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Comparison of erector spinae plane block with paravertebral block for thoracoscopic surgery: a meta-analysis of randomized controlled trials

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Abstract

Introduction The efficacy of erector spinae plane block versus paravertebral block for thoracoscopic surgery remains controversial. We conduct a systematic review and meta-analysis to explore the impact of erector spinae plane block versus paravertebral block on thoracoscopic surgery.

Methods We have searched PubMed, EMbase, Web of science, EBSCO, and Cochrane library databases through March 2022 for randomized controlled trials (RCTs) assessing the effect of erector spinae plane block versus paravertebral block on thoracoscopic surgery. This meta-analysis is performed using the random-effect model.

Results Seven RCTs are included in the meta-analysis. Overall, compared with erector spinae plane block for thoracoscopic surgery, paravertebral block results in significantly reduced pain scores at 12 h ($SMD = 1.12$; 95% CI 0.42 to 1.81; $P = 0.002$) and postoperative anesthesia consumption ($SMD = 1.27$; 95% CI 0.30 to 2.23; $P = 0.01$), but these two groups have similar pain scores at 1-2 h ($SMD = 1.01$; 95% CI − 0.13 to 2.15; $P 0.08$) and 4–6 h ($SMD = 0.33$; 95% CI − 0.16 to 0.81; $P = 0.19$), as well as incidence of nausea and vomiting ($OR 0.93$; 95% CI 0.38 to 2.29; $P = 0.88$).

Conclusions Paravertebral block may be better for the pain relief after thoracoscopic surgery than erector spinae plane block.

Keywords Erector spinae plane block, Paravertebral block, Thoracoscopic surgery, Pain scores, Randomized controlled trials, Meta-analysis

Introduction

Thoracoscopic surgery is a less invasive and traumatic surgical procedure for both minor and major oncological lung surgeries, and it is able to improve post-operative respiratory function and reduce hospital length of stay [1–3]. Thoracoscopic surgery has been widely used to treat various diseases such as esophageal cancer and lung cancer [4–6]. However, 25% of patients are estimated to experience moderate-to-severe pain after thoracoscopic surgery [7]. Inadequate analgesia delays patient recovery and prolongs the hospital stays.

Due to the limited efficacy and adverse events of current analgesic methods, many kinds of regional anesthesia techniques such as thoracic epidural analgesia and paravertebral block have been developed to alleviate post-operative pain after thoracoscopic surgery [8, 9]. Erector spinae plane block also obtains widespread application because of simple application and safety [10].

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However, the optimal regional anaesthesia technique among erector spinae plane block versus paravertebral block is not well established for thoracoscopic surgery [10–14]. This meta-analysis aims to investigate the efficacy and safety of erector spinae plane block versus paravertebral block for thoracoscopic surgery.

Materials and methods

Ethical approval and patient consent are not required because this is a systematic review and meta-analysis of previously published studies. The systematic review and meta-analysis are conducted and reported in adherence to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) [15, 16].

Search strategy and study selection

Two investigators have independently searched the following databases (inception to March 2022): PubMed, EMbase, Web of science, EBSCO, and Cochrane library databases. The electronic search strategy is conducted using the following keywords: "erector spinae plane block" OR "ESPB" AND versus "paravertebral block" OR "PVB" AND "thoracoscopic" OR "thoracoscopy". We also check the reference lists of the screened full-text studies to identify other potentially eligible trials.

The inclusive selection criteria are as follows: (1) population: patients undergoing thoracoscopic surgery; (2) intervention: erector spinae plane block; (3) comparison: paravertebral block; (4) study design: RCT. We exclude patients with spinal deformities, infection at or near the puncture site, abnormal coagulation, a history of allergy to local anesthetics, a history of psychiatric disorders or inability to cooperate.

Data extraction and outcome measures

We have extracted the following information: author, number of patients, age, male, body mass index, American Society of Anesthesiologists (ASA, I/II) and detail methods in each group etc. Data have been extracted independently by two investigators, and discrepancies are resolved by consensus. We also contact the corresponding author to obtain the data when necessary. The primary outcomes are pain scores at 1–2 h, 4–6 h and 12 h. Secondary outcomes include postoperative anesthesia consumption, nausea, and vomiting. Pain scores were evaluated by visual analogue score (VAS).

Quality assessment in individual studies

Methodological quality of the included studies is independently evaluated using the modified Jadad scale [16, 17]. There are 3 items for Jadad scale: randomization (0–2 points), blinding (0–2 points), dropouts and withdrawals (0–1 points). The score of Jadad Scale varies from 0 to 5

points. An article with Jadad score ≤ 2 is considered to be of low quality. If the Jadad score ≥ 3, the study is thought to be of high quality [18].

Statistical analysis

We estimate the mean difference (MD) or standard mean difference (SMD) with 95% confidence interval (CI) for continuous outcomes and odd ratio (OR) with 95%CI for dichotomous outcomes. The random-effect model is used when encountering significant heterogeneity, otherwise fixed-effect model is applied. Heterogeneity is reported using the I^2 statistic, and $I^2 > 50\%$ indicates significant heterogeneity [19]. Whenever significant heterogeneity is present, we search for potential sources of heterogeneity via omitting one study in turn for the meta-analysis or performing subgroup analysis. Publication bias is not evaluated because of the limited number (< 10) of included studies. All statistical analyses are performed using Review Manager Version 5.3 (The Cochrane Collaboration, Software Update, Oxford, UK).

Quality of evidence

The quality of evidence for each outcome was evaluated based on the methodological quality and the confidence in the results, and it was assessed by GRADE recommendations as high quality, moderate quality, low quality, or very low quality [20].

Results

Literature search, study characteristics and quality assessment

A detailed flowchart of the search and selection results is shown in Fig. 1. 276 potentially relevant articles are identified initially. 92 duplicates and 174 papers after checking the titles/abstracts were excluded. Three studies were removed because of the study design and seven RCTs were ultimately included in the meta-analysis [10–14, 21, 22].

The baseline characteristics of the seven eligible RCTs in the meta-analysis are summarized in Table 1. The seven studies are published between 2019 and 2022, and total sample size is 411. Erector spinae plane block and paravertebral nerve block were performed by using bupivacaine or ropivacaine. Among the seven studies included here, three studies report pain scores at 1–2 h, 4–6 h and 12 h [10, 12, 22], six studies report postoperative anesthesia consumption [10–14, 21], as well as four studies report nausea and vomiting [10, 11, 14, 22]. Jadad scores of the seven included studies vary from 4 to 5, and all seven studies are considered to have high quality according to quality assessment (Table 2).
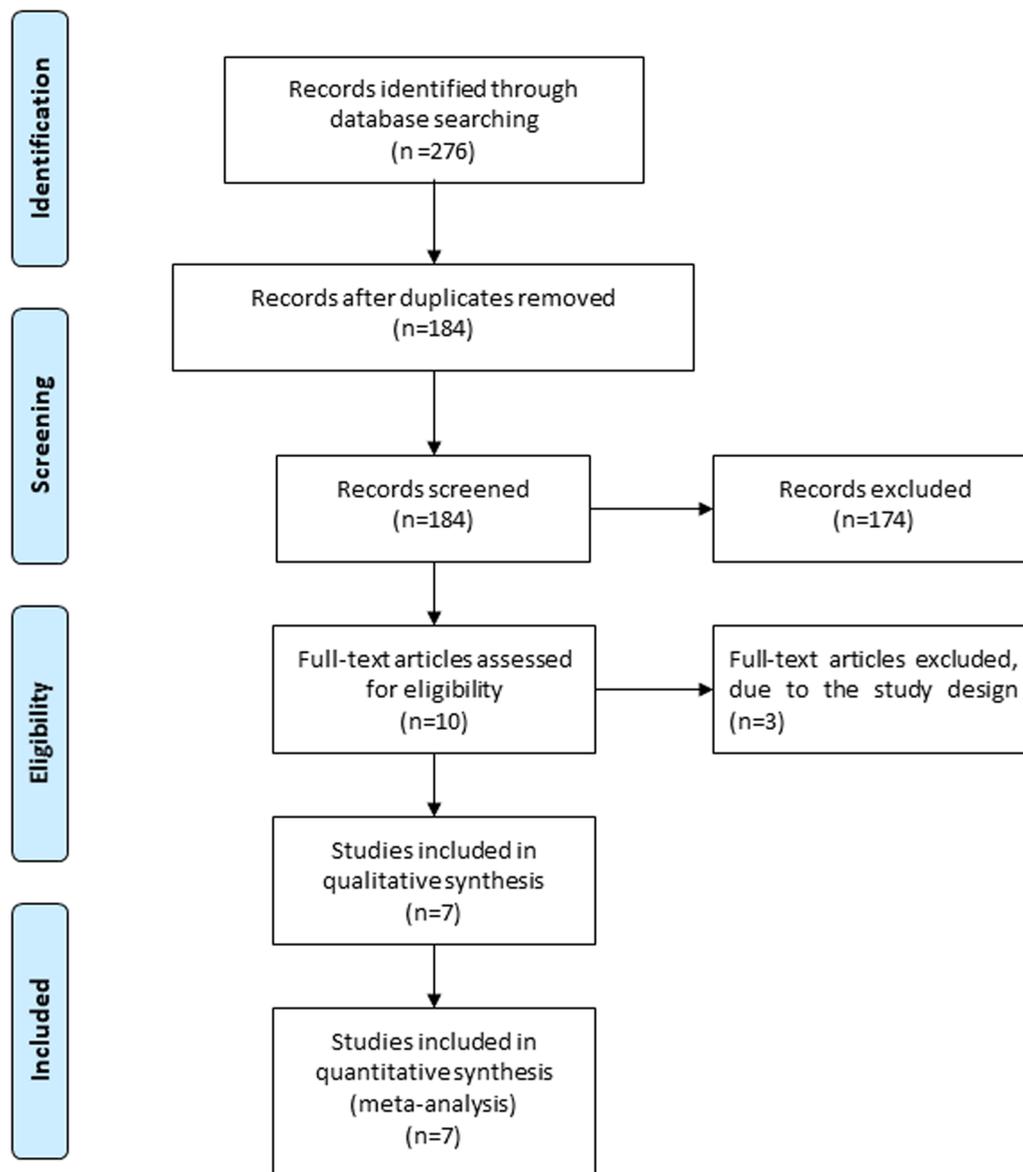
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Fig. 1 Flow diagram of study searching and selection process

Primary outcomes: pain scores at 1–2 h, 4–6 h and 12 h

The results suggested that compared to paravertebral block for thoracoscopic surgery, erector spinae plane block results in similar pain scores at 1–2 h (very low quality, SMD = 1.01; 95% CI − 0.13 to 2.15; $P = 0.08$) with significant heterogeneity among the studies ($I^2 = 95\%$, heterogeneity $P < 0.00001$, Fig. 2) and 4–6 h (very low quality, SMD = 0.33; 95% CI − 0.16 to 0.81; $P = 0.19$) with significant heterogeneity among the studies ($I^2 = 83\%$, heterogeneity $P = 0.003$, Fig. 3), but is associated with significantly higher pain scores at 12 h (low quality,

SMD = 1.12; 95% CI 0.42 to 1.81; $P = 0.002$) with significant heterogeneity among the studies ($I^2 = 92\%$, heterogeneity $P < 0.00001$, Fig. 4).

Sensitivity analysis

Significant heterogeneity is only observed among the included studies for primary outcomes, but there is still significant heterogeneity when performing sensitivity analysis via omitting one study in turn or subgroup analysis based on anesthetic drugs to detect the heterogeneity (Fig. 5).

Table 1 Characteristics of included studies

NO	Author	ESPB group							PVB group							Operation	Analgesic medication	Outcomes	Jada scores
		Number	Age (years)	Male (n)	Body mass index (kg/m^2)	ASA (I/II)	Methods		Number	Age (years)	Male (n)	Body mass index (kg/m^2)	ASA (I/II)	Methods					
1	Zhang 2022	22	54.41±7.61	11	25.56±3.01	7/15	ESPB with 30 ml of 0.5% ropivacaine hydrochloride		22	54.32±6.56	10	25.47±2.65	9/13	PVB with 30 ml of 0.5% ropivacaine hydrochloride	Elective thoracoscopic pulmonary lobectomy	0.05 mg/kg of midazolam, 0.5 µg/kg of sufentanil, 0.6 mg/kg of rocuronium, and 0.3 mg/kg of etomidate Were given sequentially by intravenous infusion	Pain scores at 1–2 h, 4–6 h and 12 h, postoperative analgesic consumption, nausea and vomiting	4
2	Fu 2022	20	57.25±11.25	14	23.4±2.46	12/8	ESPB with 20 ml of 0.5% ropivacaine		22	58.63±6.04	8	23.79±2.78	14/8	PVB with 20 ml of 0.5% ropivacaine	Video-assisted thoracoscopic surgery	Propofol 2.0 mg/kg, sufentanil 0.4 µg/kg and cis-atracurium 0.2 mg/kg	Postoperative analgesic consumption, nausea and vomiting	4
3	Turhan 2021	35	53.31±9.03	19	24.38±1.57	13/19	ESPB with 20 mL of 0.5% bupivacaine		35	53.97±7.34	16	23.78±2.04	13/18	PVB with 20 mL of 0.5% bupivacaine	Thoracoscopic lung surgery	Propofol (2 mg/kg), fentanyl (3 mcg/kg) and rocuronium (0.5 mg/kg)	Pain scores at 1–2 h, 4–6 h and 12 h, postoperative analgesic consumption	4
4	Zhao 2020	33	59±5	18	–	11/21	ESPB with 15 mL of 0.4% ropivacaine		33	57±6	11	–	9/24	PVB with 15 mL of 0.4% ropivacaine	Video-assisted thoracic surgery	Etomidate (0.1 mg/kg), propofol (1 mg/kg), sufentanil (0.3 µg/kg) and cis-atracurium (0.15 mg/kg)	Postoperative analgesic consumption	4

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Table 1 (continued)

NO	Author	ESPB group						PVB group						Operation	Analgesic medication	Outcomes	Jada scores
		Number	Age (years)	Male (n)	Body mass index (kg/m²)	ASA (I/II)	Methods	Number	Age (years)	Male (n)	Body mass index (kg/m²)	ASA (I/II)	Methods				
5	Çiftçi 2020	30	47.33±10.21	15	–	16/14	ESPB with 20 mL of 0.25% bupivacaine	30	47.53±10.43	15	–	11/19	PVB with 20 mL of 0.25% bupivacaine	Video assisted thoracic surgery	Propofol (2–2.5 mg/kg), fentanyl (1–1.5 µg/kg), and rocuronium bromide (0.6 mg/kg)	Postoperative analgesic consumption, nausea and vomiting	5
6	Chen 2020	24	51.6±10.4	13	22.9±2.6	9/15	ESPB with 6.7 ml of 0.375% ropivacaine	24	58.1±7.0	15	23.5±2.4	9/15	PVB with 7 ml of 0.375% ropivacaine	Elective thoracoscopic partial pulmonary resection surgery	Sufentanil 0.5 µg/kg, propofol 1.5–2.0 mg/kg and rocuronium 0.8 mg/kg	Postoperative analgesic consumption	5
7	Taketa 2019	41	70±7	23	23.6±3.4	2/29	ESPB with 20 mL of 0.2% levobupivacaine	40	67±8	25	23.4±3.2	2/29	PVB with 20 mL of 0.2% levobupivacaine	Video-assisted thoracic surgery	Fentanyl (50 µg), remifentanil (0.2–0.5 µg/kg/min) and rocuronium (0.6–1 mg/kg)	Pain scores at 1–2 h, 4–6 h and 12 h, nausea and vomiting	4

ASA: American Society of Anesthesiologists

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Table 2 The quality of evidence for each outcome by GRADE recommendations

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 group versus PVB group				
pain scores at 1-2 h		The mean pain scores at 1-2 h in the intervention groups was **1.01 higher** (0.13 lower to 2.15 higher)		195 (3 studies)	⊕⊖⊖⊖ very low[1,2]	
pain scores at 4-6 h		The mean pain scores at 4-6 h in the intervention groups was **0.33 higher** (0.16 lower to 0.81 higher)		195 (3 studies)	⊕⊖⊖⊖ very low[1,2]	
pain scores at 12 h		The mean pain scores at 12 h in the intervention groups was **1.12 higher** (0.42 to 1.81 higher)		195 (3 studies)	⊕⊕⊖⊖ low[1,2]	
postoperative analgesic consumption		The mean postoperative analgesic consumption in the intervention groups was **1.27 standard deviations higher** (0.3 to 2.23 higher)		330 (6 studies)	⊕⊖⊖⊖ very low[1,2,3]	SMD 1.27 (0.3 to 2.23)
Nausea and vomiting	Study population		OR 0.93 (0.38 to 2.29)	227 (4 studies)	⊕⊕⊕⊖ moderate[1]	
	254 per 1000	241 per 1000 (115 to 439)				
	Moderate					
	236 per 1000	223 per 1000 (105 to 414)				

*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).

CI: Confidence interval; OR: Odds ratio;

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.

[1] unclear blinding
[2] I2>75%
[3] favor different groups
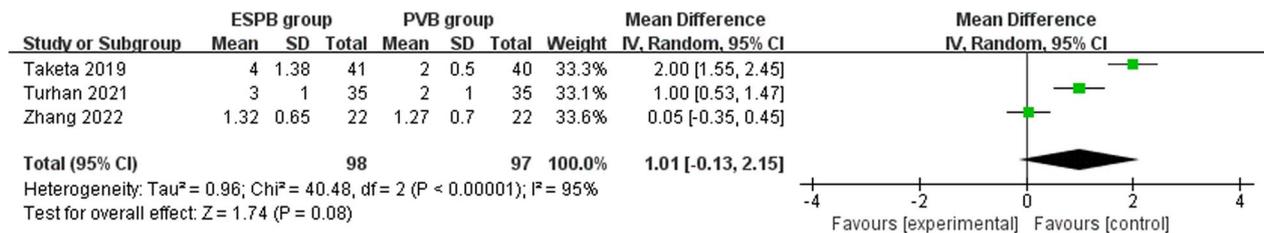

Fig. 2 Forest plot for the meta-analysis of pain scores at 1–2 h
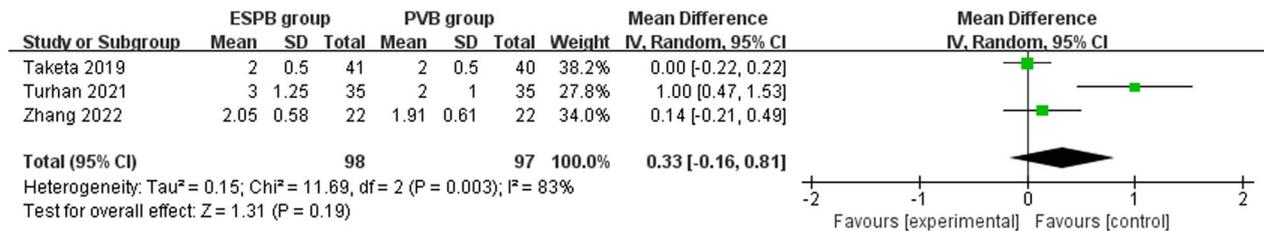

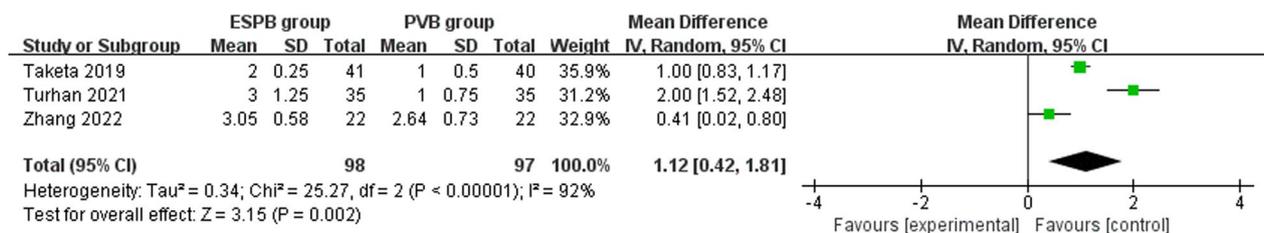**Fig. 3** Forest plot for the meta-analysis of pain scores at 4–6 h

Fig. 4 Forest plot for the meta-analysis of pain scores at 12 h

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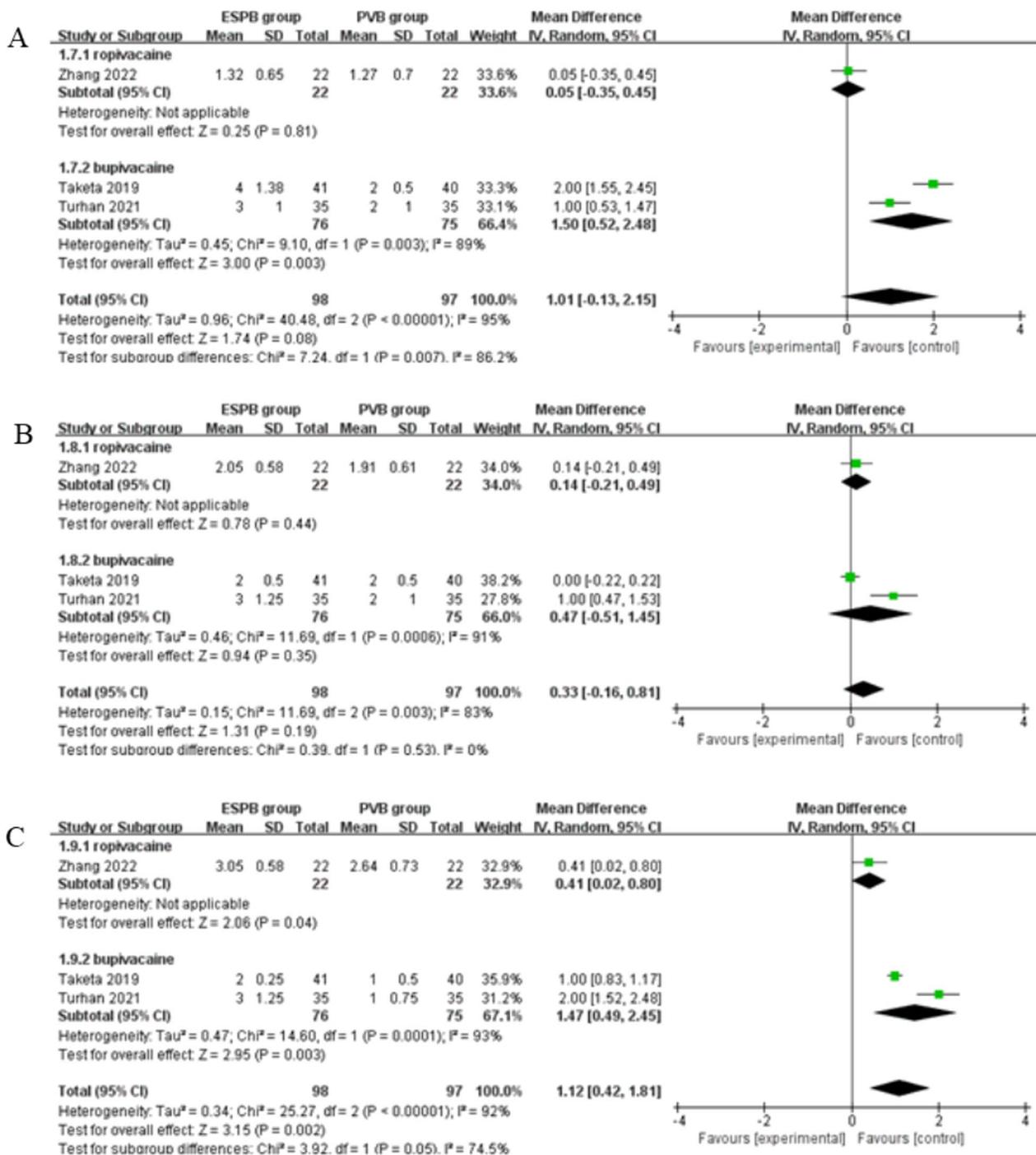
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Fig. 5 Forest plot for the subgroup analysis of pain scores at **A** 1–2 h, **B** 4–6 h and **C** 12 h

Secondary outcomes

Erector spinae plane block needs increased postoperative anesthesia consumption (very low quality, SMD = 1.27; 95% CI 0.30 to 2.23; *P* = 0.01; Fig. 6) than paravertebral block for thoracoscopic surgery, but the incidence of nausea and vomiting is comparable between erector spinae plane block and paravertebral block (moderate quality, OR 0.93; 95% CI 0.38 to 2.29; *P* = 0.88; Fig. 7).

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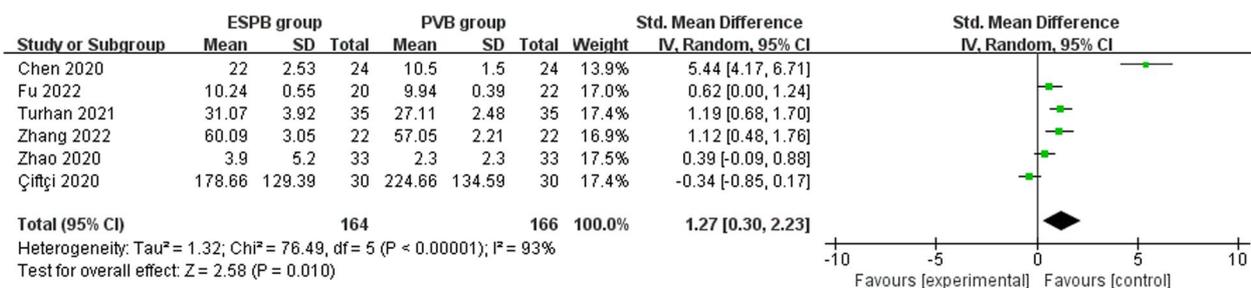
Fig. 6 Forest plot for the meta-analysis of postoperative analgesic consumption
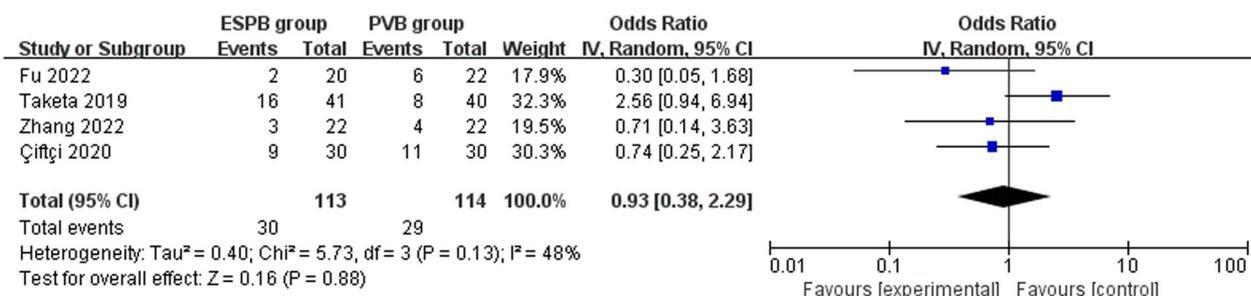
Fig. 7 Forest plot for the meta-analysis of nausea and vomiting

Discussion

Our meta-analysis included seven RCTs and 411 patients. The results suggested that paravertebral block led to substantially reduced pain scores at 12 h and postoperative anesthesia consumption than erector spinae plane block for thoracoscopic surgery, but pain scores at 1–2 h and 4–6 h were similar between two groups.

Many patients still suffer from obvious postoperative pain after thoracoscopic surgery, and needs pharmacologic and regional interventions [23–28]. Multimodal analgesia methods has been widely developed and include nonsteroidal anti-inflammatory drugs, opioids, patient-controlled analgesia (PCA), infiltration analgesia and thoracal epidural block [29]. There are many nerve block methods that are developed for thoracoscopic surgery. Thoracic epidural analgesia (TEA) is a commonly used method for analgesia following thoracotomy, but results in high risk of complications [30]. Both erector spinae plane block and paravertebral nerve block demonstrate important potential in managing postoperative pain for thoracoscopic surgery [10, 11, 31, 32].

Regarding the sensitivity analysis, significant heterogeneity is seen when performing the analysis by omitting one study in turn or subgroup analysis based on anesthetic drugs. It may be caused by several factors including different analgesic drugs (i.e. ropivacaine and bupivacaine) and various concentrations (e.g. ropivacaine 0.25% and 0.5%). In addition, the detail methods and procedures of thoracoscopic surgery are different due to various diseases, and may produce different baseline pain intensity.

Our results found that paravertebral block showed significantly better analgesic efficacy than erector spinae plane block for thoracoscopic surgery. The possible reasons are speculated as, paravertebral block is a nerve block technique by which local anesthetic is injected directly into the thoracic paravertebral space to block the thoracic spinal nerve and the branches as well as the sympathetic trunk, and the local anesthetic could spread cranially and caudally through the loose connective tissue of the thoracic paravertebral space [33], as well as laterally to the intercostal and epidural spaces [34]. These can provide analgesia comparable to that of the thoracic segmental epidural block [11].

In addition, paravertebral block and erector spinae plane block demonstrated similar incidence of nausea and vomiting in our meta-analysis. There were no adverse events such as pneumothorax, nerve injury or local hematoma [10]. This meta-analysis has several potential limitations. Firstly, our analysis is based on only seven RCTs, and more RCTs with larger sample size should be conducted to explore this issue. Next, different types, concentrations, and methods of anesthetic drugs

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in included RCTs may have an influence on the pooling results. Finally, different thoracoscopic surgeries produce various baseline pain intensity.

Conclusions

Paravertebral block may be superior to erector spinae plane block for pain control after thoracoscopic surgery.

Declarations

Ethical approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

References

1. Guo W, Ma X, Yang S, Zhu X, Qin W, Xiang J, Lerut T, Li H. Combined thoracoscopic-laparoscopic esophagectomy versus open esophagectomy: a meta-analysis of outcomes. Surg Endosc. 2016;30(9):3873–81.
2. Sun K, Liu D, Chen J, Yu S, Bai Y, Chen C, Yao Y, Yu L, Yan M. Moderate-severe postoperative pain in patients undergoing video-assisted thoracoscopic surgery: a retrospective study. Sci Rep. 2020;10(1):795.
3. Morris BN, Henshaw DS, Royster RL. Survey of pain management in thoracoscopic surgery. J Cardiothorac Vasc Anesth. 2018;32(4):1756–8.
4. Murakawa T, Sato H, Okumura S, Nakajima J, Horio H, Ozeki Y, Asamura H, Ikeda N, Otsuka H, Matsuguma H, Yoshino I, Chida M, Nakayama M, Iizasa T, Okumura M, Shiono S, Kato R, Iida T, Matsutani N, Kawamura M, Sakao Y, Funai K, Furuyashiki G, Akiyama H, Sugiyama S, Kanauchi N, Shiraishi Y. J. Metastatic Lung Tumor Study Group of, Thoracoscopic surgery versus open surgery for lung metastases of colorectal cancer: a multi-institutional retrospective analysis using propensity score adjustmentdagger. Eur J Cardio-Thoracic Surg. 2017;51(6):1157–63.
5. Kinjo Y, Kurita N, Nakamura F, Okabe H, Tanaka E, Kataoka Y, Itami A, Sakai Y, Fukuhara S. Effectiveness of combined thoracoscopic-laparoscopic esophagectomy: comparison of postoperative complications and midterm oncological outcomes in patients with esophageal cancer. Surg Endosc. 2012;26(2):381–90.
6. Pham TH, Perry KA, Dolan JP, Schipper P, Sukumar M, Sheppard BC, Hunter JG. Comparison of perioperative outcomes after combined thoracoscopic-laparoscopic Ivor-Lewis esophagectomy and open Ivor-Lewis esophagectomy. Am J Surg. 2010;199(5):594–8.
7. Sen Y, Xiyang H, Yu H. Effect of thoracic paraspinal block-propofol intravenous general anesthesia on VEGF and TGF-β in patients receiving radical resection of lung cancer. Medicine. 2019;98(47): e18088.
8. Kang K, Meng X, Li B, Yuan J, Tian E, Zhang J. Effect of thoracic paravertebral nerve block on the early postoperative rehabilitation in patients undergoing thoracoscopic radical lung cancer surgery. World J Surg Oncol. 2020;18(1):1–7.
9. Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The erector spinae plane block: a novel analgesic technique in thoracic neuropathic pain. Reg Anesth Pain Med. 2016;41(5):621–7.
10. Zhang JW, Feng XY, Yang J, Wang ZH, Wang Z, Bai LP. Ultrasound-guided single thoracic paravertebral nerve block and erector spinae plane block for perioperative analgesia in thoracoscopic pulmonary lobectomy: a randomized controlled trial. Insights Imaging. 2022;13(1):16.
11. Fu Z, Zhang Y, Zhou Y, Li Z, Wang K, Li H, Jiang W, Liu Z, Cao X. A comparison of paravertebral block, erector spinae plane block and the combination of erector spinae plane block and paravertebral block for post-operative analgesia after video-assisted thoracoscopic surgery: a randomised controlled trial. J Minimal Access Surg. 2022;18(2):241–7.
12. Turhan Ö, Sivrikoz N, Sungur Z, Duman S, Özkan B, Şentürk M. Thoracic paravertebral block achieves better pain control than erector spinae plane block and intercostal nerve block in thoracoscopic surgery: a randomized study. J Cardiothorac Vasc Anesth. 2021;35(10):2920–7.
13. Zhao H, Xin L, Feng Y. The effect of preoperative erector spinae plane vs. paravertebral blocks on patient-controlled oxycodone consumption after video-assisted thoracic surgery: a prospective randomized, blinded, non-inferiority study. J Clin Anesthesia. 2020;62:109737.
14. Çiftçi B, Ekinci M, Çelik EC, Tukaç İC, Gölboyu BE, Günlüoǧlu MZ, Atalay YO. Ultrasound-guided erector spinae plane block and thoracic paravertebral block for postoperative analgesia management following video-assisted thoracic surgery: a prospective, randomized, controlled study. JARSS. 2020;28(3):170–8.
15. D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, P. Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J Clin Epidemiol. 2009;62(10):1006–12.
16. He B, Zhao J-Q, Zhang M-Z, Quan Z-X. Zoledronic acid and fracture risk: a meta-analysis of 12 randomized controlled trials. Eur Rev Med Pharmacol Sci. 2021;25:1564–73.
17. Jadad AR, Moore RA, Carroll D, Jenkinson C, Reynolds DJM, Gavaghan DJ, McQuay HJ. Assessing the quality of reports of randomized clinical trials: Is blinding necessary? Control Clin Trials. 1996;17(1):1–12.
18. Kjaergard LL, Villumsen J, Gluud C. Reported methodologic quality and discrepancies between large and small randomized trials in meta-analyses. Ann Intern Med. 2001;135(11):982–9.
19. Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med. 2002;21(11):1539–58.
20. Guyatt GH, Oxman AD, Vist GE, Kunz R, Falck-Ytter Y, Alonso-Coello P, Schunemann HJ, Group GW. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008;336(7650):924–6.
21. Chen N, Qiao Q, Chen R, Xu Q, Zhang Y, Tian Y. The effect of ultrasound-guided intercostal nerve block, single-injection erector spinae plane block and multiple-injection paravertebral block on postoperative analgesia in thoracoscopic surgery: A randomized, double-blinded, clinical trial. J Clin Anesth. 2020;59:106–11.
22. Taketa Y, Irisawa Y, Fujitani T. Comparison of ultrasound-guided erector spinae plane block and thoracic paravertebral block for postoperative analgesia after video-assisted thoracic surgery: a randomized controlled non-inferiority clinical trial. Region Anesthesia Pain Med. 2019.
23. Davies RG, Myles PS, Graham JM. A comparison of the analgesic efficacy and side-effects of paravertebral vs epidural blockade for thoracotomy–a systematic review and meta-analysis of randomized trials. Br J Anaesth. 2006;96(4):418–26.

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24. J.F. Sztain, R.A. Gabriel, E.T. Said, Thoracic Epidurals are Associated With Decreased Opioid Consumption Compared to Surgical Infiltration of Liposomal Bupivacaine Following Video-Assisted Thoracoscopic Surgery for Lobectomy: A Retrospective Cohort Analysis, Journal of cardiothoracic and vascular anesthesia (2018).

25. Adhikary SD, Pruett A, Forero M, Thiruvenkatarajan V. Erector spinae plane block as an alternative to epidural analgesia for post-operative analgesia following video-assisted thoracoscopic surgery: a case study and a literature review on the spread of local anaesthetic in the erector spinae plane. Indian J Anaesth. 2018;62(1):75–8.

26. Wang X, Wang K, Wang B, Jiang T, Xu Z, Wang F, Yu J. Effect of oxycodone combined with dexmedetomidine for intravenous patient-controlled analgesia after video-assisted thoracoscopic lobectomy. J Cardiothorac Vasc Anesth. 2016;30(4):1015–21.

27. Zhang Y, He B, Zhao J, Zhang M, Ren Q, Zhang W, Xu S, Quan Z, Ou Y. Addition of celebrex and pregabalin to ropivacaine for posterior spinal surgery: a randomized, double-blinded, placebo-controlled trial. Am J Rhinol Allergy. 2021;15:735–42.

28. Zhao J, Zhang S, Li X, He B, Ou Y, Jiang D. Comparison of minimally invasive and open transforaminal lumbar interbody fusion for lumbar disc herniation: a retrospective cohort study. Med Sci Monit: Int Med J Exp Clin Res. 2018;24:8693–8.

29. Piccioni F, Segat M, Falini S, Umari M, Putina O, Cavaliere L, Ragazzi R, Massullo D, Taurchini M, Del Naja C, Droghetti A. Enhanced recovery pathways in thoracic surgery from Italian VATS Group: perioperative analgesia protocols. J Thorac Dis. 2018;10(Suppl 4):S555-s563.

30. Khoshbin E, Al-Jilaihawi AN, Scott NB, Prakash D, Kirk AJ. An audit of pain control pathways following video-assisted thoracoscopic surgery. Innovations (Philadelphia, Pa). 2011;6(4):248–52.

31. Pişkin Ö, Gökçe M, Altınsoy B, Baytar Ç, Aydın BG, Okyay RD, Küçükosman G, Bollucuoğlu K, Ayoğlu H. Effects of continuous erector spinae plane block on postoperative pain in video-assisted thoracoscopic surgery: a randomized controlled study. Gen Thorac Cardiovasc Surg. 2022;70(1):64–71.

32. Liu L, Ni XX, Zhang LW, Zhao K, Xie H, Zhu J. Effects of ultrasound-guided erector spinae plane block on postoperative analgesia and plasma cytokine levels after uniportal VATS: a prospective randomized controlled trial. J Anesth. 2021;35(1):3–9.

33. Albokrinov AA, Fesenko UA. Spread of dye after single thoracolumbar paravertebral injection in infants. A cadaveric study. Eur J Anaesthesiol. 2014;31(6):305–9.

34. Richardson J, Lönnqvist PA, Naja Z. Bilateral thoracic paravertebral block: potential and practice. Br J Anaesth. 2011;106(2):164–71.

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