A randomized trial of erector spinae plane block for analgesia after video-assisted thoracoscopic surgery

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Research article

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Abstract

Background: Erector spinae plane block (ESPB) is a novel local nerve block technique. However, evidence regarding the impact of ESPB on postoperative pain management after video-assisted thoracoscopic surgery (VATS) is lacking. This randomized controlled trial aimed to evaluate the effect of erector spinae plane block on postoperative analgesia and intra-operative opioid consumption for video-assisted thoracoscopic surgery patients. Methods: We randomly allocated 91 participants to block with 30ml ropivacaine 0.375% (n=45), or no block without placebo or sham procedure (n=46). We analyzed results from 41 participants in each group ultimately. The primary outcome was postoperative NRS pain score. The secondary outcome was intra-operative sufentanil consumption. Postoperative QoR-40 scores and postoperative complications were also recorded. Results: Erector spinae plane block reduced the median (IQR) pain scores during postoperative 0-1h, 1-6h, 6-12h and 12-24h: 3 (3-5) vs. 6 (5-7), p<0.0001; 5 (3-5) vs. 6 (5-7), p<0.0001; 4 (3-5) vs. 6 (5-7), p<0.0001 and 4 (3-5) vs. 5 (5-7), p<0.0001, respectively. Block also reduced the mean (SD) intra-operative total sufentanil consumption and per hour, per kilogram sufentanil consumption, as well as increased the median (IQR) global QoR-40 scores on POD1. Conclusions: Erector spinae plane block can be used to reduce postoperative pain and intra-operative opioid consumption for VATS patients.

Background

Professor Henrik Kehlet first raised the concept of "**Enhanced Recovery After Surgery**" （ERAS）in 1997， aiming to reduce the physical and psychological trauma caused by the surgery, so as to relieve the stress of the patients, reduce the postoperative complications and enhance the quality of recovery [1,2]. Recently, ERAS has also been adopted by the field of thoracic surgery, with more and more studies related to thoracic ERAS [3,4]. Rib retraction, separation of the costovertebral joints, tissue traction, incision and suture, visceral and intercostal nerve injuries, chest tube stimulation, postoperative cough and respiratory stimulation are all pain sources of thoracic surgery, thus making it one of the most painful operation among all kinds of surgeries [5-8]. Postoperative pain is the primary factor affecting postoperative recovery of thoracic surgery patients: Short-term adverse effects includes respiratory depression, atelectasis, pulmonary infection, neuroendocrine disorders of urinary retention and dyssomnia; long-term chronic pain can even cause the change of patient's personality and behavior, which seriously affect patients' daily life [9-11]. So effective postoperative analgesia is an important component of thoracic ERAS. Due to its smaller incisions, video-assisted thoracic surgery (VATS) can distinctly reduce postoperative pain compared to open chest surgery [12,13], nevertheless pain control after VATS remains challenging. Currently, thoracic epidural analgesia, paravertebral nerve block and intercostal nerve block are the most commonly used analgesic methods to relieve postoperative pain after thoracic surgery. However, analgesic techniques that are easy to perform and have fewer severe complications may be more suitable for thoracoscopic surgery, such as the erector spinae plane block (ESPB) [14,15]. Reduction of intra-operative opioids consumption may benefit patients from different aspects including reducing postoperative complications and inhibiting cancer recurrence or metastasis [16-18]. Although many

previous studies demonstrated that erector spinae plane block could provide an efficient analgesia for different surgeries, a clinical trial of analgesic effect of ESPB for thoracoscopic surgery is still lacking.

We aimed to test whether pre-operative ESPB could reduce postoperative pain and intra-operative sufentanil consumption for VATS patients.

Methods

Patients

The study was a randomized control trial approved by the Institutional Review Board of Shanghai Pulmonary Hospital, Shanghai, China (K18-189). We declared that the study adhered to CONSORT guidelines. All participants provided written informed consent.

We enrolled 103 patients (18–80 years old, BMI<30kg.m-2, weight≥40kg) with an American Society of Anesthesiologists' (ASA) physical status class of I or II, who were scheduled for elective thoracoscopic surgery. Exclusion criteria were as follows: infection at local block site; allergy to local anesthetics; preexisting neurological deficit or psychiatric illness; liver failure; serum creatinine > 1.5 mg.dl-1, chronic pain or chronic opioid use; history of alcoholism or drug abuse; pregnancy and inability to accomplish the pain assessment.

Randomization and blind

Participants were randomly allocated into two groups to erector spinae plane block or no block, in a 1:1 ratio using a computer-generated sequence, with allocations sealed in opaque envelopes. An investigator opened the envelope one day before surgeries and performed the erector spinae plane block, if allocated, in the pre-anesthesia room one hour before induction of anesthesia. The surgeons, attending anesthesiologist, outcome assessor and data analysts were all blind from the group assignment.

Study procedures

The patient was placed in a lateral position and a high-frequency linear ultrasound transducer (GE LOGIQe, Wauwatosa, Wisconsin) was placed in a longitudinal orientation 3-5 cm lateral to the T4 spinous process to find the T5 transverse process. Three muscles were identified superficial to the hyperechoic transverse process shadow as follows: trapezius, rhomboid major, and erector spinae. An 8-cm 22-gauge block needle (KangDeLai; Shanghai, China) was inserted in a vertical direction until the tip reach to the T5 transverse process, as evidenced by visible linear spread of fluid between the muscles upon injection. We injected a total of 30 ml of 0.375% ropivacaine here. We defined a successful block as the loss of cold sensation to an alcohol swab in three or more dermatomes.
Participants were monitored with five-lead electrocardiogram, noninvasive blood pressure bispectral index and peripheral pulse oximetry, and also an intravenous line was in place in advance.

After anesthetic induction and neuromuscular blockade with rocuronium, subsequently, we intubated the trachea with a double-lumen tube. If necessary, radial artery catheterization for continuous arterial blood

pressure monitoring and a central venous catheter via an internal jugular vein would be placed. We maintained anesthesia with propofol and sufentanil, titrated to a bispectral index of 40-60 and a mean arterial blood pressure within ±20% of baseline. After skin closure, we stopped the infusion of propofol and sufentanil. At the end of surgery, neuromuscular blockade was antagonized with neostigmine 1mg, and the trachea was extubated when the patient was fully awake and breathing adequately. All patients had a patient control intravenous analgesia (PCIA) which is placed after the trachea extubation. The PCIA regimen consisted of sufentanil 100 μg and tropisetron 10 mg, mixed with normal saline to a total volume of 100 ml. The disposable PCIA device was set to deliver a 2 ml.h-1 background infusion and 0.5 ml on-demand bolus, with a 15-minute lockout time. Thus, the PCIA could be used for the first 48 hours postoperatively. All patients were transferred to the post-anesthesia care unit.

Study outcomes

The primary study outcome was the worst numerical rating scale (NRS) pain scores during postoperative 0-1h, 1-6h, 6-12h and 12-24h. The secondary outcome was the consumption of intra-operative sufentanil. Other outcomes included the global QoR-40 scores on postoperative day 1 (POD1) and postoperative complications. QoR-40 is consisted of 40 questions assessing 5 recovery domains: emotional status, physical comfort, psychological support, physical independence, and pain [19]. The range of global QoR-40 scores is from 40 (poorest score) to 200 (best score). The postoperative complications which we recorded included postoperative nausea and vomiting (PONV), urinary retention, dizziness, atelectasis and pneumonia.

Statistical analysis

Based on our previous institutional unpublished retrospective data of the worst NRS pain scores during postoperative 6-12 h in patients who underwent VATS with none block (SD 2.4), we defined that a total of 41 patients per group would be needed to achieve a decrease in mean pain of 1.5 with 80% power with 5% alpha. Up to 20% of patients were assumed to be dropouts, so we enrolled 103 patients.

We compared continuous variables with the t-test or Mann–Whitney U-test, and categorical variables with the Chi-squared test or Fisher's exact test, as appropriate. We also used the Chi-square test or the Fisher's exact test to compare the incidence of postoperative adverse effects. $P<0.05$ was considered significant for these comparisons. All statistical analyses were performed using IBM SPSS software, (version 20.0).

Results

We analyzed the results from 82 out of 103 recruited participants (Fig. 1 and Table 1). ESPB reduced the worst NRS pain scores during postoperative 0-1h, 1-6h, 6-12h and 12-24h (Table 2). The block also reduced total intra-operative sufentanil consumption, 104.6 (23.4) μg vs. 122.3 (28.9) μg, p=0.0032, and per hour, per kilogram sufentanil consumption, 0.82 (0.17) μg.kg-1.h-1 vs. 1.30 (0.33) μg.kg-1.h-1, $p<$ 0.0001.

Table 1 Patient demographic and perioperative data

	Erector spinae plane block		
Variables	**Yes**	**No**	**P value**
	n=41	**n=41**	
Gender; female	19 (46.3%)	26 (63.4%)	0.120
Age; year	60.5 (9.9)	57.2 (8.3)	0.102
Weight; kg	63.7 (10.9)	61.6 (8.3)	0.331
Height; cm	165.6 (8.4)	163.1 (6.9)	0.139
BMI (kg/m2)	23.1 (3.0)	23.1 (2.6)	0.987
ASA (I/II); I	23 (56.1%)	20 (48.8%)	0.507
Lung function			
FEV 1% of predicted	2.5 (0.6)	2.7 (0.5)	0.159
FVC of predicted	3.1 (0.7)	3.3 (0.6)	0.174
FEV 1 /FVC (%) of predicted	81.0 (7.6)	83.1 (1.8)	0.0971
Operation; L/LW/S/W/O	21/3/11/4/2	15/3/10/11/2	0.365
Duration of surgery (min)	96.9 (44.8)	80.4 (44.5)	0.0985
Preoperative QoR-40 scores			
Global QoR-40	195 (193-196)	195 (193-196)	0.913
Emotional status	44 (43-44)	43 (43-44)	0.694
Physical comfort	58 (56.5-59)	58 (57-59)	0.841
Physical independence	25 (24-25)	25 (24-25)	0.917
Psychological support	35 (34-35)	35 (34-35)	0.777
Pain	35 (34-35)	35 (34-35)	0.699

Values are number (proportion), median (IQR) or mean (SD). FEV 1, forced expiratory volumein1s; FVC, forced vital capacity; L: Lobectomy; LW: Lobectomy + wedge resection; S: Segmentectomy; W: Wedge resection; O: others.

Table 2 The worst NRS pain scores during the first 24h after thoracoscopic surgery.

Time after surgery; h	Erector spinae plane block		
	Yes n=41	No n=41	*p* valued
0-1	3 (3-5)	6 (5-7)	<0.0001
1-6	5 (3-5)	6 (5-7)	<0.0001
6-12	4 (3-5)	6 (5-7)	<0.0001
12-24	4 (3-5)	5 (5-7)	<0.0001

Values are median (IQR).

Postoperative QoR-40 scores were demonstrated in Table 3. The global QoR-40 scores on POD1 were higher in the ESPB group than in the control group: 186 (180.5-188.5) vs. 181 (171-186), p=0.0015. Except for physical independence, the scores of emotional status, physical comfort, psychological support and pain in the block group were all slightly superior to the control group (Table 3). The erector spinae plane block did alter the number of participants who occurred PONV and dizzy in the first 24 postoperative hours, compared with no block, but the difference had no statistically significant (we reckoned that maybe the sample size was not large enough): 8/41 (19.5%) vs. 10/41 (24.3%), p = 0.594 and 0/41 (0.0%) vs. 2/41 (4.9%), p = 0.494. No urine retention, atelectasis and pneumonia occurred in either group.

Table 3 QoR-40 Scores on postoperative day 1 after thoracoscopic surgery.

	Erector spinae plane block		
	Yes n=41	No n=41	p valued
Global QoR-40	186 (180.5-188.5)	181 (171-186)	0.0015
Emotional status	43 (42-45)	42 (40-44)	0.0046
Physical comfort	53 (50-55)	50 (47-54)	0.0151
Physical independence	24 (24-24)	24 (23-24)	0.213
Psychological support	30 (30-31)	30 (30-30)	0.0124
Pain	35 (34-35)	34 (33-35)	0.0012

Values are median (IQR).

Discussion

Pre-operative ESPB improved postoperative pain, reduced intra-operative sufentanil consumption and promote quality of recovery in the first 24 h after thoracoscopic pulmonary resection when compared with no block.

Opioids are the most classical and common drugs for intra-operative analgesia, but they also bring pernicious side effects such as respiratory depression, addiction, nausea and vomiting, urinary retention and pruritis, which affect patients' rapid recovery and prognosis [16,20]. Our clinical trial showed that ESPB could reduce intra-operative sufentanil consumption. From this point, ESPB played a significant role in reducing early postoperative complications and promoting quality of recovery.

In addition, this block provided an efficient analgesic effect and could relieve the postoperative pain of patients underwent VATS. Surgery, stress, opioid and pain are all factors which affect long-term prognosis including cancer recurrence and metastasis of malignant tumor patients [17]. Regional nerve block technology could enhance preservation of perioperative immune function and possibly reduce the incidence of cancer recurrence by attenuating the neuroendocrine stress response, reducing opioid use and relieving pain [17,21]. ESPB is a novel regional nerve block method and can reduce intra-operative opioid consumption, ease stress and improve postoperative pain of patients who underwent VATS, thus we confer that this block may possess significant clinical value for ameliorating long-term prognosis of lung cancer patients. Among the 82 patients analysed in our study, 52/82 (63.4%) were lung cancer. Therefore, it may be plausible to improve the prognosis of patients with lung cancer by erector spinae plane block before the surgery.

In addition to alleviating early postoperative pain and reducing intra-operative opioids consumption, the advantages of erector spinae plane block are as follows: compared with paravertebral nerve block and epidural block, this block almost has no apparent adverse complications including spinal anesthesia, epidural hematoma, severe hypotension, which was confirmed by a retrospective analysis of 242 patients [15]. Moreover, the transverse process is easier to identify under ultrasound guidance, making it much easier to learn and perform with much lower risk of pleura piercing. However, the differences on postoperative analgesia between this block and other classical regional nerve block methods such as epidural block and paravertebral nerve block are still uncertain, which require further to explore. Currently, preliminary results from our ongoing research showed that there were no differences on postoperative analgesia and postoperative rapid recovery between erector spinae plane block and paravertebral block, but erector spinae plane block has better patient satisfaction and easier performance.

Our study had several limitations. The sample size was small, thus there was no statistical difference between these two groups on postoperative complications. Moreover, due to the short follow-up window, no patients were recorded occurring atelectasis or pneumonia, which was inconsistent with previously published studies. Further clinical trials are required to explore the effect of ESPB on long-term prognosis of lung cancer patients. Our study did not control the local anesthetic block with placebo injectate or a sham procedure that might lead to the potential risk of performance bias.

Conclusion

Pre-operative ESPB with ropivacaine can improve early postoperative pain and reduce intra-operative sufentanil consumption for thoracoscopic surgery patients.

Abbreviations

VATS: Video-assisted thoracoscopic surgery; ESPB: Erector spinae plane block; NRS: Numeric rating scale; QoR-40: 40-item quality of recovery questionnaire scores; POD1: Postoperative day 1; ERAS: Enhanced recovery after surgery; PCIA: Patient-controlled intravenous analgesia; PONV: Postoperative nausea and vomiting; ASA: America Society of Anesthesiologist; BMI: Body mass index; FEV 1: forced expiratory volumein1s; FVC: forced vital capacity; L: Lobectomy; LW: Lobectomy + wedge resection; S: Segmentectomy; W: Wedge resection; O: others.

Declarations

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Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

ZMW and YJ designed this study and wrote the manuscript. XMJ performed the experiments. MS assisted with data analysis. ZMW and XL revised the final manuscript. All the authors contributed to the final version of the manuscript.

Ethics approval and consent to participate

The research protocol was approved by the Medical Ethics Committee of Shanghai Pulmonary Hospital, Shanghai, China (No: K18-189), and all the patients signed the written informed consent voluntarily.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

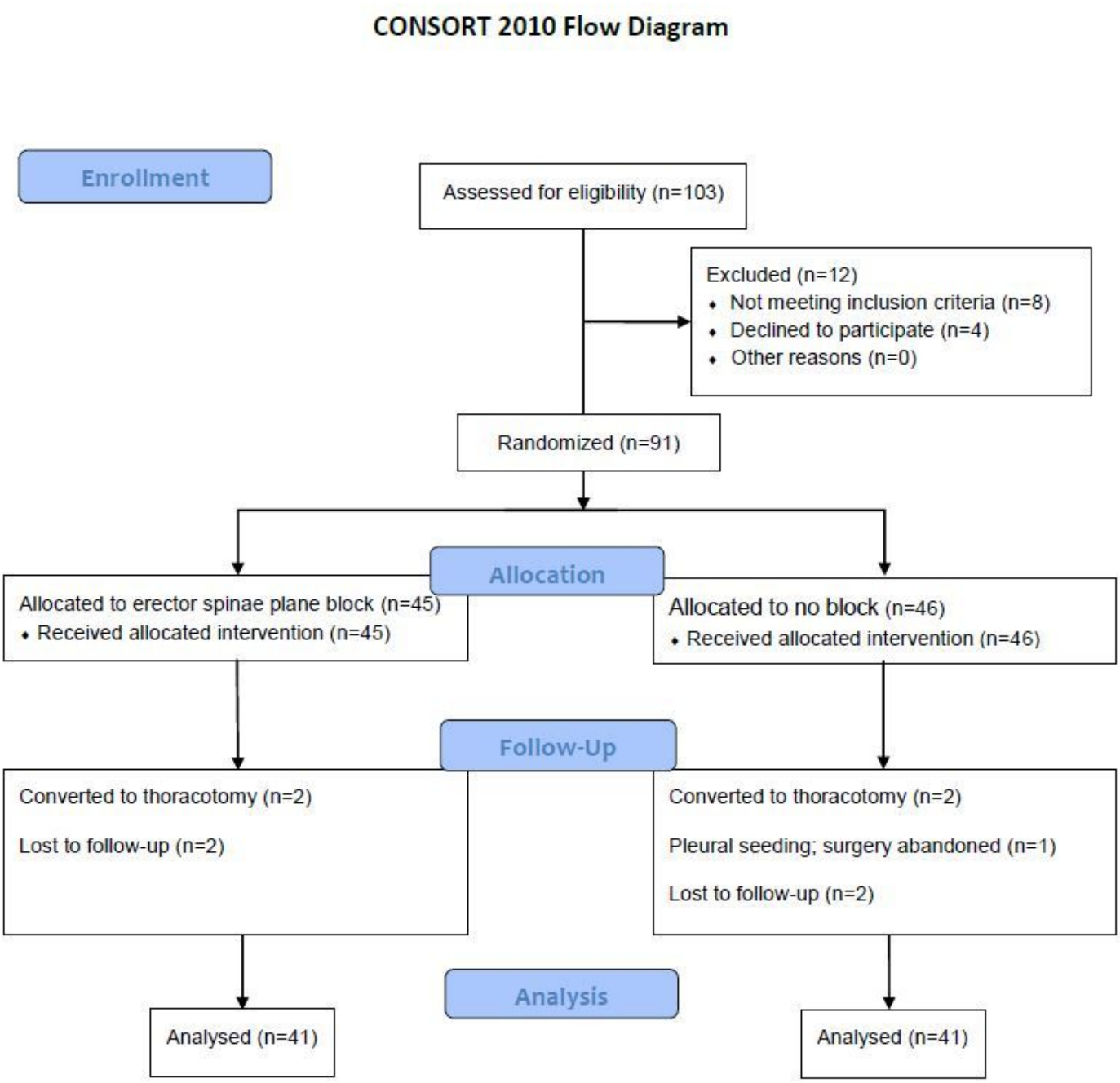

Figure 1

CONSORT flow diagram of participant recruitment and treatment.

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