

META-ANALYSIS

The analgesic effect of erector spinae plane block in thoracic surgery: a systematic review and meta-analysis of randomized controlled trials

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Abstract

The erector spinae plane block (ESPB) is a new analgesic technology that came out for the first time in 2016. Some studies have shown that it can provide effective analgesia in thoracic surgery. This systematic review and meta-analysis is to evaluate the analgesic effect of ESPB in patients undergoing thoracic surgery. Embase, PubMed, The Cochrane Library, VIP database, CNKI, Wanfang database, CBM, were systematically searched, from 2010 to December, 2020. Randomised controlled trials (RCTs) were included to assess the analgesic effect of the ESPB in thoracic surgery. Eighteen studies with a total of 1303 patients were included. ESPB group reduced postoperative 48-hour pain scores at rest or movement at different time points compared with the control group. ESPB group also showed lower incidence of postoperative nausea and vomiting (PONV) (odds ratio, OR = 0.48, 95% CI = 0.33 0.71, $P < 0.05$). ESPB group were better at the number of patient-controlled intravenous analgesia (PCIA) pressing times (mean difference, MD = -6.83, 95% CI = -8.73 -4.94, $P < 0.05$). This review has shown that compared with simple general anesthesia (GA), GA combined with ESPB significantly decreases postoperative pain, PONV and opioids requirements following thoracic surgery.

Keywords

Erector spinae plane block; Thoracic surgery; Analgesia; Meta-analysis; Randomized controlled trial

1. Introduction

Pain following thoracic surgery procedures compromises respiratory function, increases the incidence of pulmonary complications, and extends the hospital stay [1]. Postoperative pain causes the release of chemicals and cytokines, which can make the body in a state of stress and adversely affect multiple organ systems [2]. If acute postoperative pain is not controlled in a timely and proper fashion, it can lead to chronic postsurgical pain in up to fifty percent of patients [3]. Therefore, improved postoperative analgesia mode is of great importance to thoracic surgery patients.

General anesthesia (GA) combined with patient-controlled intravenous analgesia (PCIA) is widely used in thoracic surgical procedures. However, this analgesia technique may lead to postoperative nausea and vomiting (PONV), respiratory depression, and drowsiness since the use of large amounts of opioids [4, 5].

With the rapid development of ultrasound-guided visualization techniques, GA combined with various regional blocks have become more and more popular in clinical practice. Previous studies have shown that anesthesia effects is greatly improved if the diffusion of local anesthetics in the blocked region is performed under ultrasound guidance [6, 7]. As

one kind of regional block, the erector spinae plane block (ESPB) came out for the first time in 2016, Forero proposed: ESPB achieved good results in treating neuropathic pain [8]. Subsequent studies suggested that ESPB could also achieve good results when applied to perioperative analgesia during thoracic and abdominal surgery [9].

However, no researchers have conducted a systematic review and meta-analysis only focus on thoracic surgery, so the analgesic effect of ESPB in thoracic surgery patients is still inconclusive. Therefore, this study was undertaken to evaluate the analgesic effect of ESPB in thoracic surgery patients compared to patients undergoing only GA, and provide it with clinical application.

2. Methods

2.1 Materials and methods

We conducted a systematic review of the analgesic effect of ESPB in thoracic surgery patients based on the PRISMA principle. The study was registered on the PROSPERO platform. Registration number: CRD 42021223677.

2.2 Selection criteria

The inclusion criteria included studies involving thoracic surgery patients in randomized controlled trials (RCT), in which patients in the experimental group received single ESPB, compared to a control group which received no block or only normal saline. The primary outcome was postoperative pain scores at different time points using either a visual analogue scale (VAS) or a numerical rating scale (NRS). The secondary outcome was the incidence of PONV, and the number of PCIA pressing times.

Exclusion criteria include non-thoracic surgery patients, non-RCT studies without the original data or data that could not be used for conversion; case reports, letters, repeated publications, and systematic reviews.

2.3 Search strategy

Embase, PubMed, The Cochrane Library, VIP database, CNKI, Wanfang database and CBM were searched by using the combination of subject words and free words. Search words included Erector spinae plane block, ESPB, ESP, thoracic, video-assisted thoracoscopic surgery, VATS, and randomized controlled trial, RCT, and so on. Although ESPB was first proposed in 2016, we searched the literature over the last ten years in order to avoid omissions. The retrieval time was from 2010 to December, 2020.

2.4 Literature screening and data extraction

After systematic and comprehensive literature retrieval, Endnote X7 software was used for literature selection and classification. Two researchers screened all literature according to the selection criteria to determine the final inclusion. Then they read the remaining literature independently, used the same form to record and analyze, and asked a third-party to arbitrate if inclusion could not be resolved. The extraction contents included: first author, publication time, sample size of both groups, puncture site, type and concentration of local anesthetics, VAS or NRS scores at different times, incidence of PONV, and the number of PCIA pressing times. In the process of data extraction, two evaluators independently measured the relevant data expressed as graphs before calculating the mean value. Data presented as median (interquartile range) was uniformly converted into the form of mean and standard deviation according to the method provided in the Cochrane system evaluator's manual.

2.5 Quality assessment

The Cochrane Manual RCT risk bias assessment tool was used for quality assessment, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias.

2.6 Statistical analysis

Revman 5.3 statistical software was used for data processing and forest plot drawing. Measurement data were expressed

by mean difference (MD) and 95% confidence intervals (CI), count data were expressed by odds ratio (OR) and 95% CI. The Q test and I^2 test were used to test for heterogeneity: if $P > 0.1$ and $I^2 < 50\%$, the heterogeneity was small and the data was analyzed by fixed effects model; when $P \leq 0.1$ or $I^2 \geq 50\%$, the heterogeneity was significant and sensitivity or subgroup analysis was conducted to find the cause. Random effects models were used when no source of heterogeneity was found.

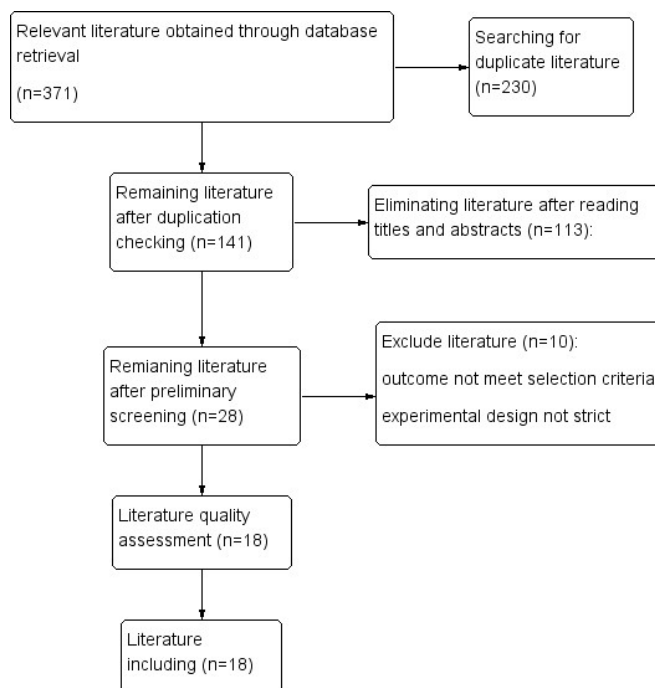


FIGURE 1. Literature screening flow chart.

3. Results

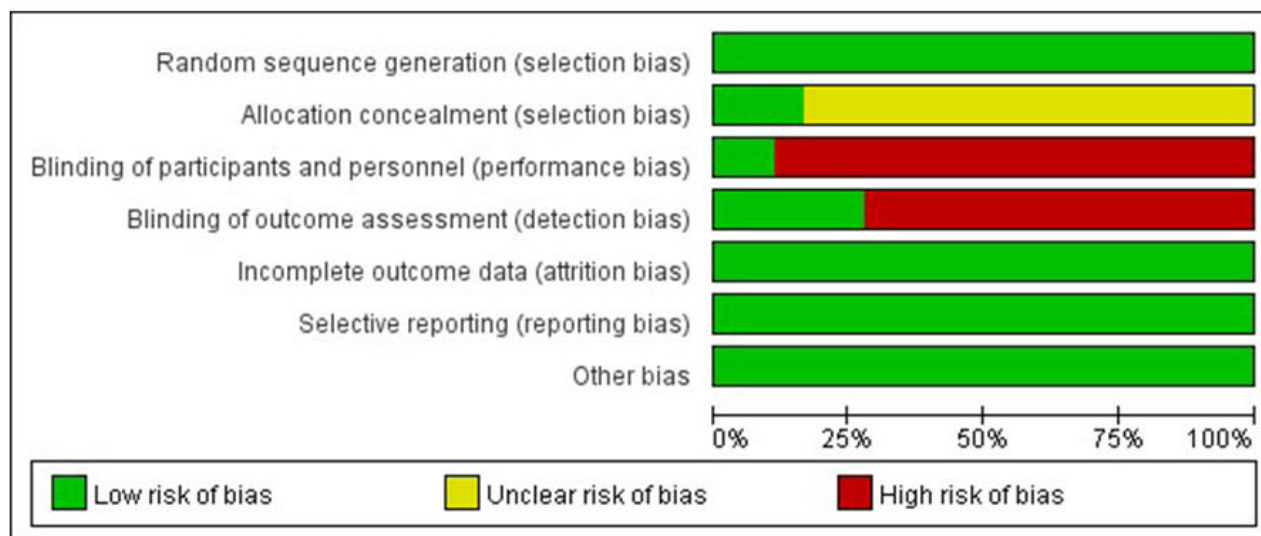
A total of 371 studies were retrieved, of which 18 RCTs were included [10–27]. There were 1303 patients: 652 in ESPB group and 651 in control group. The screening flow chart is shown in Fig. 1. The basic characteristics of the included literature are shown in Table 1. The Cochrane risk bias assessment results for all the references are displayed in Fig. 2.

3.1 Pain scores at different time points

3.1.1 Postoperative 2 hour pain scores

Among all included studies, twelve studies [10, 11, 13–15, 19, 20, 22–25, 27] and seven studies [10, 11, 13, 15, 23, 25, 27] reported postoperative 2 hour pain scores at rest or movement respectively. Pain scores of ESPB group were significantly lower than those of the control group at rest or movement. (MD = -1.98 , 95% CI = $-2.55 \sim -1.42$, $I^2 = 98\%$, $P < 0.05$; MD = -2.62 , 95% CI = $-3.40 \sim -1.85$, $I^2 = 95\%$, $P < 0.05$) (Fig. 3), the differences were statistically significant. There was great heterogeneity between studies, but no cause was found after conducting sensitivity and subgroup analyses.

A



B

	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)	Selective reporting (reporting bias)	Other bias
Bahadir 2019	+	?	+	+	+	+	+
Bahadir 2020	+	?	+	+	+	+	+
Bian 2019	+	?	+	+	+	+	+
Chen 2020	+	?	+	+	+	+	+
Lin 2020	+	+	+	+	+	+	+
Lin W 2019	+	?	+	+	+	+	+
Ma 2017	+	?	+	+	+	+	+
Shim 2020	+	+	+	+	+	+	+
Tian 2019	+	?	+	+	+	+	+
Wang G 2018	+	?	+	+	+	+	+
Wang J 2019	+	?	+	+	+	+	+
Wang Y 2018	+	?	+	+	+	+	+
Yang 2019	+	?	+	+	+	+	+
Yao 2020	+	+	+	+	+	+	+
Zhang C 2018	+	?	+	+	+	+	+
Zhang Y 2020	+	?	+	+	+	+	+
Zhao 2019	+	?	+	+	+	+	+
Zhou 2019	+	?	+	+	+	+	+

FIGURE 2. Cochrane risk bias assessment.

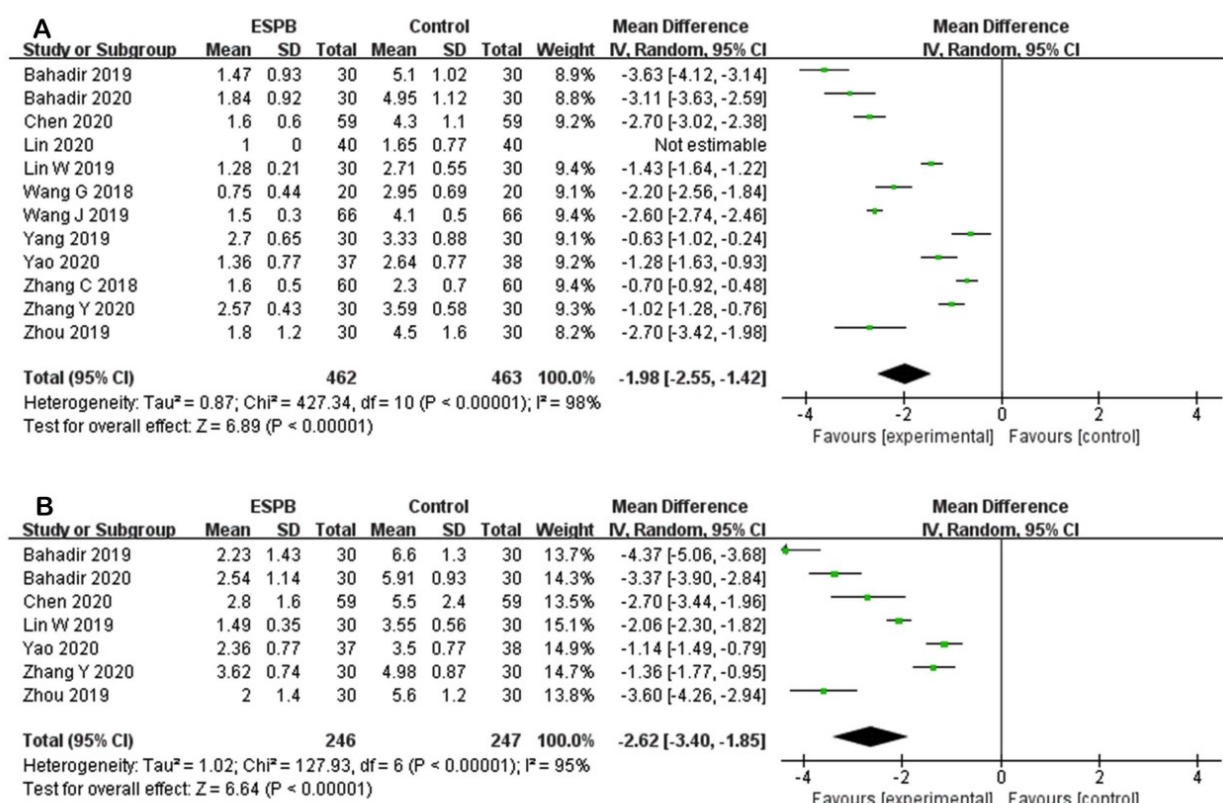


FIGURE 3. Forest plots of postoperative 2 hour pain scores. (A) postoperative 2 hour pain scores at rest. (B) postoperative 2 hour pain scores at movement.

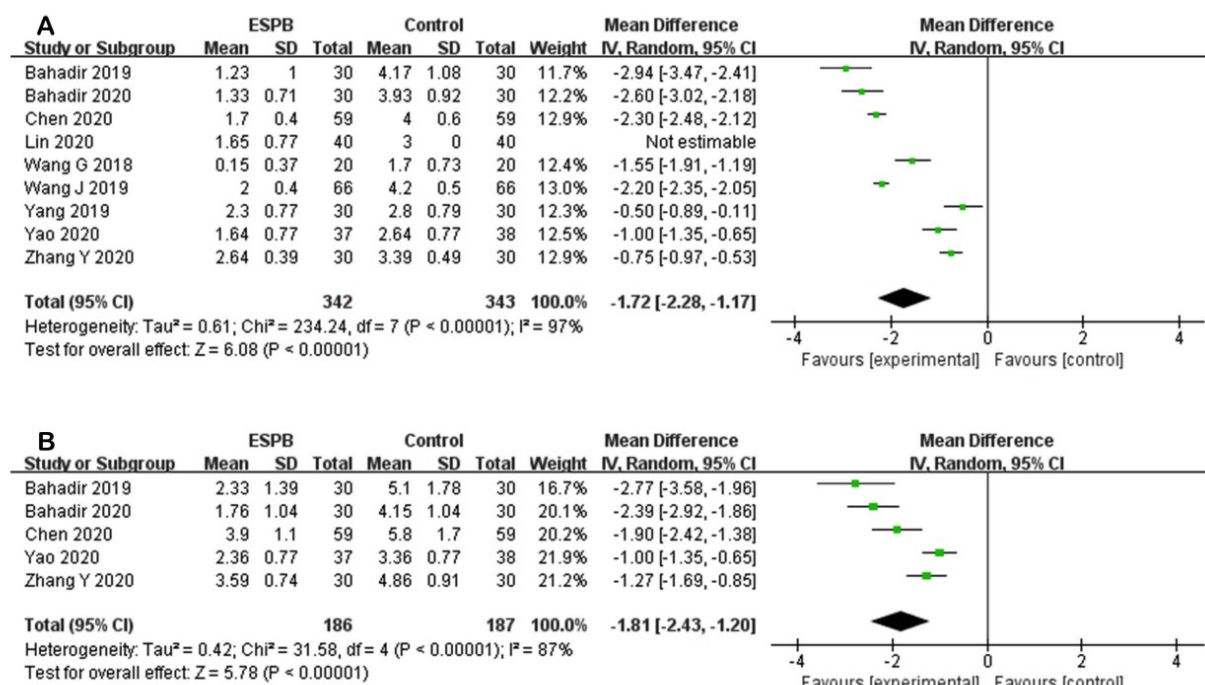


FIGURE 4. Forest plots of postoperative 8 hour pain scores. (A) postoperative 8 hour pain scores at rest. (B) postoperative 8 hour pain scores at movement.

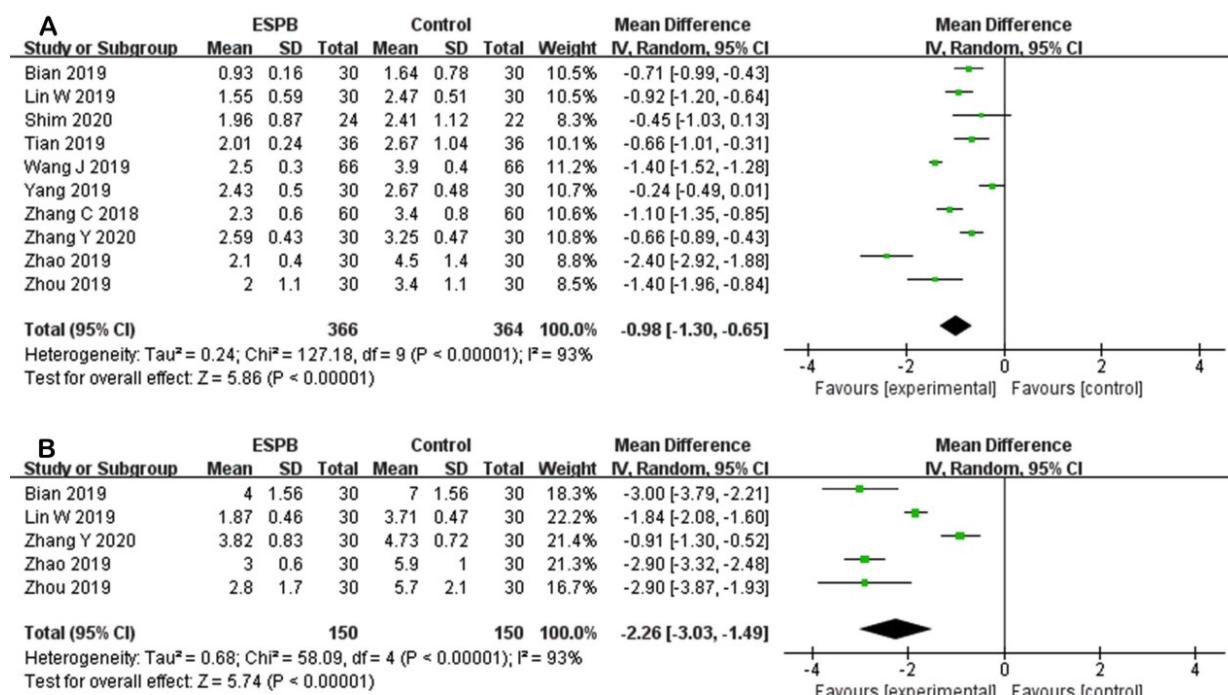


FIGURE 5. Forest plots of postoperative 12 hour pain scores. (A) postoperative 12 hour pain scores at rest. (B) postoperative 12 hour pain scores at movement.

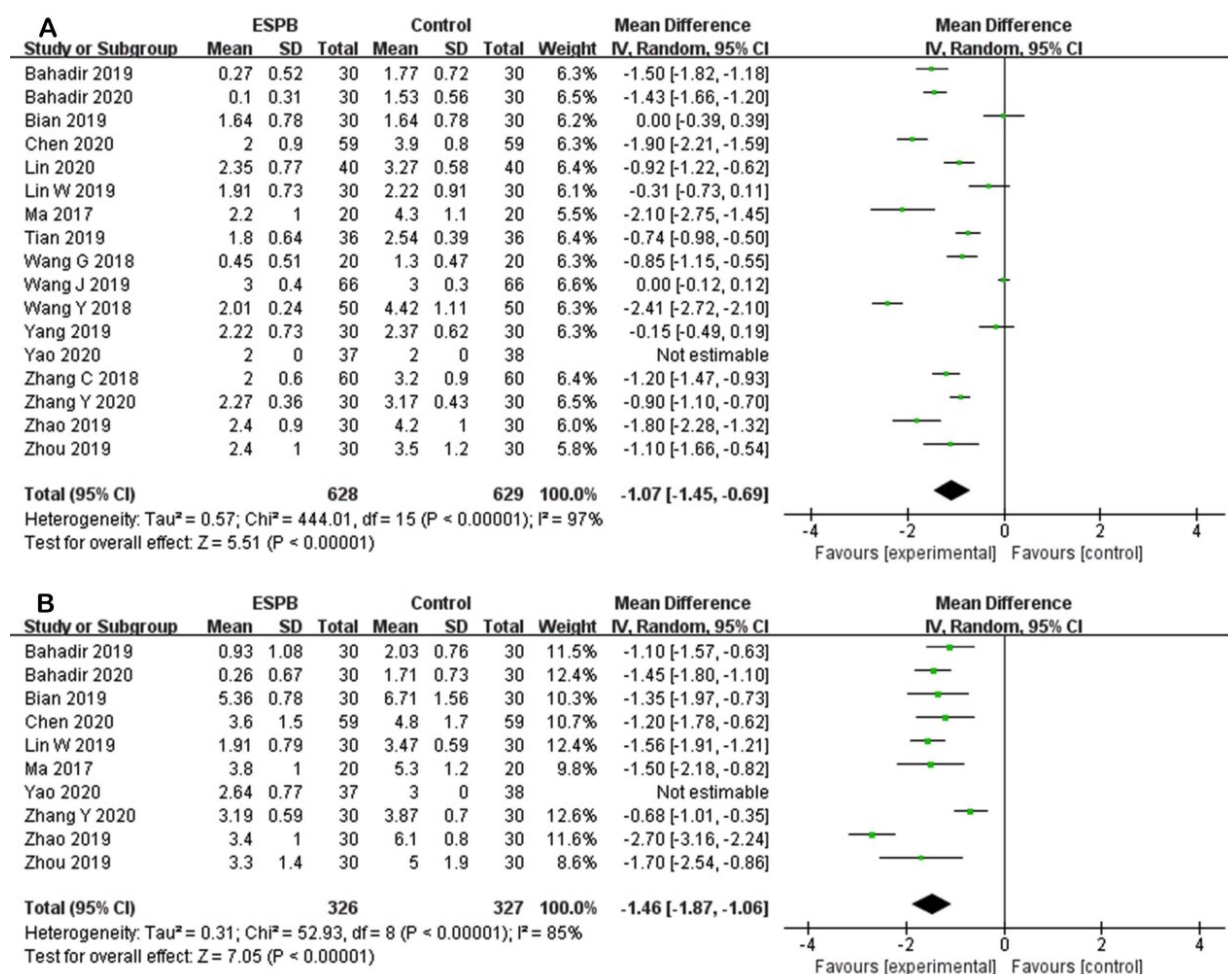


FIGURE 6. Forest plots of postoperative 24 hour pain scores. (A) postoperative 24 hour pain scores at rest. (B) postoperative 24 hour pain scores at movement.

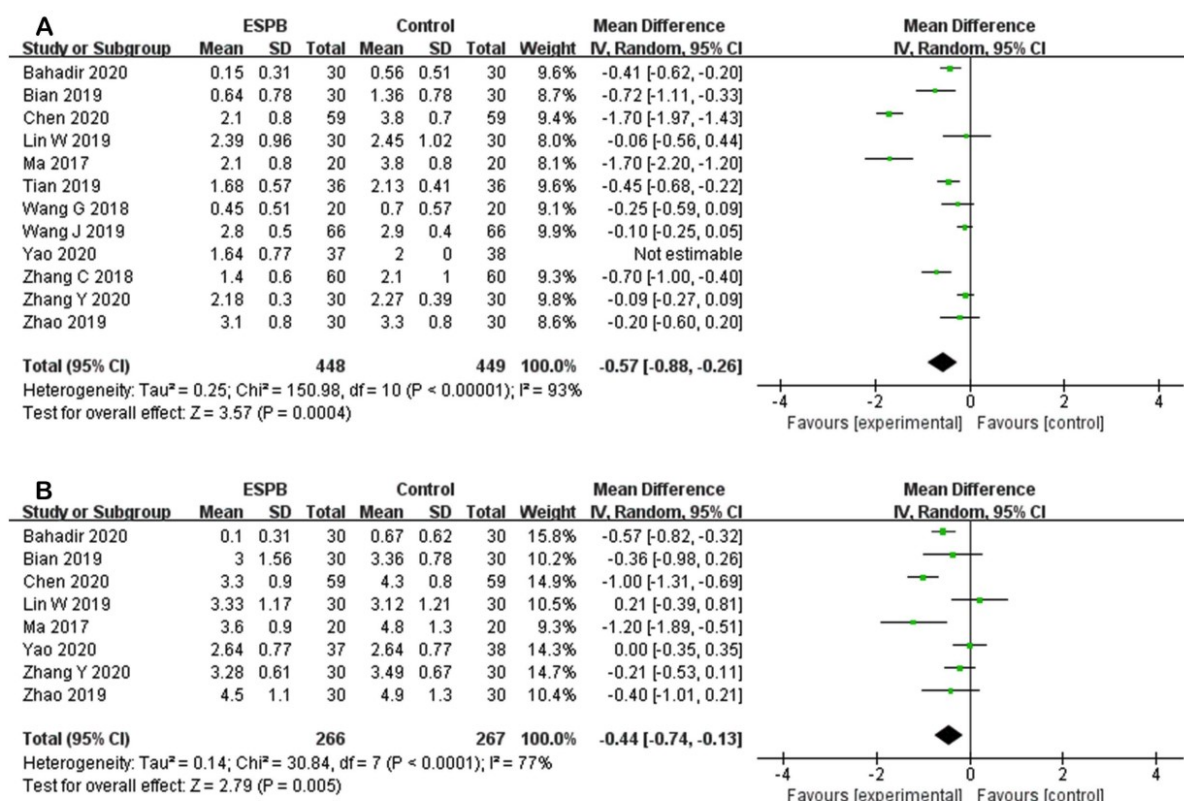


FIGURE 7. Forest plots of postoperative 48 hour pain scores. (A) postoperative 48 hour pain scores at rest. (B) postoperative 48 hour pain scores at movement.

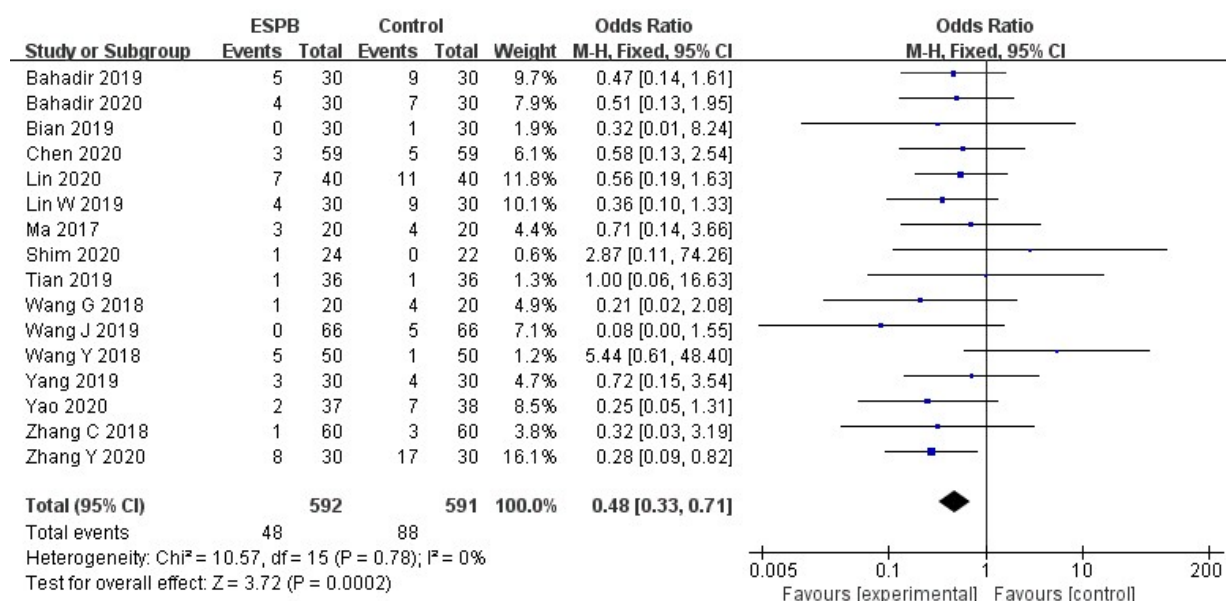


FIGURE 8. Forest plots of PONV.

TABLE 1. Characteristics of the included literature.

Including literature	Sample (ESPB/control)	Puncture location	Local anesthetic dose	Control measures	Pain score scale	Outcome indicator
Bahadir2019	30/30	T5	20 mL 0.25% bupivacaine	No block	VAS	1, 2
Bahadir2020	30/30	T5	20 mL 0.25% bupivacaine	No block	VAS	1, 2
Bian2019	30/30	T5	20 mL 0.5% ropivacaine	No block	VAS	1, 2, 3
Chen2020	59/59	Not clear	30 mL 0.5% ropivacaine	No block	VAS	1, 2, 3
Lin2020	40/40	T5	25 mL 0.4% ropivacaine	No block	NRS	1, 2
Lin W2019	30/30	T5	25 mL 0.4% ropivacaine	Normal saline	VAS	1, 2
Ma2017	20/20	T5	30 mL 0.5% ropivacaine	No block	VAS	1, 2, 3
Shim2020	24/22	T5	25 mL 0.5% ropivacaine	Normal saline	NRS	1, 2
Tian2019	36/36	T5	20 mL 0.5% ropivacaine	No block	VAS	1, 2, 3
Wang G2018	20/20	T5	30 mL 0.375% ropivacaine	Normal saline	VAS	1, 2, 3
Wang J2019	66/66	T5	30 mL 0.5% ropivacaine	No block	VAS	1, 2
Wang Y2018	50/50	T5	30 mL 0.5% ropivacaine	No block	VAS	1, 2, 3
Yang2019	30/30	T5	20 mL 0.375% ropivacaine	Normal saline	VAS	1, 2
Yao2020	37/38	T5	25 mL 0.5% ropivacaine	Normal saline	NRS	1, 2
Zhang C2018	60/60	T5	25 mL 0.5% ropivacaine	No block	VAS	1, 2, 3
Zhang Y2020	30/30	T5	20 mL 0.5% ropivacaine	No block	NRS	1, 2, 3
Zhao2019	30/30	T5	30 mL 0.5% ropivacaine	No block	VAS	1, 3
Zhou2019	30/30	T4	15 mL 0.5% ropivacaine	No block	VAS	1, 3

1: Visual analogue scale (VAS) or Numerical rating scale (NRS); 2: Postoperative nausea and vomiting; 3: Number of patient-controlled intravenous analgesia (PCIA) pressing times.

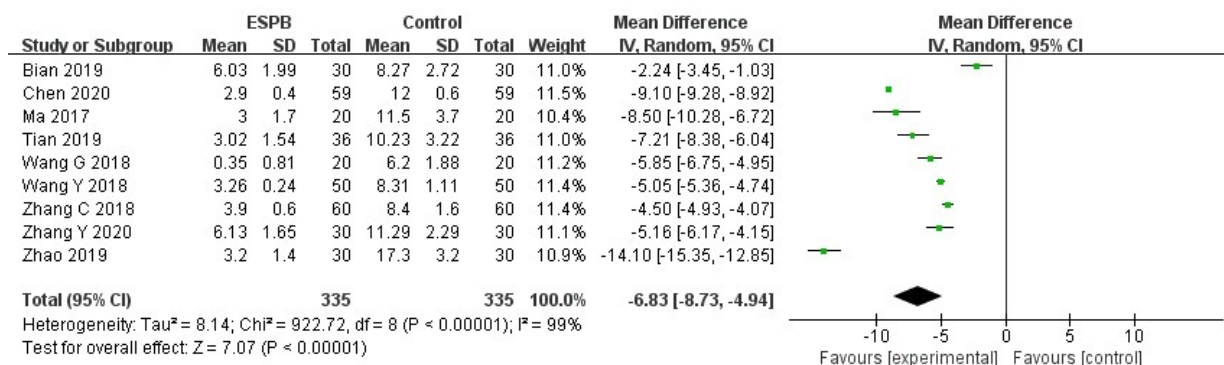


FIGURE 9. Forest plots of the number of PCIA pressing times.

3.1.2 Postoperative 8 hour pain scores

Among all included studies, nine studies [10, 11, 13, 14, 19, 20, 22, 23, 25] and five studies [10, 11, 13, 23, 25] reported postoperative 8 hour pain scores at rest or movement respectively. Pain scores in the ESPB group were lower than those in the control group at rest or movement. ($MD = -1.72$, 95% $CI = -2.28 \sim -1.17$, $I^2 = 97\%$, $P < 0.05$; $MD = -1.81$, 95% $CI = -2.43 \sim -1.20$, $I^2 = 87\%$, $P < 0.05$) (Fig. 4), the differences were statistically significant.

3.1.3 Postoperative 12 hour pain scores

Among the included studies, ten studies [12, 15, 17, 18, 20, 22, 24–27] and five studies [12, 15, 25–27] reported postoperative 12 hour pain scores at rest or movement respectively. Pain scores of the ESPB group were significantly lower than those of the control group at rest or movement. ($MD = -0.98$, 95% $CI = -1.30 \sim -0.65$, $I^2 = 93\%$, $P < 0.05$; $MD = -2.26$, 95% $CI = -3.03 \sim -1.49$, $I^2 = 93\%$, $P < 0.05$) (Fig. 5), the differences were statistically significant.

3.1.4 Postoperative 24 hour pain scores

Among the included studies, seventeen studies [10–16, 18–27] and ten studies [10–13, 15, 16, 23, 25–27] reported postoperative 24 hour pain scores at rest or movement respectively. Pain scores in the ESPB group were significantly lower than those of the control group at rest or movement. ($MD = -1.07$, 95% $CI = -1.45 \sim -0.69$, $I^2 = 97\%$, $P < 0.05$; $MD = -1.46$, 95% $CI = -1.87 \sim -1.06$, $I^2 = 85\%$, $P < 0.05$) (Fig. 6), the differences were statistically significant.

3.1.5 Postoperative 48 hour pain scores

Among the included studies, twelve studies [11–13, 15, 16, 18–20, 23–26] and eight studies [11–13, 15, 16, 23, 25, 26] reported postoperative 48 hour pain scores at rest or movement respectively. Pain scores in the ESPB group were significantly lower than those of the control group at rest or movement. ($MD = -0.57$, 95% $CI = -0.88 \sim -0.26$, $I^2 = 93\%$, $P < 0.05$; $MD = -0.44$, 95% $CI = -0.74 \sim -0.13$, $I^2 = 77\%$, $P < 0.05$) (Fig. 7), the differences were statistically significant.

3.2 PONV

Sixteen studies [10–25] compared the incidence of PONV. The heterogeneity test showed: $I^2 = 0\%$, $P = 0.78$, indicating

that the heterogeneity between the studies was small. The incidence of PONV in the ESPB group was significantly lower than that in the control group ($OR = 0.48$, 95% $CI = 0.33 \sim 0.71$, $I^2 = 0\%$, $P < 0.05$) (Fig. 8), the difference was statistically significant.

3.3 Number of PCIA pressing times

Nine studies [12, 13, 16, 18, 19, 21, 24–26] reported the number of PCIA pressing times. There was heterogeneity between studies ($I^2 = 99\%$, $P < 0.1$), and random effects models were used to combine statistics. The results suggested that the number of PCIA pressing times in the ESPB group was significantly lower than the control group ($MD = -6.83$, 95% $CI = -8.73 \sim -4.94$, $I^2 = 99\%$, $P < 0.05$) (Fig. 9), the difference was statistically significant.

4. Discussion

Postoperative pain increases systematic stress responses which contributes to adverse complications [28]. Multimodal analgesia relieves postoperative pain, controls surgical stress and achieves early recovery through a combination of analgesics and/or complex regional blocks [29]. ESPB is located near the intervertebral foramen and rapidly diffuses into the paravertebral space after injection of a local anesthetic, which effectively blocks the dorsal, ventral, and communicating branches of the spinal nerves [30]. Since its introduction in 2016, ESPB has been recognized as a simple, safe, feasible and effective analgesic method in multiple clinical trials [31]. When ESPB is used for thoracotomy analgesia, the incidence of nerve injury and total spinal anesthesia is lower than epidural analgesia and thoracic paravertebral block (TPVB) [32], which has resulted in its increasing application in clinical practice.

This meta-analysis has demonstrated that: (1) GA combined with ESPB can alleviate postoperative pain comparing to GA alone; (2) the incidence of PONV with ESPB is significantly lower than that with GA alone; (3) the number of PCIA pressing times with ESPB is less than GA, resulting in less need for analgesics. There were no complications associated with ESPB puncture. These results were in accordance with previous study [33].

Several studies have showed that ESPB could achieve satisfactory analgesia results in different types of surgery. Ueshima H [34] found that ESPB could obviate the use of opioids during

thoracic surgery, and intravenous anesthesia of opioids-free could be used for intraoperative maintenance of anesthesia, providing both intraoperative analgesia and stable hemodynamics. Chin KJ [35] indicated that bilateral ESPB used in four patients undergoing abdominal hernia repair surgery achieved good analgesia in the range of upper chest to L2 or L3, and reduced the dosage of postoperative opioids within the first 24 hours, which resulted in longer and more sustained postoperative analgesia.

Several studies have reported that ESPB may reduce postoperative complications. Huang W [33] found that ESPB resulted in equivalent analgesic efficacy to TPVB without an increased incidence of PONV and was a suitable alternative choice to TPVB. Another meta-analysis [36] found that postoperative pain scores in patients who received ESPB were lower than those in the control group at rest or at movement, regardless of whether they had thoracic or spinal and abdominal surgery. Researchers also proved that ESPB reduced PONV and provided comfortable experience with patients.

There are several limitations of our study: First, the dosage, concentration and types of local anesthetics were different, which may lead to high heterogeneity. Second, pain scores are subjective indicators and they are greatly influenced by age, race and educational levels. Third, all included studies contained different languages, and there may be differences in regional and observational indicators. Finally, due to the limitation of the blinded methods of studies included, future researches should perform more analyses which includes more studies with blinded methods to provide valuable information for clinical practice.

In conclusion, we found that the application of ESPB in thoracic surgery is a promising analgesic technique and can effectively relieve patients' postoperative pain, decrease the incidence of PONV, and reduce the number of PCIA press times. Additional multicenter studies with a larger sample size, using blinded techniques are necessary to document the favorable effects of ESPB in thoracic surgery patients.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

YL and HXL designed the study and collected related paper. YL and HXL drafted and revised the manuscript. YLH and HYG performed statistical analyses. YL, YLH and HYG participated in the design of the review and helped to draft and revise the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- [1] Gagne S, McIsaac DI. Modifiable risk factors for patients undergoing lung cancer surgery and their optimization: a review. *Journal of Thoracic Disease*. 2018; 10: S3761–S3772.
- [2] Kehlet H. Multimodal approach to control postoperative pathophysiology and rehabilitation. *British Journal of Anaesthesia*. 1997; 78: 606–617.
- [3] Bayman EO, Brennan TJ. Incidence and severity of chronic pain at 3 and 6 months after thoracotomy: meta-analysis. *The Journal of Pain*. 2014; 15: 887–897.
- [4] Simonelli MC, Doyle LT, Columbia M, Wells PD, Benson KV, Lee CS. Effects of Connective Tissue Massage on Pain in Primiparous Women After Cesarean Birth. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*. 2018; 47: 591–601.
- [5] Schmidt P, Berger MB, Day L, Swenson CW. Home opioid use following cesarean delivery: How many opioid tablets should obstetricians prescribe? *Journal of Obstetrics and Gynaecology Research*. 2018; 44: 723–729.
- [6] Saad FS, El Baradie SY, Abdel Aliem MAW, Ali MM, Kotb TAM. Ultrasound-guided serratus anterior plane block versus thoracic paravertebral block for perioperative analgesia in thoracotomy. *Saudi Journal of Anaesthesia*. 2018; 12: 565–570.
- [7] Zhu M, Gu Y, Sun X, Liu X, Chen W, Miao C. Ultrasound-Guided Intercostal Nerve Block Following Esophagectomy for Acute Postoperative Pain Relief in the Postanesthesia Care Unit. *Pain Practice*. 2018; 18: 879–883.
- [8] Forero M, Adhikary SD, Lopez H, Tsui C, Chin KJ. The Erector Spinae Plane Block: A Novel Analgesic Technique in Thoracic Neuropathic Pain. *Regional Anesthesia & Pain Medicine*. 2016; 41: 621–627.
- [9] De Cassai A, Bonvicini D, Correale C, Sandei L, Tulgar S, Tonetti T. Erector spinae plane block: a systematic qualitative review. *Minerva Anestesiologica*. 2019; 85: 308–319.
- [10] Ciftci B, Ekinci M, Celik EC, Tukac IC, Bayrak Y, Atalay YO. Efficacy of an Ultrasound-Guided Erector Spinae Plane Block for Postoperative Analgesia Management After Video-Assisted Thoracic Surgery: A Prospective Randomized Study. *Journal of Cardiothoracic and Vascular Anesthesia*. 2020; 34: 444–449.
- [11] Ciftci B, Ekinci M, Celik EC, Tukac IC, Golboyu BE, Gunluoglu MZ, et al. Ultrasound-guided erector spinae plane block and thoracic paravertebral block for postoperative analgesia management following video-assisted thoracic surgery: a prospective, randomized, controlled study. *Anestezi Dergisi*. 2020; 28: 170–178.
- [12] Bian Y, Lu J, Liu Z, Zhang N, Xue C. Comparison of analgesic effects of ultrasound-guided paravertebral nerve block and erector spinae plane block in thoracoscopic lobectomy. *Shandong Medical Journal*. 2019; 59: 62–64. (In Chinese)
- [13] Chen A, Xiang Y, Luo P, Ye Y. Effect of ultrasound-guided erector spinae plane block on analgesia after thoracoscopic surgery. *Chinese Remedies & Clinics*. 2020; 20: 887–889.
- [14] 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. *Journal of Anesthesia*. 2021; 35: 3–9.
- [15] Lin W, Chai B, Lin F, Li S, Zhang C, Ma B. Effect of dexmedetomidine combined with ropivacaine used in erector spinae plane block on

- postoperative pain after thoracoscopic surgery. *Practical Pharmacy and Clinical Remedies*. 2019; 22: 697–700.
- [16] Ma D, Ren H, Rui Y, Ma Z, Wu A, Wang Y. Effect of ultrasound-guided single erector spinae plane block on postoperative self-controlled intravenous analgesia in patients undergoing video-assisted thoracoscopic lobectomy. *Journal of Clinical Anesthesiology*. 2017; 33: 965–967.
- [17] Shim JG, Ryu KH, Kim PO, Cho EA, Ahn JH, Yeon JE, *et al.* Evaluation of ultrasound-guided erector spinae plane block for postoperative management of video-assisted thoracoscopic surgery: a prospective, randomized, controlled clinical trial. *Journal of Thoracic Disease*. 2020; 12: 4174–4182.
- [18] Tian M, Liu X, Liu F, Cao L. The application of ultrasound-guided erector spinae plane block in thoracoscopic radical resection of lung cancer. *Journal of Bethune Medical Science*. 2019; 17: 336–338. (In Chinese)
- [19] Wang G. The effect of ultrasound-guided single erector spinae plane block on analgesia in patients undergoing tuberculous empyema thoracotomy. *Journal of Imaging Research and Medical Applications*. 2018; 2: 180–182.
- [20] Wang J, Guo P, Lu J, Gao Q, Sheng J. Analgesic effect of pulmonary lobectomy under erector spinae plane block. *Zhejiang Journal of Traumatic Surgery*. 2019; 24: 843–845. (In Chinese)
- [21] Wang Y, Kong M. Analgesic Effect of Single Erector Spinae Block After Ultrasound Guided Operation. *China Continuing Medical Education*. 2018; 10: 88–90.
- [22] Yang J, Ma L, Qiu Y. Effect of ultrasound-guided single erector spine plane block for analgesia after video-assisted thoracoscopic surgery. *Chinese Journal of Postgraduates of Medicine*. 2019; 42: 481–484.
- [23] Yao Y, Fu S, Dai S, Yun J, Zeng M, Li H, *et al.* Impact of ultrasound-guided erector spinae plane block on postoperative quality of recovery in video-assisted thoracic surgery: A prospective, randomized, controlled trial. *Journal of Clinical Anesthesia*. 2020; 63: 109783.
- [24] Zhang C, Wang J, Chen Y. Effect of ultrasound guided ESP block combined with PCIA on the analgesia of post-thoracoscopy lung cancer resection. *Oncology Progress*. 2018; 16: 967–969.
- [25] Zhang Y, Zhao D, Xu D, Lan Z, Peng W. Effect of ultrasound-guided erector spinae plane block on postoperative analgesia and cellular immunity in patients undergoing video-assisted thoracoscopic lobectomy. *China Journal of Endoscopy*. 2020; 26: 41–48.
- [26] Zhao Y, Yu S, Zheng S, Tao Y, Wang G. Application of ultrasound-guided erector spinae plane block on intraoperative and postoperative analgesia in patients undergoing chronic empyema. *Journal of Clinical Anesthesiology*. 2019; 35: 129–132.
- [27] Zhou J, Liu S, Cui M, Hu Z. Effects of ultrasound-guided erector spinae plane block on analgesic effect and stress response in elderly patients undergoing single hole thoracoscopic radical resection of pulmonary carcinoma. *Chongqing Yixue*. 2019; 48: 1213–1215. (In Chinese)
- [28] Maxwell C, Nicoara A. New developments in the treatment of acute pain after thoracic surgery. *Current Opinion in Anesthesiology*. 2014; 27: 6–11.
- [29] Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. *The American Journal of Surgery*. 2002; 183: 630–641.
- [30] Chin KJ, Adhikary S, Forero M. Is the erector spinae plane (ESP) block a sheath block? A reply. *Anaesthesia*. 2017; 72: 916–917.
- [31] El-Boghdadly K, Pawa A. The erector spinae plane block: plane and simple. *Anaesthesia*. 2017; 72: 434–438.
- [32] Raft J, Chin KJ, Belanger ME, Clairoux A, Richebe P, Brulotte V. Continuous Erector Spinae Plane Block for thoracotomy analgesia after epidural failure. *Journal of Clinical Anesthesia*. 2019; 54: 132–133.
- [33] Huang W, Wang W, Xie W, Chen Z, Liu Y. Erector spinae plane block for postoperative analgesia in breast and thoracic surgery: A systematic review and meta-analysis. *Journal of Clinical Anesthesia*. 2020; 66: 109900.
- [34] Ueshima H, Otake H. Erector spinae plane block provides effective pain management during pneumothorax surgery. *Journal of Clinical Anesthesia*. 2017; 40: 74.
- [35] Chin KJ, Adhikary S, Sarwani N, Forero M. The analgesic efficacy of pre-operative bilateral erector spinae plane (ESP) blocks in patients having ventral hernia repair. *Anaesthesia*. 2017; 72: 452–460.
- [36] Cai Q, Liu GQ, Huang LS, Yang ZX, Gao ML, Jing R, *et al.* Effects of erector spinae plane block on postoperative pain and side-effects in adult patients underwent surgery: A systematic review and meta-analysis of randomized controlled trials. *International Journal of Surgery*. 2020; 80: 107–116.

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