Topical Review

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Erector spinae plane block in acute interventional pain management: a systematic review

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Abstract: Erector Spinae Plane Block (ESPB) was described by Forero in 2016. ESPB is currently widely used in acute postoperative pain management. The benefits of ESPB include simplicity and efficacy in various surgeries. The aim of this review was to conduct a comprehensive overview of available evidence on erector spinae plane block in clinical practice. We included randomized controlled trials and systematic reviews reporting the ESPB in human subjects. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Twenty-one articles including five systematic reviews and 16 randomized controlled trials were included and analyzed. ESPB appears to be an effective, safe, and simple method for acute pain management in cardiac, thoracic, and abdominal surgery. The incidence of side effects has been reported to be rare. A critical issue is to make sure that new evidence is not just of the highest quality, in form of well powered and designed randomized controlled trials but also including a standardized and homogeneous set of indicators that permit to assess the comparative effectiveness of the application of ESPB in acute interventional pain management.

Keywords: acute pain management; erector spinae plane block; regional anesthesia.

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Introduction

Erector Spinae Plane Block (ESPB) was described by Forero [1] in 2016 is rapidly becoming one of the most commonly used fascial plane blocks in regional anesthesia. ESPB has been used in numerous types of surgeries. The benefits of ESPB include simplicity and efficacy [2]. The number of publications on ESPB is expanding rapidly. The purpose of this review was to conduct a comprehensive overview of available evidence on erector spinae plane block in clinical practice and to clarify key concepts regarding this topic in the literature, examining what research is being conducted, as well as to identify and analyze knowledge gaps.

Methods

Search strategy

Protocol: We defined the scope of this review to include randomized controlled trials (RCT) and systematic reviews reporting the ESPB in human subjects. The review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Participants/population

Articles were included in this systematic review if they mentioned ESPB acute pain management.

1) Age – 18 years and older;
2) Acute postoperative pain that was assessed using the standard scales such as visual analog scale (VAS) or numeric rating scale (NRS);
3) Application of ESPB for acute pain management;
4) Articles describing the use of ESPB after other methods of regional anesthesia failed were also considered;
5) The following types of articles were included:
   a) Systematic reviews and meta-analyses;
   b) Clinical trials (we focused on the recently published clinical trials which were not included in the previous systematic review);

The following articles were excluded from the study:

1) Cadaveric studies;
2) Animal studies;

3) Case reports and case series;
4) Pediatric surgery (<18 years old);
5) Articles reporting chronic pain;
6) The quality and intensity of the pain was not properly described and graded in the article;

Settings: Any healthcare settings (Medical centers, hospitals, clinics).
Types of study to be included: randomized controlled clinical trials and systematic reviews.

Literature search

We conducted a systematic literature search in PubMed, EMBASE and Google scholar (2018–2019). The search involved both free text and Medical Subject Headings (MeSH) terms and included "erector spinae plane block", "ESP", "acute pain".

We excluded the articles that did not meet the review criteria according to the title and abstract. The identified papers were examined and cross-referenced to identify additional papers of relevance.

We extracted the following data: author, year, citation, types of surgery, objectives, comparator, complications, and outcomes.

The primary study goal of this review was to compare the analgesic efficacy of ESPB to other modalities of postoperative pain management (other types of regional blocks and analgesia without blocks). The secondary goals were to compare opioid consumption or requirement, safety (side effects and complications) and patients' satisfaction.

Results

Study characteristics

The literature search yielded 38 potentially relevant publications. Seventeen articles were excluded following the review of abstracts (animal studies, editorials, pediatric surgery, articles published not in the English language). Therefore, 21 relevant articles: Five systematic reviews and 16 individual randomized clinical trials (reporting 919 patients) were included in the review (Figure 1). Data of the patient characteristics including, author, year, citation, types of surgery, objectives, comparator, complications, and outcomes (Tables 1 and 2).

Summary of evidence

The analyzed randomized clinical trials compared the analgesic efficacy, opioid consumption safety, opioid-related side effects of ESPB group and control groups. All 16 studies showed the superiority (in terms of efficacy of postoperative analgesia and/or reduction in postoperative opioid requirement and/or time to first opioid administration) of ESPB to control groups (intravenous non-interventional postoperative analgesia and/or other regional blocks) in cardiac, thoracic, abdominal and spinal surgery.

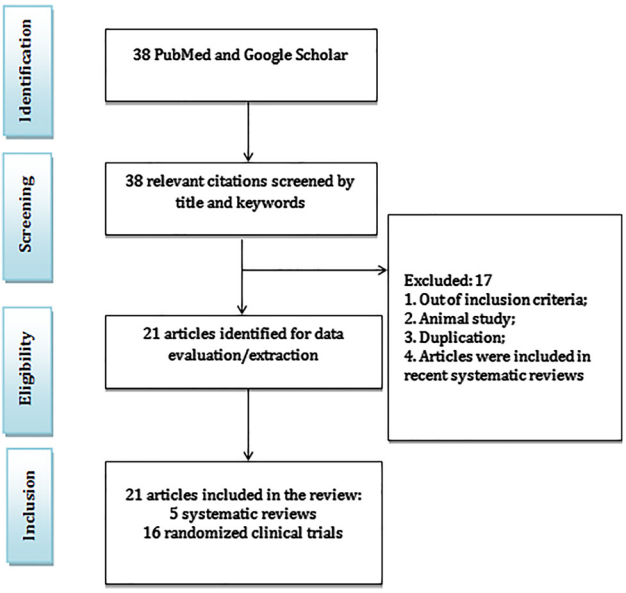

Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram.

One systematic review concluded that the evidence on efficacy and safety are controversial and there is no sufficient evidence to support ESPB [3]. Another systematic review reported that ESPB was superior to "no intervention", inferior to pectoralis nerve block and similar to paravertebral block at reducing pain scores and postoperative opioid consumption. The rest of systematic reviews concluded that ESPB was superior to control (efficacy of postoperative analgesia and/or reduction in postoperative opioid requirement and/or time to first opioid administration) [5–7]. One systematic review reported that ESPB can reduce the incidence of postoperative nausea and vomiting (PONV) most likely due to reduction in opioid requirement [6].

Summary of systematic reviews

Lumbar spinal surgery

Qiu et al. conducted the systematic review in which they included 11 publications, two RCT, case report, case series, retrospective cohort study [3]. The study included the following outcomes: opioid consumption, opioid-related and block-related side effects, sensory and motor changes, VAS or NRS score, and patient satisfaction. The efficacy of ESPB in lumbar spinal surgery was controversial [3].

Breast surgery

Two systematic reviews that focused on ESPB in breast surgery have been published to date. In the first systematic

Table 1: Systematic reviews.

Author; year	Surgery	Study groups and number of participants, n	Study goals	Types and number of studies included	Number of patients	Level of ESPB	Local anesthetic used	Complications	Comments/Conclusions
Qiu et al. 2020 [3]	Lumbar spinal surgery		(1) Opioid consumption; (2) Sensory and motor changes; (3) Opioid-related and block-related side effects and adverse events; (4) VAS or NRS score; (5) Patient satisfaction were collected	11 (2 RCT) Case report, case series, retrospective cohort study, RCTs	171	T8 to L4	Bupivacaine, ropivacaine and lidocaine		Effectiveness and safety are controversial. Insufficient evidence to support.
Leong et al. 2020 [4]	Breast surgery		Pain scores and 24 h oral morphine incidence of PONV	13 (RCT)	861	T4	Bupivacaine	Pneumothorax – 2.6% in the paravertebral block group; No reports of complications of the other blocks	ESPB is more effective than general anesthesia alone at reducing postoperative opioid consumption and pain scores up to 24 h. ESPB is inferior to the pectoralis nerve block; ESPB is similar to paravertebral block.
Cai et al. 2020 [5]	Spinal, thoracic and abdominal surgery.	ESP block vs. placebo	(1) Visual analog scale (VAS) at rest/at movement, postoperative morphine consumption in 24 h; (2) Rate of postoperative nausea and vomiting (PONV)	18 (RCTs)	1,041				Superior to placebo spinal, thoracic, and abdominal surgeries; Reducing the postoperative complications.
ElHawary et al. 2020 [6]	Breast surgery	ESPB vs. tumescent anesthesia or no block	Pain scores, opioid consumption and complications	32 articles (6 RCT, 26 case reports and case series)	RCT-259 Case series – 60	T2–T4	Ropivacaine, bubivacaine	Pneumothorax (3 min after ESPB)	ESPB can decrease postoperative pain, incidence of PONV and opioid consumption.
De Cassai et al. 2020 [7]	Cardiothoracic, abdominal, vertebral, orthopedic		Pain scores, opioid consumption, time to first analgesic requirement; side effects and complications	130 (4 RCT)					ESPB resulted in lower opioids use; a longer time to first analgesic. Analgesic efficacy was comparable to epidural analgesia.

Table 2: Clinical trials.

Author; year; country	Surgery	Objective	Study group and number of participants, n	Complications	Outcomes
Wang et al. 2019 [8]	Thoracotomy	To compare the effects of preoperative ESPB and preoperative wound infiltration on perioperative opioid consumption and postoperative pain	ESPB group – 30; Control group (wound infiltration) – 30	PONV was lower in group ESPB than that in wound infiltration group	Preoperative ESPB could significantly reduce perioperative opioid consumption, provide a better postop. analgesia and decrease opioid-related adverse events.
Altiparmak et al. 2019 [9]	Laparoscopic cholecystectomy	To assess the effect of ESPB on postoperative opioid. The secondary aims are to assess the effects of ESPB on intraop. fentanyl need and postoperative pain scores	ESPB group – 21; Group control – 20		ESPB provided significant reduction in postoperative opioid consumption, intraoperative fentanyl need and postop. pain scores.
Gaballah et al. 2019 [10]	Video-assisted thoracoscopy	Pain severity, time to first postoperative analgesia, and intraop. and postop. analgesic requirements	ESPB – 30; SPB group – 30	No major side effects were observed in either groups	ESPB provided superior analgesia and longer time to first required analgesic.
Yayik et al. 2019 [11]	Lumbar spinal decompression surgery	The effect of the ESPB on postop. opioid consumption and pain scores	Interventional group – 30; Control group – 30		ESPB can be used in multimodal analgesia practice to reduce opioid consumption and relieve acute postoperative pain.
Altıparmak et al. 2019 [12]	Mastectomy surgery	The effects of ESPB performed using two different concentrations of bupivacaine on intraop. fentanyl requirements, postoperative tramadol consumption and pain scores	Interventional group – 21; Control group – 21		ESPB with both concentrations of bupivacaine provided effective postoperative analgesia; The higher concentration of bupivacaine was more effective in reducing postoperative tramadol consumption.
Elyazed et al. 2019 [13]	Open epigastric hernia repair	Analgesic efficacy of ESPB	Interventional group – 21; Control group – 21	No significant difference in complications. One patient in control group and two patients in the erector spinae plane block group developed intraoperative hypotension.	ESPB provided lower postoperative VAS pain scores and decreased consumption of both intraoperative fentanyl and postoperative rescue analgesia.
Macaire et al. 2019 [14]	Open cardiac surgery	To assess the efficacy of continuous ESPB total opioid requirement perioperative opioid consumption at 48 h	Interventional group – 47; Control group – 20		ESPB is associated with a significant decrease in intraoperative and postoperative opioid consumption.
Kamel et al. 2020 [15]	Total abdominal hysterectomy	To compare the UG ESPB and bilateral TAP block in postoperative analgesia after open total abdominal hysterectomy	ESPB group – 24; TAPB group – 24		Bilateral UG ERBP provided more better and longer analgesia with less morphine requirement compared to TAPB.
Gawęda et al. 2020 [16]	Cardiac surgery (mitral or tricuspid valve repair)	To compare ESPB with combined ESPB and PECS block	ESPB group – 15; PECS group – 15		Combined ESPB and pectoralis nerve (PECS) blocks reduced requirement of oxycodone via PCA, pain intensity on the VAS, and improved patient satisfaction.

Table 2: (continued)

Author; year; country	Surgery	Objective	Study group and number of participants, n	Complications	Outcomes
Kwon et al. 2020 [17]	Laparoscopic cholecystectomy	To assess the visceral analgesic efficacy of ESPB	ESPB group – 26; Control group – 27	Nausea, however there was no difference between two groups	The ESPB group was associated with lower analgesic consumption than ESPB group at all time-points. Pain intensity was lower in the ESPB group at 6 h postoperatively.
Nagaraja et al. 2018 [18]	Cardiac surgery	To compare continuous TEA with ultrasound-guided bilateral erector spinae block for perioperative pain management in cardiac surgery	ESPB group – 25; TEA group – 25	No complications reported in either group	ESPB can serve as an alternative to TEA in postoperative analgesia in cardiac surgery.
Aksu et al. 2019 [19]	Breast surgery	To evaluate the efficacy of the UG ESPB in breast surgery and estimate opioid consumption	ESPB group – 25; No intervention group – 25	No complications observed in either group	There was a significant opioid-sparing analgesic effect in ESPB group.
Chen et al. 2020 [20]	Thoracoscopic surgery	To determine the analgesic effect of UG intercostal nerve block, ESPB and multiple-injection paravertebral block after thoracoscopic surgery	ESPB group – 25; Intercostal nerve block group – 25; Multiple-injection paravertebral block group – 25	No significant complications	
Finnerty et al. 2020 [21]	Minimally invasive thoracic surgery	To compare the analgesic efficacy of ESPB and SAPB after minimally invasive thoracic surgery	ESPB group – 30; SAPB group – 30		ESPB compared to SAPB provides better analgesia and superior quality of recovery at 24 h.
Krishna et al. 2019 [22]	Adult cardiac surgery	To compare the analgesic efficacy of bilateral ESPB and conventional pain management cardiac surgery	ESPB group – 53 Control group – 53		ESPB safely provided significantly better and longer pain relief compared to intravenous paracetamol and tramadol.
Swisher et al. 2020 [23]	Breast surgery	To compare the analgesic efficacy of ESPB and PVBs after breast surgery	ESPB group – 50 PVB group – 50		PVBs provided better analgesia and reduced opioid requirements after non-mastectomy breast surgery.

UG, ultrasound-guided; ESPB, erector spinae plane block; PECS, pectoralis nerve blocks; TAPB, transversus abdominis plane block; TEA, thoracic epidural anesthesia; SAPB, serratus anterior plane block; PVB, paravertebral block; PONV, post anesthesia nausea and vomiting.

review, Leong et al. compared ESPB with pectoral nerve block and general anesthesia without regional anesthetic block [4]. Thirteen RCTs were analyzed in the review. ESPB was more effective compared to general anesthesia alone at reducing pain and postoperative opioid consumption. There was no clinical difference in pain intensity between the ESPB and pectoralis nerve block groups.

In the second systematic review focusing on breast surgery, ESPB was compared to tumescent anesthesia or "no block". The pain scores, opioid consumption and complications were assessed. The study analyzed 32 articles (six RCTs, 26 case reports and case series) [6]. The authors concluded that ESPB could decrease postoperative pain, incidence of PONV and opioid consumption [6].

Spinal, thoracic and abdominal surgery

ESPB was compared to placebo in various types of surgeries: spinal, thoracic and abdominal surgeries. The pain scores

(VAS) at rest, at movement, postoperative morphine consumption in 24 h and rate of PONV were assessed [5]. Eighteen RCTs were included in the systematic review. The quality of evidence profile (by GRADE) was scored as moderate in the majority of cases (6 moderate, 1 high and 1 low) [5]. ESPB was superior to placebo in spinal, thoracic, and abdominal surgeries. ESPB reduced the incidence of PONV [5].

In the next study, ESPB resulted in lower opioid consumption and longer time to first analgesic request in analgesia in thoracic, abdominal and vertebral surgeries [7]. Analgesic efficacy was comparable to epidural analgesia in thoracic, abdominal and vertebral surgeries [7].

Clinical trials

Thoracic surgery

In the first thoracic surgery study, the authors aimed to assess the analgesic effect of the ultrasound-guided intercostal nerve block, ESPB and multiple-injection paravertebral block after thoracoscopic surgery [20]. Seventy-five patients (Intercostal nerve block group – 25 patients; ESPB group – 25 patients, and multiple-injection paravertebral block group – 25 patients) were enrolled in the study [20]. There was a significant difference in morphine consumption at 24 h in the postoperative period among all three groups [20]. The analgesic effect of ultrasound-guided multiple-injection paravertebral block was superior to intercostal nerve block and single-injection ESPB. Intercostal nerve block and single-injection ESPB were equally effective [20].

In the next study, ESPB demonstrated superior analgesia and a longer time to first required analgesics compared to Serratus Plane Block in video-assisted thoracoscopy [10]. There were no major side effects observed in either of the study groups [10].

Finnerty et al. compared the analgesic efficacy of ESPB and serratus anterior plane block after minimally invasive thoracic surgery [21]. Sixty-patients were enrolled in the study (ESPB group – 30 and serratus anterior plane block group – 30). ESPB provided better analgesia, superior quality of recovery at 24 h and lower morbidity than serratus anterior plane block [21].

Wang et al. studied the effects of preoperative ESPB and preoperative wound infiltration with local anesthetics on perioperative opioid consumption and postoperative pain in thoracotomy patients [8]. Sixty patients (ESPB group – 30 patients and wound infiltration group – 30 patients) were included in the study. The authors found that preoperative ESPB could reduce perioperative opioid consumption, provide a better postoperative analgesia and decrease opioid-related adverse events [8]. The incidence of PONV was lower in the ESPB group than that in the wound infiltration group [8].

Cardiac surgery

We included three articles that studied ESPB in cardiac surgery. First study aimed at assessing the efficacy of continuous ESPB and opioids consumption at 48 h in open cardiac surgery [14]. The authors reported that ESPB was associated with a significant decrease in intraoperative and postoperative opioid consumption [14].

Gawęda et al. showed that combined ESPB and pectoralis nerve (PECS) blocks reduced requirement of oxycodone via patient control analgesia, pain intensity on the VAS, and improved patient satisfaction in mitral or tricuspid valve repair surgery [16].

The next study that aimed to compare the analgesic efficacy of bilateral ESPB and conventional pain management cardiac surgery, demonstrated that ESPB provided significantly better and longer pain relief compared to a combination of intravenous paracetamol and tramadol [22].

Breast surgery

The analgesic effect of ESPB was compared to "no block control" after breast surgery [19]. Fifty patients were enrolled (ESPB group – 25 patients; "no block" group – 25 patients) [19]. The postoperative morphine requirement was significantly lower in the ESPB group compared to the control group during a 24 h period [19]. There was a significant opioid-sparing analgesic effect in ESPB group [19].

Swisher et al. compared the analgesic efficacy of ESPB and paravertebral block [23]. One hundred patients (ESPB group – 50 patients; paravertebral block group – 50 patients) were enrolled in the study [23]. The authors aimed to determine whether more technically difficult paravertebral block might be replaced with the less risky fascial block. Paravertebral block group showed better analgesia and reduced opioid requirements after non-mastectomy breast surgery [23].

Laparoscopic cholecystectomy

We included two randomized clinical trials that studied ESPB after laparoscopic cholecystectomy. In the first study, Altiparmak et al. assessed the effect of ESPB on intraoperative fentanyl requirement, postoperative opioid requirement and postoperative pain scores in laparoscopic cholecystectomy [9]. The authors reported that ESPB resulted in significant reduction in intraoperative fentanyl requirement, overall

postoperative opioid requirement and reduction of postoperative pain scores [9].

Kwon et al. also aimed at comparing the efficacy of ultrasound-guided bilateral ESPB and "no block" in the postoperative somatic pain after laparoscopic cholecystectomy. Twenty-six patients were included (ESPB group – 26 and 27 patients in the control group) [17]. ESPB resulted in a significant reduction in opioid consumption. The authors also concluded that ESPB might be able to induce both somatic and visceral analgesia [17].

Open hernia repair

Analgesic efficacy of ESPB group was compared to "no block control group" in open epigastric hernia repair [13]. Forty-two patients (ESPB group – 21 and control – 21) were included in the study [13]. ESPB was more effective in pain management and in the reduction of consumption of both intraoperative fentanyl and postoperative rescue analgesia. There was no difference in complication rates reported [13].

Total abdominal hysterectomy

The analgesic efficacy and opioid consumption of ESPB and bilateral transversus abdominis plane block were compared in open total abdominal hysterectomy. ESPB demonstrated better and longer analgesia with less morphine requirement [15].

Patient satisfaction and safety of ESPB

Although it was difficult to obtain a comparable assessment of patient satisfaction with ESPB with the information available, this procedure was well tolerated and patients were generally satisfied. We did not find articles that reported a negative attitude toward the procedure. We found only one randomized control clinical trial that reported a case of pneumothorax in ESPB group (3 min after ESPB) [6]. Another systematic review reported that the rate of pneumothorax in the paravertebral block group – 2.6% [6]. Two publications reported PONV in the ESPB group [13, 17].

Discussion

The main findings of this review are the diverse types of interventions and clinical situations in which ESPB is used. Another relevant finding is that most authors report that ESPB is an effective and safe procedure in pain management. In the majority of systematic reviews and clinical trials, ESPB was superior to control in postoperative pain management, reduced opioid requirement and lower level of opioid-related side effects (such as PONV).

When a new technique is tested, a critical question to elucidate is its safety profile. Although it is difficult to make any strong conclusion on the safety of ESPB no major life-threatening complications have been reported to date. However, since the efficacy of ESPB depends on a high volume of level anesthetics injected in the erector spinae plane and its further redistribution within the plane, intravascular administration might have a critical importance and the risk of local anesthetic toxicity (LAST) should be always considered [24]. The LAST management training for everyone who participates in patient management (anesthesiologists, surgeons, emergency care physicians, nurses) might be recommended.

Data from this review suggest that ESPB is indicated in situations when regional anesthesia, such as epidural and spinal can result in the sympathetic block and hemodynamic instability and might not be well tolerated by some patients and even contraindicated. ESPB appears to be safe in terms of risks of epidural hematoma in hypocoagulable states. Since there are no major vessels in the close proximity to ESPB, the risks of vascular injury and subsequently intravascular administration of local anesthetics or hematoma formation is probably less likely to occur compared to other methods of regional anesthesia [24].

Volume and concentration of injectate

The use of higher volume/lower concentration solutions for plane blocks has been suggested in order to reduce the risk of LAST, as higher volume of anesthetic solutions cover more segments providing a sufficient level of analgesia [12], but what is the ideal volume and concentration of local anesthetic is still an open question.

The benefits of low concentration local anesthetic solution include a reduced risk of LAST, however, low concentration of local anesthetics may always provide with sufficient level of postoperative analgesia and opioids can be necessary (in this case the risk of LAST can be lower but risks of insufficiently managed pain and opioid-related side effects can be higher).

In the study conducted by Altıparmak et al., both concentrations of bupivacaine (0.25 and 0.375%) were effective after radical mastectomy surgery [12]. However, higher concentrations of bupivacaine (0.375%) reduced postoperative tramadol consumption more significantly lower. Moreover, the NRS scores in the group with high

concentration of bupivacaine were significantly lower compared to low concentration [12]. Altıparmak et al. also reported that the incidence of PONV was significantly lower in the high bupivacaine concentration group most likely due to reduced tramadol consumption [12].

Limitations and future research

Our literature search may have failed to find all publications. A major limitation of this work is its qualitative nature, which is due both to the limited quality and number of the available randomized control clinical trials as well as to the heterogeneity of the structure of the published literature.

Conclusion

ESPB appears to be an effective, safe, and simple method for acute pain management in cardiac, thoracic, and abdominal surgery. Will the ESPB become a decisive anesthetic and pain control strategy? To answer this question, valid evidence is necessary. A critical issue is to make sure that new evidence is not just of the highest quality, in form of well powered and designed randomized clinical trials, but also including a comparable and homogeneous set of indicators that permit to assess the comparative effectiveness of ESPB in interventional pain management to identify the specific indications and clinical conditions in which should be indicated.

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