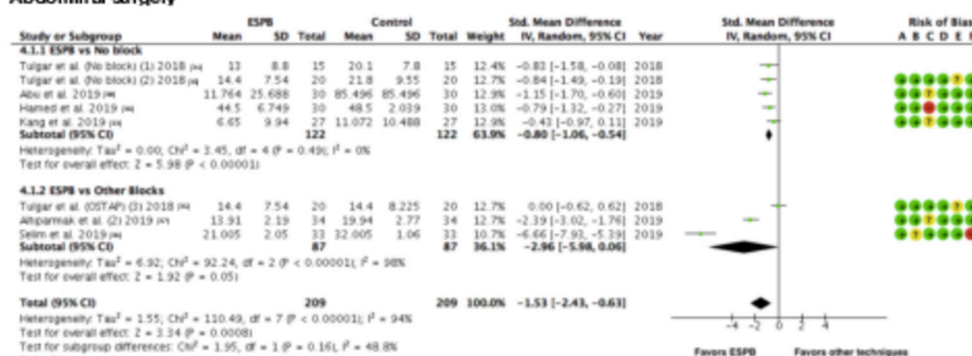
Breast surgery



Thoracic surgery



Abdominal surgery



Vertebral surgery

