

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

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Received 4 July 2019

Revised 29 October 2019

Accepted 29 October 2019

Published Online First

8 November 2019

ABSTRACT

Background and objectives The anesthetic characteristics of ultrasound-guided erector spinae plane block (ESPB) remain unclear. We compared the analgesic efficacies of ESPB and thoracic paravertebral block (TPVB) for analgesia after video-assisted thoracic surgery (VATS).

Method In this prospective randomized non-inferiority trial, 88 patients undergoing VATS randomly received ESPB or TPVB. All patients received continuous infusion of 0.2% levobupivacaine (8 mL/hour) after injection of a 20 mL 0.2% levobupivacaine bolus. The primary outcome was median differences between the groups in postoperative numerical rating scale (NRS) scores at rest, 24 hours postoperatively.

Results Eighty-one patients completed the study. The median difference in NRS scores at rest 24 hours postoperatively was 1 (range 0–1), demonstrating the non-inferiority of ESPB to TPVB. NRS scores at rest were significantly lower in the TPVB group at 1, 2 and 24 hours postoperatively ($p=0.02$, 0.01 and 0.006 , respectively). NRS scores on movement were similar. More dermatomes in parasternal regions were anaesthetized in the TPVB group ($p<0.0001$). Total plasma levobupivacaine concentrations were significantly lower in the ESPB group within 20 hours postoperatively ($p=0.036$).

Conclusions The analgesic effect of ESPB after VATS was non-inferior to that of TPVB 24 hours postoperatively.

Trial registration number UMIN000030658.

INTRODUCTION

Recently, there has been remarkable changes in the concept of thoracic paravertebral block (TPVB), and several indirect TPVB approaches have been described¹; erector spinae plane block (ESPB) is a representative indirect TPVB method, reported by Forero *et al*² in 2016. Most indirect TPVBs, including ESPB, are interfascial plane blocks. In ESPB, the large volume of solution injected between the thoracolumbar fascial planes beneath the erector spinae muscle might affect multiple intercostal nerves. In recent cadaveric studies, contrary opinions regarding drug spread have been presented, without a clear consensus regarding mechanism

of action. Some studies postulated that the anesthetic spreads into the thoracic paravertebral space (TPVS) or epidural space,^{3,4} while others state that it expands to the outer surface of the thoracic wall but not into the TPVS.⁵

In the clinical field, numerous studies have reported that ESPB could provide a favorable analgesic effect in the thoracoabdominal region.⁶ Additionally, ESPB has been reported to be an effective tool for performing cardiothoracic surgery more easily and safely^{7–10}; therefore, it could serve as a good substitute for standard treatment modalities, such as epidural block or TPVB.^{11,12} However, no prospective studies have examined the analgesic effects as well as the anesthetic characteristics of the ESPB compared with the TPVB for thoracic surgery.

We hypothesized that the ESPB might provide analgesia as effective as that of TPVB for thoracoscopic surgery. This study was designed to investigate whether the analgesic effect of ESPB is non-inferior to that of TPVB for lung surgery, in accordance with the Consolidated Standards of Reporting Trials statement.¹³

METHODS

This study was registered in the UMIN Clinical Trials Registry (UMIN-CTR; Principal investigator: Taro Fujitani, 1 January 2018). Between March 2018 and February 2019, we enrolled patients with American Society of Anesthesiologists physical status 1–3 who were scheduled for radical lobectomy under complete video-assisted thoracic surgery (VATS), with three trochal ports, for lung cancer. The trochal ports were made at the fifth and sixth intercostal levels. The chest drain was inserted before the skin closure at the seventh or eighth intercostal level. Exclusion criteria included age <20 or >80 years, allergy to local anesthetics, BMI $>30\text{ kg/m}^2$ or the presence of coagulopathy, history of ipsilateral thoracotomy, daily use of opioid analgesics, mental or neurological disorders, allergy to analgesics (acetaminophen, non-steroidal anti-inflammatory drugs or opioids), disorder in communication and scheduled thoracotomy with rib cutting or pleurectomy. After written informed consent was obtained, patients were randomly assigned to two treatment groups: the ESPB group and the TPVB group. Allocation was performed



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To cite: Taketa Y, Irisawa Y, Fujitani T. *Reg Anesth Pain Med* 2020;**45**:10–15.

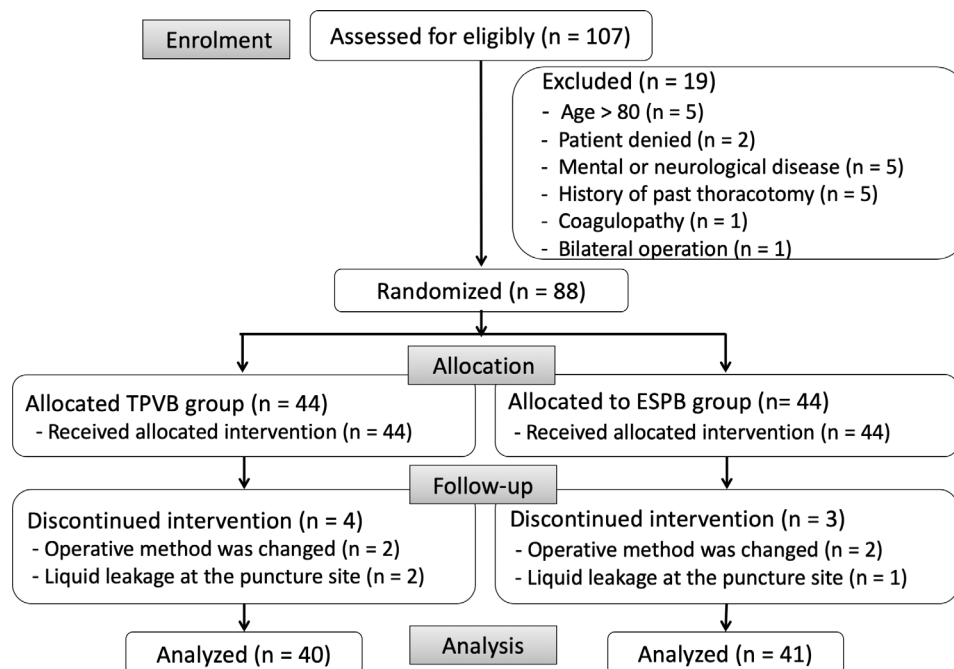


Figure 1 Flow diagram of the patients. ESPB, erector spinae plane block; TPVB, thoracic paravertebral block.

automatedly using a computer-generated identifier. The anesthesiologist (YT) oversaw patients' enrollment and allocation. All procedures were performed by anesthesiologists other than those in charge of the operation, who were skilled in ultrasound-guided nerve blockade.

General anesthesia technique

Patients received general anesthesia with standardized monitoring. General anesthesia was induced using fentanyl (50 µg), propofol target-controlled infusion (TCI) and continuously infused remifentanyl (0.2–0.5 µg/kg/min). After administration of rocuronium (0.6–1 mg/kg), the patient was intubated with a double-lumen tracheal tube. Anesthesia was maintained using propofol TCI to achieve a bispectral index range of 40–60, with continuous infusion of remifentanyl (0.1–0.5 µg/kg/min) and rocuronium (6–7 µg/kg/min). Intravenous fentanyl (2 µg/kg) was injected both during surgery and at skin closure. Acetaminophen (1000 mg) and metoclopramide (10 mg) were administered intravenously prior to tracheal extubation. Fentanyl intravenous patient-controlled rescue analgesia (bolus dose of 0.5 µg/kg and lockout interval of 10 min, without background infusion) was initiated. Intravenous flurbiprofen (50 mg) or acetaminophen (1000 mg) was available at the patient's request as additional analgesia when pain control was insufficient, even with the limited use of rescue fentanyl. For prevention of postoperative nausea and vomiting (PONV), intravenous metoclopramide (10 mg) was administered at 6 and 12 hours postoperatively.

Regional anesthesia technique

Ultrasound-guided TPVB and ESPB catheterization were performed after anesthesia induction with patients in the lateral position using a microconvex array transducer (5–8 MHz).

In the TPVB group, an 18-gage Tuohy epidural needle was inserted at the T4 or T5 intercostal level, where the main skin incision was to be made, using the paralaminar in-plane approach.¹⁴ After needle penetration into the thoracic paravertebral space (TPVS), 5–10 mL saline was injected, and ventral movement of the parietal pleura was confirmed to identify the

needle tip position. A 20-gage multiorifice epidural catheter was inserted 2–2.5 cm beyond the needle tip and left in place. The needle was then removed, and a small amount of air-mixed saline was injected through the catheter to confirm that it produced a bubble inside the TPVS, without air or blood aspiration.

In the ESPB group, the identical transducer was placed in a sagittal position where the main skin incision was to be made to visualize the T4 or T5 transverse process. An 18-gage Tuohy epidural needle was inserted from cephalad to caudal (in-plane technique) until contact was made with the transverse process, and 5–10 mL saline was injected to confirm the hydrodissection of the interfascial plane. Then, an epidural catheter was inserted 2.5 cm beyond the needle tip. After needle removal, a small amount of air-mixed saline was injected through the catheter to confirm that the bubble was visualized in the interfascial space between the erector spinae muscle and the thoracolumbar fascia.

The catheter insertion sites in both groups were covered with a film dressing to conceal which approach was being used. In both groups, 20 mL of 0.2% levobupivacaine was administered through the catheter at the beginning of the surgery, followed by continuous infusion of 0.2% levobupivacaine at 8 mL/hour using a disposable pump (Vessel Fuser; Fuji Systems Corporation, Tokyo, Japan) for 50 hours.

Postoperative management

All patients were transferred to the intensive care unit (ICU) after recovering from general anesthesia. An anesthesiologist blinded to the block procedure assessed anesthetized dermatomes at the paraspinous, anterior axillary, midclavicular and parasternal regions by cold and pinprick tests using von Frey filaments, at 6 and 20 hours after the initial intraoperative levobupivacaine bolus injection. Anesthetized dermatomes were defined as areas of reduced sensitivity to pinprick stimulation as compared with the contralateral side. An ICU nurse, blinded to the protocols, evaluated postoperative pain at rest and on movement, using a numerical rating scale (NRS; 0=no pain, 10=maximum pain imaginable) at 1, 2, 4, 8, 12, 24 and 48 hours postoperatively. PONV was assessed using a five-point numerical scale

Table 1 Patient characteristics and surgical values

| | TPVB | ESPB |
|--|--------------|--------------|
| Sample size, n | 40 | 41 |
| Patient characteristics | | |
| Mean age (SD) in years | 67 (8) | 70 (7) |
| Mean BMI (SD) in kg/m ² | 23.4 (3.2) | 23.6 (3.4) |
| Sex, n (%) | | |
| Male | 25 (62.5) | 23 (56.1) |
| Female | 15 (37.5) | 18 (43.9) |
| ASA status, n (%) | | |
| I | 2 (5) | 2 (4.8) |
| II | 29 (72.5) | 29 (70.7) |
| III | 9 (22.5) | 8 (19.5) |
| Surgical values | | |
| Mean duration of surgery (SD) in minutes | 178.6 (28.2) | 179.3 (48.0) |
| Mean duration of anesthesia (SD) in minutes | 267.2 (31.4) | 265.8 (46.7) |
| Mean intraoperative fentanyl use (SD) in µg/kg | 6.5 (0.65) | 6.5 (0.45) |
| Mean intraoperative remifentanyl use (SD) in µg/kg/min | 0.24 (0.06) | 0.27 (0.06) |

ASA, American Society of Anesthesiologists; ESPB, erector spinae plane block; TPVB, thoracic paravertebral block.

(0=no symptoms, 1=scarcely, 2=usually, 3=most of the time and 4=all the time) through self-questionnaires at 48 hours postoperatively.

Postoperative plasma levobupivacaine measurement

The time-course of plasma concentration of levobupivacaine in arterial blood samples, obtained at 0.5, 1, 2, 4, 6 and 20 hours after the initial intraoperative levobupivacaine bolus injection in all patients, was measured using liquid chromatography (LC). The collected samples were immediately centrifuged, and the plasma samples were stored frozen until measurement. The plasma concentration of levobupivacaine was measured using LC-tandem mass spectrometry with an electrospray ionization technique. All samples were prepared using deproteination with acetonitrile. Chromatographic separation was achieved with two mobile phases ((A) 5 mM ammonium acetate buffer (pH adjusted to 5.2 with acetic acid) and (B) acetonitrile; A:B=62:38). The calibration curves were linear between 0.5 and 2000 ng/mL with $1/\chi^2$ weighting ($r \geq 0.99$).

Outcomes

The primary outcome of this study was the median differences in the NRS scores between the TPVB and the ESPB groups, at rest, 24 hours postoperatively. The secondary outcomes were NRS scores at rest, dynamic pain scores, the amount of rescue fentanyl use per weight, the number of anesthetized dermatomes (6 and 20 hours after the initial bolus injection), the total plasma levobupivacaine concentration, the number of additional analgesics use by each patient and the PONV scores.

Sample size calculation

According to the pilot study ($n=12$, unpublished data), the mean NRS scores at rest 24 hours postoperatively after ESPB was 1.6, and the SD of the NRS scores at rest after TPVB was 1.2. Based on the proposal that the acceptable non-inferiority margin should be determined as a difference from placebo,^{15–17} we defined an acceptable non-inferiority margin as 0.5 according to a previous placebo-controlled study¹⁸ with a retention rate

of 50%. However, we changed this non-inferiority margin to 1 during the peer review process to reflect a more practical clinical perspective and to avoid inappropriate Type II error rate in this non-inferiority trial. A sample size of 74 was required to provide a power of 0.8 and a one-sided α of 0.025. We recruited 88 patients into the study, given the possibility of dropout.

Statistical analysis

For the non-inferiority evaluation, we calculated the 95% CIs of the median differences in NRS scores, using the Hodges-Lehman estimator.^{19,20} Patient characteristics, surgical values and number of anesthetized dermatomes were shown as mean (SD), while NRS scores and amount of rescue fentanyl use were shown as median (IQR). The amount of rescue fentanyl used, NRS scores, PONV scores and the number of additional analgesics use were analyzed using the Wilcoxon rank-sum test. The levobupivacaine concentrations and the number of anesthetized dermatomes were evaluated using repeated-measures two-factor analysis of variance (ANOVA), and post hoc multiple comparisons were made using the Bonferroni method when significant interactions were detected using ANOVA. We used the R statistical package (version 3.5.2, R Foundation for Statistical Computing) for non-inferiority and NRS analysis, and other statistical calculations were conducted using Statcel (version 4; OMS Publishing, Saitama, Japan). The target of analysis was Per Protocol Set data, which excluded cases dropped out after initiating catheter infusion to compare the analgesic effect of two different continuous nerve blocks.

RESULTS

Figure 1 shows the flow chart of the study. Eighty-eight patients were initially enrolled. Four patients in the TPVB group were excluded, due to a change to open thoracotomy in two patients and drug leakage at the catheter insertion site in two patients (incalctrant leakage and ceased infusion). Three patients in the ESPB group were also excluded, due to change in the operative method in two patients (to open thoracotomy and to partial resection in one patient each) and drug leakage at the catheter insertion site in one patient. Accordingly, we analyzed 40 patients in the TPVB group and 41 patients in the ESPB group.

There were no differences in the baseline characteristics between the groups (**table 1**). NRS scores at rest and on movement are shown in **table 2**. When comparing patients having TPVB versus ESPB, the median NRS scores at rest (IQR) at 1, 2 and 24 hours were 2 (1–3) versus 4 (1–6.5), 2 (1–3) vs 3 (2–5) and 1 (0–2) versus 1 (0–3), with p values=0.02, 0.01 and 0.006, respectively, while no significant difference was observed at other time points. The 95% CI of the median differences in NRS scores at rest 24 hours postoperatively was under 1, which indicates non-inferiority of the ESPB (**figure 2**). There was no significant difference between the two groups in NRS scores on movement at any time point.

table 3 shows the amount of rescue fentanyl used within 24 hours and 24–48 hours postoperatively in both groups. There were no statistically significant differences in the amount used per body weight in either period (TPVB vs ESPB; 6 (3–7.8) vs 6 (4.5–8.6) and 1 (0–2.5) vs 1.5 (0–3.1), $p=0.33$ and 0.43, respectively).

table 3 shows the anesthetized dermatomes, according to a pinprick test, at 6 and 20 hours after initiating the infusion. There were no significant differences between the groups at paraspinal, anterior axially and midclavicular areas at either time point ($p=0.87$, 0.79 and 0.06, respectively). However, the

Table 2 Postoperative numerical rating scale (NRS) and median differences for NRS between the TPVB group and the ESPB group

| | TPVB | ESPB | P value*† | Difference in NRS (ESPB – TPVB)‡ | |
|------------------------|-----------|-----------|-----------|----------------------------------|----------|
| | | | | Median | 95% CI |
| NRS at rest | | | | | |
| 1 hour | 2 (1–3) | 4 (1–6.5) | 0.02 | 2 | 0 to 3 |
| 2 hours | 2 (1–3) | 3 (2–5) | 0.01 | 1 | 0 to 2 |
| 4 hours | 2 (1–3) | 2 (1–3) | 0.21 | 0 | 0 to 1 |
| 8 hours | 1 (1–2) | 2 (0–3) | 0.83 | 0 | –1 to 1 |
| 12 hours | 1 (0–2) | 2 (1–2) | 0.07 | 1 | 0 to 2 |
| 24 hours | 1 (0–2) | 1 (0–3) | 0.006 | 1 | 0 to 1 |
| 48 hours | 1 (0–2) | 1 (0–2) | 0.51 | 0 | 0 to 1 |
| NRS on movement | | | | | |
| 1 hour | 3 (1–5) | 4.5 (1–7) | 0.08 | 1 | 0 to 3 |
| 2 hours | 3 (2–5) | 4 (2–6) | 0.13 | 1 | 0 to 2 |
| 4 hours | 3 (1–4) | 3 (2–5) | 0.15 | 1 | 0 to 2 |
| 8 hours | 3 (1–4) | 3 (2–5) | 0.65 | 0 | –1 to 1 |
| 12 hours | 3 (2–4) | 3.5 (2–5) | 0.12 | 1 | 0 to 2 |
| 24 hours | 3 (2–5) | 4 (3–6) | 0.09 | 1 | 0 to 1.5 |
| 48 hours | 3 (2.5–5) | 3 (2–5) | 0.62 | –1 | 0 to 0.5 |

Data are presented as median (IQR).

Difference of NRS=NRS of ESPB minus NRS of TPVB.

*P value compares the TPVB group and the ESPB group.

†Wilcoxon rank-sum test used to compare medians between the groups.

‡Hodges–Lehman estimator used to calculate 95% CI of the median differences.

NRS, numerical rating scale; TPVB, thoracic paravertebral block;

ESPB, erector spinae plane block.

number of anesthetized dermatomes at the parasternal region was significantly greater in the TPVB than in the ESPB group ($p < 0.0001$). There were no interaction effects between block methods and the time lapsed for any region.

The number of additional analgesic drugs used and the PONV score distributions are shown in [table 3](#). The number of additional analgesics used was significantly higher in the ESPB group than in the TPVB group ($p = 0.008$). PONV score distributions did not differ significantly between the groups ($p = 0.08$).

The total plasma levobupivacaine concentrations are depicted in [figure 3](#). The mean (SD) concentrations at 0.5, 1, 2, 6, 12 and 20 hours after the starting infusion were 0.27 (0.11), 0.28 (0.12), 0.34 (0.16), 0.52 (0.23), 0.57 (0.23) and 0.84 (0.31) $\mu\text{g}/\text{mL}$, respectively, in the ESPB group, versus 0.42 (0.17), 0.40 (0.17), 0.43 (0.18), 0.57 (0.28), 0.64 (0.33) and 0.96 (0.46) $\mu\text{g}/\text{mL}$,

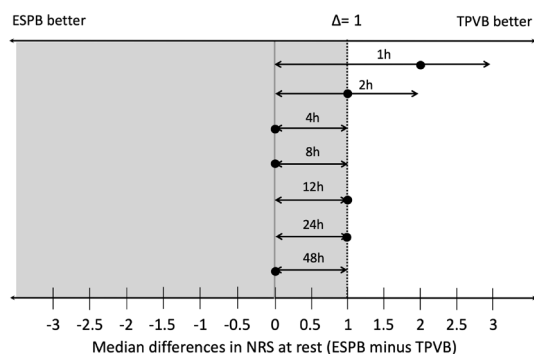


Figure 2 Median differences for NRS scores at rest. Error bars representing 95% CIs. Δ , margin of non-inferiority margin. Tinted area indicates zone of non-inferiority. ESPB, erector spinae plane block; NRS, numeric rating scale; TPVB, thoracic paravertebral block.

Table 3 Amount of rescue fentanyl use, number of anesthetized dermatomes, PONV scores and postoperative analgesics use

| | TPVB | ESPB | P value*† |
|--|-----------|-------------|-----------|
| Sample size, n | 40 | 41 | |
| Median amount of postoperative rescue fentanyl uses (IQR) in $\mu\text{g}/\text{kg}$ | | | |
| 0–24 hours | 6 (3–7.8) | 6 (4.5–8.6) | 0.33 |
| 24–48 hours | 1 (0–2.5) | 1.5 (0–3.1) | 0.43 |
| Mean number of anesthetized dermatomes (SD) after initiating the infusion | | | |
| Paraspinal | | | |
| 6 hours | 3.8 (1.5) | 4.1 (1.5) | 0.87 |
| 20 hours | 4.1 (1.4) | 3.8 (1.5) | |
| Anterior axillary | | | |
| 6 hours | 4.4 (1.3) | 3.9 (1.6) | 0.79 |
| 20 hours | 4.1 (1.1) | 3.3 (1.2) | |
| Midclavicular | | | |
| 6 hours | 4.2 (1.1) | 3.3 (1.2) | 0.06 |
| 20 hours | 4.2 (1.2) | 3.4 (1.1) | |
| Parasternal | | | |
| 6 hours | 3.1 (1.3) | 0.3 (0.4) | <0.0001 |
| 20 hours | 3.2 (1.4) | 0.6 (0.6) | |
| PONV scores, n (%) | | | |
| 0 | 32 (80) | 25 (61) | 0.08 |
| 1 | 4 (10) | 11 (26.8) | |
| 2 | 3 (7.5) | 2 (4.9) | |
| 3 | 1 (2.5) | 3 (7.3) | |
| 4 | 0 (0) | 0 (0) | |
| Number of additional analgesics use, n (%) | | | |
| 0 time | 27 (57.5) | 15 (36.6) | 0.008 |
| 1 time | 9 (22.5) | 18 (43.9) | |
| 2 times | 4 (10) | 8 (19.5) | |

PONV was assessed using a five-point numerical scale (0=no symptom, 1=scarcely, 2=usually, 3=most of the time, 4=all the time).

*P value compares the TPVB group and the ESPB group.

†Amount of rescue fentanyl, PONV scores and additional analgesics use were analyzed using Wilcoxon rank-sum test, and number of anesthetized dermatomes was analyzed using repeated-measures two-factor ANOVA.

ANOVA, analysis of variance; ESPB, erector spinae plane block; PONV, postoperative nausea and vomiting; TPVB, thoracic paravertebral block.

mL, respectively, in the TPVB group. In both groups, the concentrations continued to increase over time after the start of continuous infusion. The maximum concentration was 1.911 $\mu\text{g}/\text{mL}$

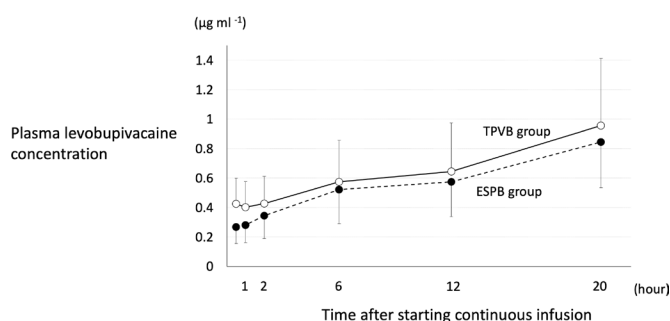


Figure 3 Total plasma levobupivacaine concentrations in the TPVB and the ESPB group. Samples were collected at six time points of 0.5 hour, 1 hour, 2 hours, 4 hours, 6 hours and 20 hours after the start of catheter infusion. The round markers represent the mean values, with the error bars representing the SD. Statistically significant differences were observed between the groups ($p < 0.036$). TPVB, thoracic paravertebral block; ESPB, erector spinae plane block.

in the TPVB group at 20 hours after the initial bolus injection. Repeated-measures two-factor ANOVA showed that the total plasma levobupivacaine concentrations in the ESPB group were significantly lower than those in the TPVB group ($p=0.036$). There was no interaction effect between block methods as the time lapsed ($p=0.29$).

All anesthesia procedures were conducted without complications, and we did not experience any adverse event, including pneumothorax, hematoma, bilateral anesthesia, intrapleural catheter protrusion and local anesthetic toxicity.

DISCUSSION

This prospective randomized study demonstrated that the median difference in static pain scores between the TPVB and the ESPB groups at 24 hours postoperatively was under the non-inferiority margin, which suggested that the analgesic effects of a continuous ESPB were comparable with that of TPVB for VATS on the first postoperative day. These findings at 24 hours are supported by a recent study by Fang *et al*,²¹ which compared single-shot ESPB with TPVB for thoracic surgery and reported no significant differences between the two blocks in terms of pain scores or opioid consumption but showed relatively fewer complications in the ESPB group.

The ESPB did demonstrate higher static pain scores than the TPVB group, particularly at early postoperative time points (1 and 2 hours), where the IQRs of NRS scores in the ESPB group were quite large, and the 95% CIs of the median NRS score differences at rest between the groups were greater. These differences should be interpreted with caution, however, as they represent secondary outcome metrics. Additionally, it is likely that the differences are clinically irrelevant, especially in the setting of multimodal therapy that was not part of our study protocol.

As for the anesthetized dermatomal range of ESPB, it was consistent with our previous observational study of ESPB for VATS, which reported a weak anesthetic effect in the parasternal region.²² Previous cadaveric studies differed on the proposed mechanism of action of ESPB. Adhikary *et al*³ reported distribution of solution into the paravertebral space and epidural space whereas Ivanusic *et al*⁵ reported that almost no solution reached the paravertebral space. Dautzenberg *et al*²³ also demonstrated that the dye distribution in ESPB was unpredictable, explaining its varied efficacy.²³ In ESPB, if enough anesthetic solution had spread to the paravertebral or epidural space to reduce sensation at multiple intercostal levels, sensation should also have been reduced across multiple levels from the dorsal to the anterior cutaneous branch region (as occurred in the TPVB group). However, since this was not observed in the ESPB group, the results of the present study aligned better with the findings of the cadaveric study of Ivanusic *et al*.⁵ Nevertheless, a previous report noted a discrepancy between the spread of anesthetic solution in the paravertebral space as detected by MRI and the actual area of reduced sensation.²⁴ Thus, the area of reduced sensation may differ from the actual area of anesthetic distribution in the paravertebral space.

In the present study, the plasma levobupivacaine concentration tended to increase over time in both groups, but no patient showed local anesthetic toxicity symptoms. The concentration was significantly lower in the ESPB than the TPVB group. Although the toxic arterial plasma levobupivacaine concentration remains to be established,²⁵ our results show that ESPB potentially prevents rapid elevation of plasma levobupivacaine concentration more than does TPVB. Whether this finding can be exploited to justify an increased dose of local anesthetic to

potentially increase clinical efficacy would require additional research.

Our study had several limitations. First, the precise catheter tip location was not confirmed in either group. Second, plasma levobupivacaine concentrations were only monitored until 20 hours after the first manual injection, and thus safety was not determined throughout the full study period. Third, since nerve blocks were used as part of the multimodal analgesia regimen, the analgesic differences between the two blocks might have been masked to some extent by the other complementary analgesia. However, in modern clinical practice, most interfascial plane blocks are used as part of multimodal analgesia, and thus we considered it to be desirable to compare those blocks based on clinical settings. Finally, our we did not study potentially more relevant outcome metrics such as hospital length of stay, postoperative escalation of care, medical economics or longer duration analgesic characteristics.

CONCLUSIONS

In conclusion, we found that the analgesic effect of ESPB was equivalent to that of TPVB after thoracoscopic surgery with lower local anesthetic blood levels. There may be some early analgesic benefits to a TPVB, but the clinical significance remains unclear.

Acknowledgements We would like to thank Dr Kinya Terao and Dr Takaki Ochi for their assistance with the study. We also thank Statista Co, Ltd for improving our manuscript and supporting our analysis. We would like to thank Editage for English-language editing. The essence of this work was to be presented at the 38th Annual Meeting of the European Society of Regional Anaesthesia & Pain Therapy congress in Bilbao, Spain (12 September 2019).

Contributors YT: patient recruitment, study design, allocation, conducting the study, data analysis and writing the paper; YI: conducting the study and writing the paper; TF: patient recruitment, study design, conducting the study and writing the paper.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests Maruishi Pharmaceutical Cooperation (Osaka, Japan), which produces and distributes levobupivacaine in Japan, provided our hospital with non-financial support. Specifically, this company agreed to measure plasma levobupivacaine concentrations in patient samples without any compensation. We provided blood samples after patients provided written informed consent, and all samples were anonymized. The company was not engaged in this study in any other manner.

Patient consent for publication Obtained.

Ethics approval We conducted a single-center, double-blinded, prospective, randomized, non-inferiority trial approved by Institutional Review Board of Ehime Prefectural Central Hospital (Approval No. 29–84, Chairperson: Yasushi Ishida, 16/02/2018).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request.

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