A randomized controlled trial comparing paravertebral block via the surgical field with thoracic epidural block using ropivacaine for post thoracotomy pain relief

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Abstract

Purpose We conducted a comparative study to evaluate analgesic efficacy between paravertebral block via the surgical field (PVB-sf), in which the catheter was inserted into the ventral side of the sympathetic trunk in the paravertebral space by a thoracic surgeon under thoracoscopic visualization, and epidural block (Epi) using ropivacaine for post thoracotomy pain relief.

Methods Lung cancer patients scheduled for lobectomy via thoracotomy were randomly allocated to receive either PVB-sf or Epi (n = 36/group). Before thoracotomy closure, 0.375% ropivacaine was administered as a bolus (PVB-sf, 20 mL; Epi, 5 mL), followed by a 300 mL continuous infusion of 0.2% ropivacaine at 5 mL/h. Postoperative pain was assessed using a visual analog scale (VAS) at various time points, including the primary endpoint of 2 h after ropivacaine bolus injection. Sensory block area, vital signs, serum ropivacaine concentrations, and side effects were also evaluated.

Results The Epi group showed significantly lower VAS scores and blood pressure, and a wider sensory block area than the PVB-sf group at all evaluation points. While the mean serum ropivacaine concentration in the PVB-sf group was significantly higher than that in the Epi group until 1 h after ropivacaine bolus injection, there was no significant difference at any subsequent assessment point. Side effect incidence was similar between the groups.

Conclusion Epi is superior to PVB-sf for the management of post-thoracotomy pain. The number of dermatomes anaesthetized by Epi was greater than that anaesthetized by PVB-sf. No difference in complication rates was observed between the two groups.

Introduction

Thoracotomy incisions are thought to be among the most painful of surgical incisions because they involve a significant amount of trauma and destructive force on pain-sensitive structures, such as multiple muscle layers, fascia, neurovascular bundles, bone, joints, and the parietal pleura [1, 2]. Typical postoperative care includes epidural analgesia (Epi), systemic opioids, and nerve blocks [1–3]. Epi is the most frequently used of these procedures, and is considered the gold standard for post-thoracotomy pain relief [4]. In addition, paravertebral block (PVB) has also gained popularity for post thoracotomy pain relief because it is reportedly associated with fewer side effects than Epi, despite having a comparable analgesic effect [3, 5–8].

We have previously reported that PVB via the surgical field (PVB-sf), in which the PVB catheter is inserted into the ventral side of the sympathetic trunk (as opposed to the dorsal side) in the paravertebral space (Supplemental Fig. 1) by a thoracic surgeon under thoracoscopic visualization according to Naja et al. [9], is not inferior to Epi in patients undergoing thoracotomy when local anesthetic ropivacaine is administered as a mixture with fentanyl [10]. Concerning the occurrence of side effects in the study, postoperative nausea/vomiting (PONV) is the most frequent anesthesia-related adverse event in the PVB-sf group (recorded in 3/35 patients), presumably due to the excessive use of opioids. Based on our previous data, we hypothesized that, if additional analgesics were administered on patient demand, the PVB-sf method by using local anesthetic alone could provide analgesic efficacy comparable with Epi and such treatment could improve perioperative patient safety by reducing PONV. Therefore, we conducted a comparative study on the analgesic efficacy of PVB-sf and Epi using ropivacaine without adjunctive

agent in lung cancer patients undergoing lobectomy via thoracotomy. Additional drugs, including narcotics, were administered on patient demand in the postoperative period.

Methods

Study design and patients

This prospective randomized trial was approved by the institutional review board at the Japanese Red Cross Nagoya Daiichi Hospital (Nagoya, Japan), and is registered with the University Hospital Medical Information Network (Study ID: UMIN000010187). Lung cancer patients scheduled for elective single-side lung lobectomy with antero- or vertical-axillary incision were recruited during an 18-month period. The patients were aged 20–80 years and had an American Society of Anesthesiologists physical status of I–II. After obtaining written informed consent and recording demographic data, the patients were allocated using a computer-generated randomization program to receive either PVB-sf (group P) or Epi (group E). The exclusion criteria were the same as those in our previous study [10] with the following additional criteria applied: combined resection of parietal pleura, coagulation disorder, thrombocytopenia, anti-coagulation therapy, and heart failure.

Anesthesia and postoperative treatment

Standard monitoring (noninvasive arterial blood pressure, electrocardiogram, and pulse oximetry) and bispectral index monitoring were performed. General anesthesia (GA) was immediately induced in group P, while an epidural catheter was inserted before anesthesia induction in group E. GA was induced with fentanyl (2 μg/kg; fentanyl injection, Daiichi Sankyo Co. Ltd., Tokyo, Japan) and propofol (1.5–2.5 mg/kg; Diprivan, AstraZeneca K.K., Osaka, Japan). Remifentanil (0.25–0.40 μg/kg/min; Ultiva, Janssen Pharmaceutical K.K., Tokyo, Japan) and rocuronium (0.6–0.8 mg/kg; Eslax, MSD K.K.,

Tokyo, Japan) were used to facilitate tracheal intubation. A radial artery cannula (20-gauge) was used for blood pressure monitoring and blood sampling. No fentanyl was administered after induction of GA, which was maintained using air, oxygen, remifentanil (0.25–0.50 μg/kg/min), and sevoflurane (1.0–1.5%; Sevofrane, AbbVie GK, Tokyo, Japan); concentrations of remifentanil and sevoflurane were adjusted to maintain systolic blood pressure changes of more than 20% from the initial values and target bispectral index values of 40–60.

In group E, the catheter was inserted as previously described [10], and no medication was given until the end of surgery. After lung lobectomy and leak testing, 5 mL of 0.375% ropivacaine (Anapeine injection, AstraZeneca K.K.) was administered as a bolus, followed by a 300 mL continuous infusion of 0.2% ropivacaine using an infusion pump (Multirate Infusor LV, Baxter Healthcare Co. Inc., Deerfield, IL, USA) at 5 mL/h through the epidural catheter. In group P, the catheter was inserted into the operative field by the surgeon as previously described [10]. All of the catheter holes were adjusted to face sympathetic nerves. On observing an upheaval of the paravertebral space, 20 mL of 0.375% ropivacaine was administered as a bolus, followed by a 300 mL of continuous infusion of 0.2% ropivacaine at 5 mL/h through the PVB catheter.

In both groups, 50 mg of indomethacin (Inteban sp., Teikoku Seiyaku Co. Ltd., Osaka, Japan) was administered in suppository form to the patients immediately after surgery. After waking from GA, 2 mg/kg of sugammadex sodium (Bridion Intravenous, MSD K.K.) was administered and the endotracheal tube was removed. Additional analgesic drugs such as flurbiprofen axetil (Ropion, Kaken Pharmaceutical Co. Ltd., Tokyo, Japan), pentazocine (Sosegon, Maruishi Pharmaceutical Co. Ltd., Osaka, Japan),

loxoprofen sodium hydrate (Roxonin, Daiichi Sankyo Co. Ltd.), and the antiemetic metoclopramide (Primperan, Astellas Pharma Inc.) were administered on patient demand under the thoracic surgeon's control until the patient left the hospital. Eighteen hours after the operation, 400 mg of celecoxib (Celecox Tablets, Astellas Pharma Inc., Tokyo, Japan) was administered, followed by 200 mg b.i.d. thereafter.

Data collection

Postoperative pain was assessed as a primary endpoint using a visual analog scale (VAS) while coughing, moving, and at rest 2 h after the bolus injection of ropivacaine; these evaluations were also performed at 1, 6, 12, 18, and 42 h after injection. The VAS consisted of a 100 mm line (0 mm, no pain; 100 mm, worst pain imaginable).

Vital signs including blood pressure and heart rate were recorded at 0.25, 0.50, 0.75, 1, 2, 6, 12, 18, and 42 h after the bolus injection of ropivacaine. At the same time points, 5 mL of blood were collected via a radial artery cannula for measurement of serum ropivacaine concentrations, except at 42 h, when blood samples were drawn from a vein. Sensory deprivation was evaluated by both the cold sign and pin prick tests at 1 h and 18 h after ropivacaine bolus injection. An anesthesiologist blinded to the analgesic method used evaluated VAS and sensory deprivation. Treatment-related adverse events including PONV, hypoxia, hypotension, bradycardia, local anesthetic intoxication, and urinary retention were also recorded. At time points when we were unable to collect blood samples or vital sign data, the event was recorded as "unobtained data."

Analysis of ropivacaine concentration

Serum samples spiked with the internal standard (IS) were treated with ethylacetate to extract ropivacaine and the IS. The ropivacaine content in the extracted sample containing 5 μg/mL of IS was measured using a reversed-phase HPLC system equipped with a UV detector and CoulArray for Windows® version 3.01 software (ESA Inc., Chelmsford, MA, USA), via a separation column (Acclaim® Mixed-Mode WCX-1, 150 mm × 4.6 mm I.D., Nippon Dionex K.K., Osaka, Japan) at 40°C. The mobile phase solvent, pH 5.25, consisted of acetonitrile and 60.6 mM potassium dihydrogen phosphate (45/55 or 30/70, v/v) and was pumped at a flow rate of 1.2 mL/min. The detection wavelength was set at 220 nm. The assay for the calibration standards was linear in the concentration range of 0–10 μg/mL, and the lowest detectable concentration was 0.05 μg/mL. Drug-free serum samples were provided by healthy volunteers for use as calibration standards.

Statistical analysis

We estimated that a minimum of 64 patients would be required for the study to have 80% power for detecting a significant between-group difference in VAS score at rest 2 h after surgery, with a medium to large effect size of a 0.7 standard deviation (SD) [11]. To compensate for unforeseen dropouts and potentially higher than expected variability, we planned to enroll 80 patients. VAS score, serum ropivacaine concentration, blood pressure, pulse rate, peripheral arterial oxygen saturation, and respiratory rate were analyzed using a linear mixed model including treatment group, time, and interaction between these variables as covariates. Least-squares means and their 95% confidence intervals were calculated for each time point, and adjustments for multiple comparisons

were made using the Tukey-Kramer test. Qualitative variables and demographic data, including age, weight, height, and body mass index, were compared using the *t*-test. Categorical data were analyzed by the Pearson chi-square test. Dermatomal sensory threshold ranges were analyzed by the Wilcoxon rank-sum test. A *p*-value of <0.05 was deemed to indicate statistical significance. All data were analyzed using SAS version 9.4 software (SAS Institute Inc., Cary, NC, USA).

Results

Between March 2013 and October 2014, 80 of the 86 enrolled patients were randomly allocated to treatment; 40 to group P and 40 to group E. After allocation, four patients in each group withdrew from the study, resulting in data from 36 patients per group in the final analysis (Fig. 1). Demographic data and surgical characteristics, including duration of anesthesia, operation, and hospitalization were comparable in both groups (Table 1).

There were statistically significant differences between the two groups with regard to postoperative pain. In addition to the primary endpoint of 2 h, all mean VAS scores in group E were significantly lower than those in group P throughout the observation period (Fig. 2). The time to first analgesic use was approximately twice as long in group E when compared with group P, and the number of flurbiprofen axetil ampoules administered in group P was greater than in group E (Table 2). Significantly higher amounts of flurbiprofen axetil and pentazocine were administered until 2 h after the operation in group P, although the total consumption of other analgesics did not differ significantly between the two groups. In the sensory threshold tests, group E exhibited significantly wider dermatomal distributions than group P at both 1 h and 18 h after ropivacaine bolus injection (Table 2).

Mean serum ropivacaine concentrations gradually increased over time and reached a maximum at 42 h after ropivacaine bolus injection in both groups, at which time the levels were not statistically significant: 1.610 μg/mL (SD 0.543) in group P and 1.745 μg/mL (SD 0.727) in group E (Fig. 3). However, there was a statistically significant difference in the change in concentration between the two groups throughout the

postoperative period. Specifically, group P had significantly higher concentrations than group E postoperatively until 1 h after ropivacaine bolus injection, presumably due to the difference in ropivacaine injection volumes: 20 mL in group P vs. 5 mL in group E.

Postoperatively, systolic and diastolic blood pressures were lower in group E than in group P, and there were statistically significant differences between the two groups throughout the observation period (Fig. 4). However, no patients required vasopressor agents. The changes in heart rate, peripheral arterial oxygen saturation, and respiratory rates were similar in both groups (data not shown). The most common treatment-related adverse event was PONV in both groups; four cases in group P and five in group E. Neither the incidence nor amount of metoclopramide consumption differed significantly between the two groups (Table 2). One patient in group E developed urinary retention, but no other side effects were observed.

Discussion

In the present study, we compared the analgesic efficacy of PVB-sf with that of Epi using ropivacaine alone. We achieved the target sample size with only eight dropouts, indicating a high success rate, as in our previous study [10]. According to the pharmacokinetic profile of fentanyl, we expected that after discontinuing its administration, the serum fentanyl concentration would drop to negligible levels postoperatively. Another narcotic drug, remifentanil, was administered continuously after induction of GA and discontinued at the end of GA. As with fentanyl, the serum remifentanil concentration was also estimated to reach ineffective levels at the VAS evaluation points, due to its short half-life. The influence of opioids administered during surgery is presumed to be negligible. Although ropivacaine was administered at a higher dose than in previous studies [10, 12], serum concentrations in both groups were under toxic plasma level even after the 42 h continuous infusion [13]. Given the similar final ropivacaine concentrations, additional drug use, and low incidence of side effects in both groups, we consider that this study constitutes a fair comparison of the analgesic effects between PVB-sf and Epi.

In the current study, Epi was superior to PVB-sf as demonstrated by the difference in the effective range of ropivacaine, indicated by sensory block range data, despite the fact that significantly more analgesics were administered in the postoperative period in PVB-sf group. The initial mean VAS scores associated with PVB-sf were approximately 80 mm. Furthermore, even the incidence of PONV did not improve as compared with our previous study, indicating that the treatment may have created an additional burden for the patients. Therefore, the hypothesis that the PVB-sf method by using local anesthetic

alone could provide sufficient analgesic efficacy comparable with that of Epi and improve perioperative patient safety by reducing PONV was rejected.

The same PVB-sf technique used in the current study did not prove inferior to Epi in our previous study [10], in which a mixture of ropivacaine and fentanyl was infused as postoperative analgesia. This implies that, in PVB, previous analgesic effects may be masked by the analgesic effects of fentanyl administered during the postoperative period. Using the PVB technique, Naja et al. [9] demonstrated that administration of a local anesthetic with dye into the ventral side of the endothoracic fascia [14] showed a multisegmental longitudinal spreading pattern, whereas injections dorsal to the endothoracic fascia resulted in a cloud-like spreading pattern, with only limited distribution over adjacent segments. In addition, use of a nerve stimulator-guided technique appeared to substantially enhance the likelihood of achieving the most desirable longitudinal spreading pattern when compared with more conventional techniques. In accordance with this evidence, the catheter for ropivacaine administration in PVB-sf was inserted into the ventral side of the endothoracic fascia in the current study. However, neither analgesic efficacy comparable with Epi nor a wide sensory block range was observed in conjunction with PVB. Catheters can be placed not only percutaneously through the back before surgery by a classic loss of resistance [15] or an ultrasound-guided method [16, 17], but also under direct vision during surgery from within the chest. Using this direct access method, the catheter tip can be safely, accurately, and easily positioned within the endothoracic fascia of the thoracic paravertebral space [18]. In contrast with the current study, previous findings have achieved 4.2 dermatomes [19] or 4.5 intercostal segments [20] with meaningful analgesic effects via PVB, in which the catheter was inserted into the dorsal side of the endothoracic fascia by an anesthesiologist

under ultrasound guidance. It is likley that the local anesthetics administered reached the sympathetic trunk in the endothoracic fascia and infiltrated widely. Here, we clearly demonstrated that the analgesic efficacy of PVB, in which the catheter was inserted into the ventral side of sympathetic trunk, may be inadequate. This discrepancy might be caused by the infiltration pattern in the ventral side of the endothoracic fascia because the dermatomal distribution in PVB-sf here is thought to be different from that estimated by Naja et al. To date, whether insertion of a PVB catheter into the ventral side of the sympathetic trunk in the paravertebral space has analgesic efficacy comparable with that into the dorsal side is still controversial [21]. Further radiographic investigations with contrast media are required to elucidate the effects of different catheter insertion sites in the paravertebral space on the spreading pattern of local anesthetics and its analgesic efficacy.

Epi may cause hypotension, urinary retention, or pulmonary complications arising from muscle weakness, and may be associated with maneuver-related risk factors including dural puncture, spinal cord puncture, and nerve injuries [22]. PVB should be considered for patients suffering coagulopathy or inflammation at the epidural catheter insertion site, for whom Epi is contraindicated [5]. In addition, unlike Epi, in which the catheter is placed into the epidural space in a blind manner, PVB can be performed safely during GA because the catheter is usually inserted under the guidance of thoracoscopy or echo-guided vision [23–25]. Therefore, anesthesiologists should aim to improve PVB by determining the optimal catheter insertion site and best catheter insertion technique in that area, together with the additional pain modalities such as patient-controlled analgesia with narcotic and intravenious administration of non-steroidal anti-inflammatory drugs.

Our study has one major limitation. Addition of opioids to a local anesthetic solution has been reported to improve the quality of sensory block and pain control [26]. We believed on the basis of our preliminary trial that our study design could be safely implemented if additional analgesics including narcotic drugs such as pentazocine were administered on patient demand. Actually, this study was performed with ethical approval because we used a higher ropivacaine dosage than has been reportedly used in previous studies [10, 12] and allowed patients to use additional analgesic drugs under the control of the thoracic surgeon. As a result, the initial mean VAS scores associated with PVB-sf were approximately 80 mm, indicating that the treatment may have created an additional burden for the patients. A definite protocol on the prescription of analgesic drugs in the postoperative period should be established for thoracic surgeons.

In conclusion, Epi was superior to PVB-sf, in which the catheter was inserted into the ventral side of the sympathetic trunk in the paravertebral space, for post-thoracotomy pain management, as indicated by differences in the effective sensory block range of local anesthetics.

Acknowledgements

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Conflict of interest

None of the authors has any conflicts of interest to declare in relation to this work.

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Figure legends

Figure 1. Participant flow diagram

Of 86 patients initially screened for eligibility, six were excluded. The remaining 80 were randomly assigned to two equally sized groups: a thoracic paravertebral blockade via the surgical field (PVB-sf) group (group P) and a thoracic epidural analgesia (Epi) group (group E). Four cases of protocol discontinuation after group allocation occurred in each group, so the final analysis included 36 patients in each group.

Figure 2. Comparison of the analgesic effects of thoracic paravertebral blockade via the surgical field and thoracic epidural analgesia

Anesthesia with ropivacaine bolus injection was performed with either thoracic paravertebral blockade via the surgical field (PVB-sf) (●: group P) or thoracic epidural analgesia (Epi) (○: group E). Analgesic effects were evaluated while coughing (a), moving (b), and at rest (c) via visual analog scale (VAS) scores at six time points: 1, 2, 6, 12, 18, and 42 h after ropivacaine treatment. Data are presented as the mean ± standard deviation. In all cases $n = 36$ except for at 1 h coughing ($n = 34$), moving ($n = 35$), and at rest ($n = 34$) in group P. Statistical differences between the two groups were assessed via a linear mixed model including treatment group, time, and interaction between these variables as covariates. Least-squares means and their 95% confidence intervals were calculated for each time point, and adjustments for multiple comparisons were made using the Tukey-Kramer test.

$^{*}p < 0.05$

Figure 3. Chronological changes in serum ropivacaine concentrations after bolus injections in the thoracic paravertebral blockade via the surgical field and thoracic epidural analgesia groups

Serum samples were collected at nine time points: 0.25, 0.50, 0.75, 1, 2, 6, 12, 18, and 42 h after ropivacaine thoracic paravertebral blockade via the surgical field (PVB-sf) (●: group P) or thoracic epidural analgesia (Epi) (○: group E). The ropivacaine concentration of each sample was measured via a reversed-phase high performance liquid chromatography system equipped with an ultraviolet detector. (a): 0.25–42 h time points. (b): An enlarged view of the 0.25–5 h time points; the double-pointed arrow section indicated in panel (a). Data represent the mean ± standard deviation, and $n = 36$ in all cases, with the following exceptions: Group P; 0.75, 1, 2, and 6 h ($n = 35$ for each), 12 h ($n = 32$), 18 h ($n = 33$), 42 h ($n = 31$), and group E; 12 h ($n = 34$), 18 h and 42 h ($n = 33$ for each). Statistical differences between the two groups were assessed via a linear mixed model including treatment group, time, and interaction between these variables as covariates. Least-squares means and their 95% confidence intervals were calculated for each time-point, and adjustments for multiple comparisons were made using the Tukey-Kramer test.

*$p < 0.05$

Figure 4. Postoperative hemodynamic variables

Systolic (circle) and diastolic (square) blood pressure was assessed in all patients at nine time-points: 0.25, 0.50, 0.75, 1, 2, 6, 12, 18, and 42 h after ropivacaine thoracic paravertebral blockade via the surgical field (PVB-sf) (● and ■: group P) or thoracic epidural analgesia (Epi) (○ and □: Group E). Data represent means ± standard deviation

(*n* = 36). Statistical differences between the two groups were assessed via a linear mixed model including treatment group, time, and interaction between these variables as covariates.

$^{*}p < 0.05$

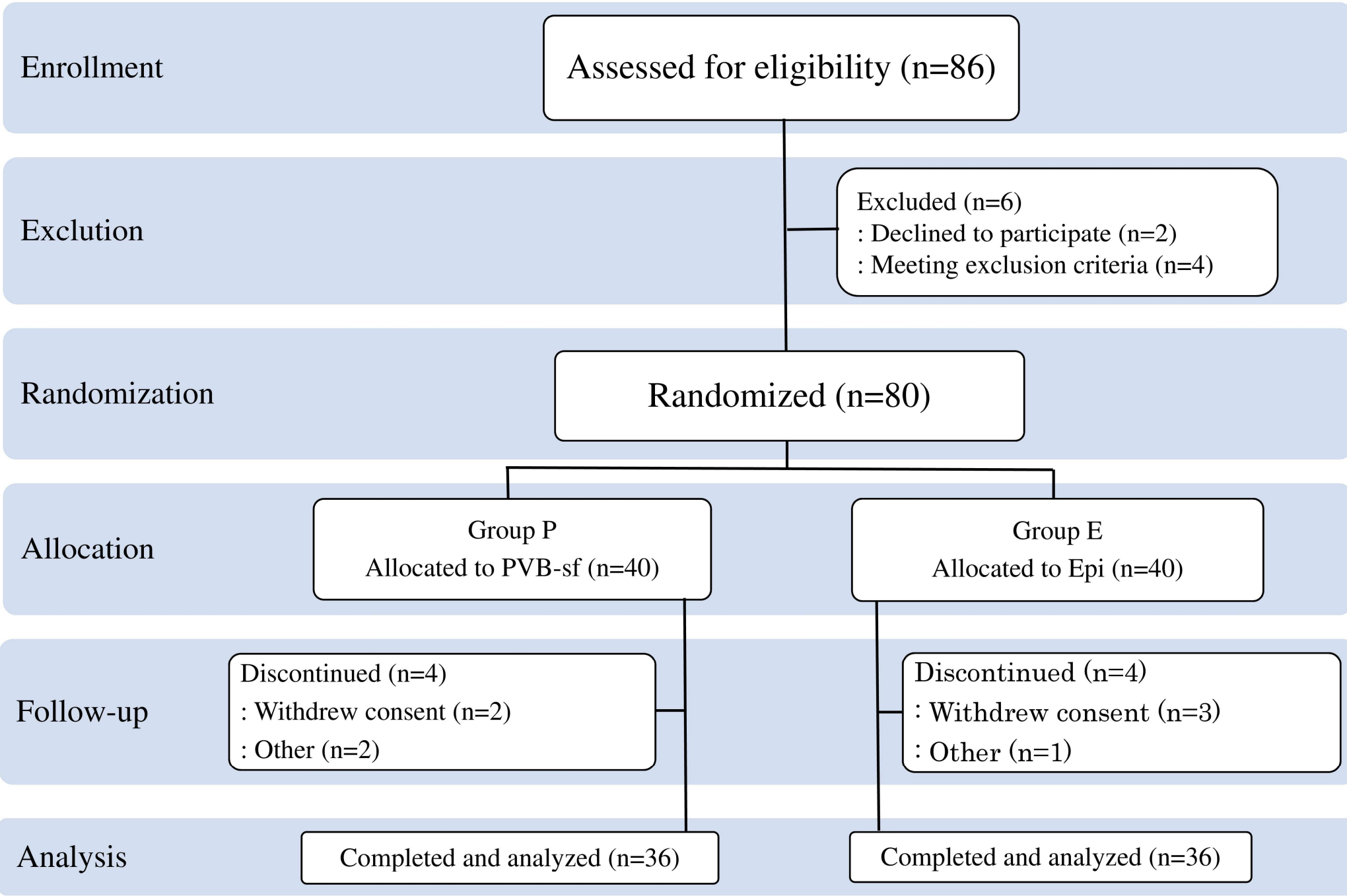

Enrollment
Assessed for eligibility (n=86)
Exclution
Excluded (n=6)
: Declined to participate (n=2)
: Meeting exclusion criteria (n=4)
Randomization
Randomized (n=80)
Allocation
Group P
Allocated to PVB-sf (n=40)
Group E
Allocated to Epi (n=40)
Follow-up
Discontinued (n=4)
: Withdrew consent (n=2)
: Other (n=2)
Discontinued (n=4)
: Withdrew consent (n=3)
: Other (n=1)
Analysis
Completed and analyzed (n=36)
Completed and analyzed (n=36)

Fig. 2

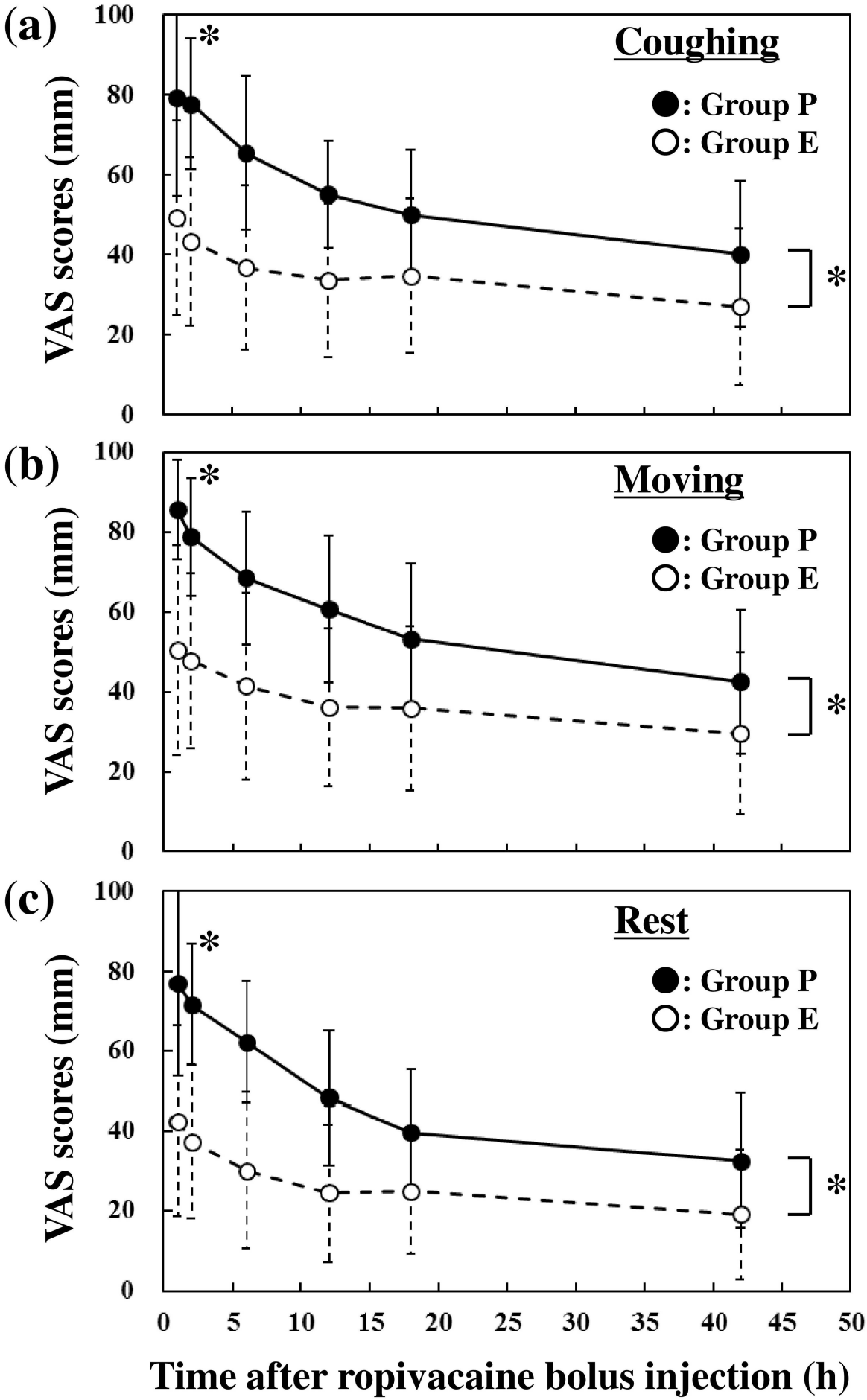

(a)
Coughing
●: Group P
○: Group E
VAS scores (mm)
100
80
60
40
20
0
*
*
(b)
Moving
●: Group P
○: Group E
VAS scores (mm)
100
80
60
40
20
0
*
*
(c)
Rest
●: Group P
○: Group E
VAS scores (mm)
100
80
60
40
20
0
*
*
0
5
10
15
20
25
30
35
40
45
50
Time after ropivacaine bolus injection (h)

Fig. 3

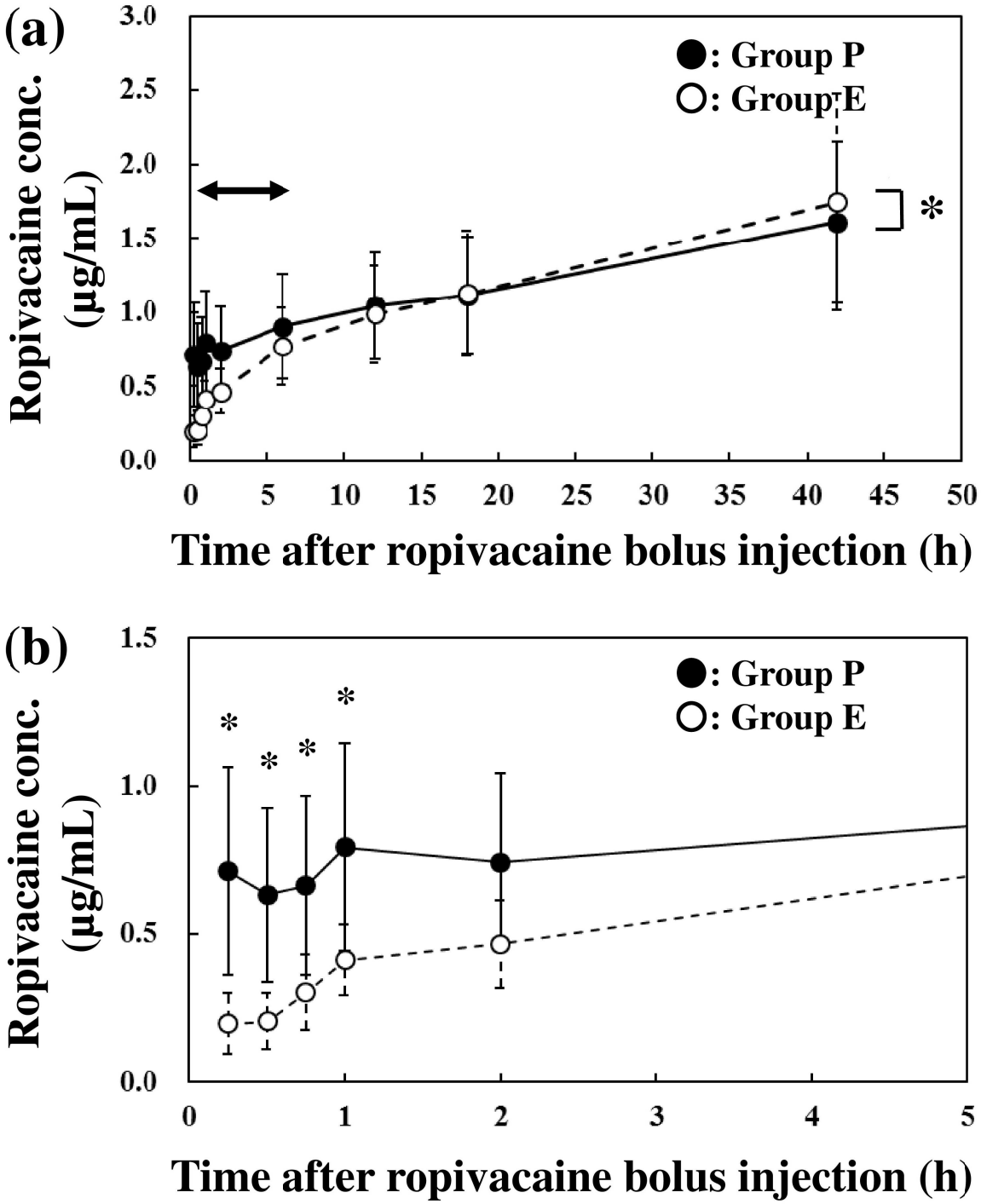

(a)
Ropivacaine conc. (μg/mL)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
●: Group P
○: Group E
*
0
5
10
15
20
25
30
35
40
45
50
Time after ropivacaine bolus injection (h)
(b)
Ropivacaine conc. (μg/mL)
1.5
1.0
0.5
0.0
●: Group P
○: Group E
*
*
*
*
0
1
2
3
4
5
Time after ropivacaine bolus injection (h)

Fig. 4

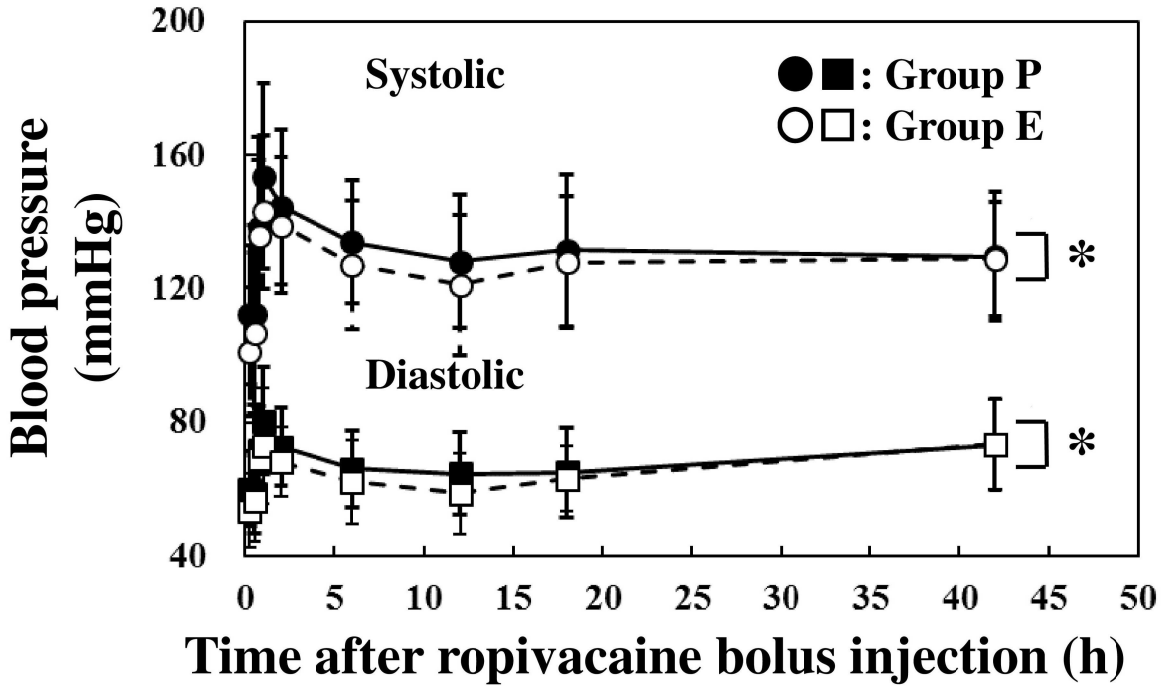

Blood pressure (mmHg)
200
160
120
80
40
Systolic
Diastolic
●■: Group P
○□: Group E
*
*
0
5
10
15
20
25
30
35
40
45
50
Time after ropivacaine bolus injection (h)

Table 1. Demographics and surgical characteristics

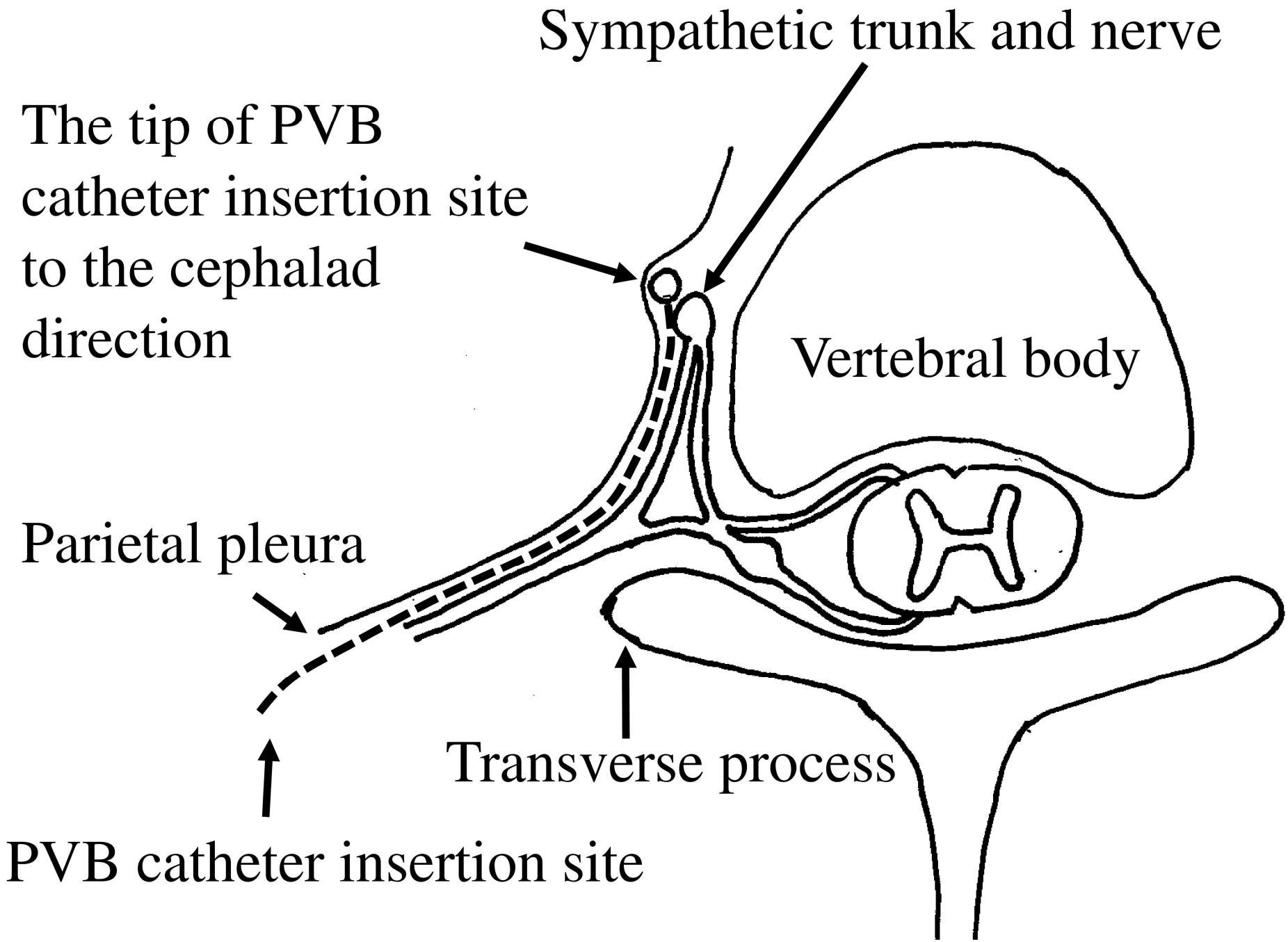
	Group P	**Group E**	***P* value**
Age (year)	67.1 ± 8.7	66.9 ± 9.7	0.95
Height (cm)	162.1 ± 8.4	161.0 ± 7.7	0.58
Body weight (kg)	61.3 ± 12.4	56.2 ± 10.4	0.07
Sex　Male : Female (number of cases)	29 : 7	28 : 8	0.77
ASA-PS *　Ⅰ :　Ⅱ　(number of cases)	10 : 26	9 : 27	0.79
Surgery			
Duration from admission into OR to starting GA (min) **	52.4 ± 6.3	63.8 ± 7.7	p < 0.01
Duration of anesthesia (min) ***	256.3 ± 49.3	246.5 ± 63.0	0.47
Operation time (min)	188.7 ± 47.0	183.9 ± 62.7	0.72
Type of operation (number of cases)			
Upper lobe lobectomy	20	25	
Upper lobe lobectomy + part of other lobe	2	0	
Middle lobe lobectomy	2	2	
Middle lobe lobectomy + part of other lobe	0	0	
Lower lobe lobectomy	11	9	
Lower lobe lobectomy + part of other lobe	1	0	
Hospitalization after surgery (day)	14.0 ± 22.3	12.6 ± 9.3	0.74

Group P: thoracic paravertebral blockade via the surgical field group.　Group E: thoracic epidural analgesia group.　* ASA-PS denotes the American Society of Anesthesiologists-Physical Status.　** OR and GA are abbreviated from operating room and general anesthesia, respectively.　*** It stands for the time from starting oxygenation to extubation.　Data are mean ± SD (n=36).　Statistical significance of the differences between 2 groups was assessed by two-tailed t-test.

Table2. Postoperative recordings

	Group P	Group E	*P* value
Treatments for patients			
Duration of postoperative drainage tube (day)	6.2 ± 10.0	4.1 ± 2.1	0.23
Duration of continuous analgesic catheter (day)	4.7 ± 2.3	5.1 ± 1.6	0.43
Duration of urethral catheter (day)	3.5 ± 4.3	4.2 ± 9.8	0.72
Additional drugs			
Duration until the first additional analgesic use after surgery (min)	57.3 ± 83.1	146.3 ± 168.5	$p < 0.01$
Additional analgesics and antiemetic (number of ampule or tablet)			
The total amount of flurbiprofen axetil (50 mg/ampule)	2.9 ± 1.3	2.3 ± 1.2	$p < 0.05$
The amount of flurbiprofen axetil until 2 h after operation	0.75 ± 0.2	0.5 ± 0.3	$p < 0.05$
The total amount of pentazocine (15 mg/ampule)	1.8 ± 1.5	1.3 ± 1.2	0.20
The amount of pentazocine until 2 h after operation	0.2 ± 0.2	0.06 ± 0.05	$p < 0.05$
Loxoprofen sodium hydrate (60 mg/tablet)	0.06 ± 0.3	0.03 ± 0.2	0.66
Metclopramide (10 mg/ampule)	0.1 ± 0.4	0.2 ± 0.6	0.76
Dermatomal ranges of sensory threshold			
Cold sign (dermatome)			
1-hr after ropivacaine bolus injection	1.6 ± 1.3	4.7 ± 2.1	$p < 0.01$
18-hr after ropivacaine bolus injection	1.3 ± 1.3	3.4 ± 1.4	$p < 0.01$
Pin prick (dermatome)			
1-hr after ropivacaine bolus injection	1.4 ± 1.3	4.6 ± 1.9	$p < 0.01$
18-hr after ropivacaine bolus injection	1.1 ± 1.0	3.1 ± 1.4	$p < 0.01$

Group P: thoracic paravertebral blockade via the surgical field group. Group E: thoracic epidural analgesia group. Data are mean ± SD (n=36). Statistical significance of the differences between 2 groups was assessed by two-tailed t-test, except for dermatomal ranges of sensory threshold of Wilcoxon rank sum test.


Sympathetic trunk and nerve
The tip of PVB catheter insertion site to the cephalad direction
Vertebral body
Parietal pleura
Transverse process
PVB catheter insertion site