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Clinical Research

A randomized double-blind controlled study comparing erector spinae plane block and thoracic paravertebral block for postoperative analgesia after breast surgery

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Background: Thoracic paravertebral block (PVB) is an effective regional block for pain control after breast surgery. However, accidentally puncturing adjacent vital structures may cause undesirable complications. Erector spinae plane block (ESPB) has been considered a safer proxy of PVB for beginners. This study aimed to evaluate the analgesic effects of ultrasound-guidance PVB and ESPB after breast surgery.

Methods: This randomized control trial was conducted in patients who underwent mastectomy. Forty-four females were randomly allocated into PVB group or ESPB group. All patients received a block with 20 ml of 0.5% levobupivacaine before general anesthesia. The primary outcome was the 24-h postoperative morphine requirements. The other outcomes of interest were postoperative pain scores, time to first analgesic request, dermatome of sensory blockade, block-related complications, and opioid adverse events.

Results: The 24-h morphine requirements were significantly lower in PVB compared to the ESPB group (3.5 ± 3.3 vs. 8.6 ± 3.8 mg, P < 0.001). The overall pain scores were also lower in the PVB group (P < 0.001). Only 14 patients in the PVB group requested additional morphine, whereas all patients in the ESPB group requested it (P = 0.004). The dermatome of sensory blockade was wider in the PVB group (7 vs. 4 levels, P = 0.019). No serious complications occurred in either group.

Conclusions: Compared to ESPB, PVB provided lower postoperative opioid requirements, lower pain scores, and wider sensory blockade after mastectomy.

Keywords: Analgesia; Breast surgery; Erector spinae plane block; Mastectomy; Paravertebral block.

INTRODUCTION

Breast surgery is one of the primary treatment options for breast cancer, the most common malignancy in female, accounting for 25% of all cancers in women [1]. However, acute pain after breast surgery can cause undesirable short-term outcomes, such as prolonged hospital stay, delayed ambulation, and patient unpleasantness. Furthermore, inadequate postsurgical pain management also contributes to obstinate chronic pain [2,3]. Regional anesthesia (RA) is an essential

aspect of multimodal analgesia, an effective method for treating acute pain and preventing chronic pain [4]. The thoracic paravertebral block (PVB), a block that has been in used for quite some time, has been found to be as effective as the thoracic epidural block, which is the gold standard for breast surgery. However, as the target of PVB was close to the pleura, it presents a technical challenge and requires expertise from the performer [5,6]. In contrast, erector spinae plane block (ESPB), a recent, simplified, superficial, and relatively safer RA technique, has also been demonstrated to be effective in controlling pain following breast surgery when performed at the fourth or fifth thoracic (T4–5) spinal level [7,8]. However, to our best knowledge, comparison studies between these two regional block techniques in breast surgery is still limited, and the results remain inconclusive [9–12]. Therefore, we aimed to compare the analgesic efficacy of ESPB to PVB for mastectomy using postoperative morphine requirements of 24 h as our primary outcome.

MATERIALS AND METHODS

This controlled, randomized, double-blinded study was conducted in a university hospital. It was approved by the Institutional Ethics committee (no. HE62148) and had been registered before enrollment started (TCTR20200105003). After obtaining written informed consent from all participants, we enrolled patients who underwent unilateral mastectomy from January to August 2020. Patients aged 18–75 years with the American Society of Anesthesiologist physical status I–III were included. Patients with the following conditions were excluded: (1) pregnancy or lactation; (2) coagulation disorders; (3) skin lesion at the block site; (4) allergy to study drugs; (5) inability to cooperate; and (6) body mass index (BMI) greater than 35 kg/m^2. Patients were randomly allocated (allocation ratio 1:1) into two groups: PVB group and ESPB group using computer-generated random numbers (http://www.randomizer.org/). The random numbers were kept in concealed-opaque envelopes.

The self-reported pain assessment using the numeric rating scale (NRS), ranging from 0 = no pain to 10 = maximum pain, was instructed on the day before surgery. On the day of surgery, patients received oral acetaminophen 1,000 mg as pre-emptive analgesia 2 h before the operation. The random sequence numbers contained in the envelope were revealed in the procedural area by an anesthesiologist who was not involved in data collection. Each patient received a block on their back under sedation, and the data recorder was not present at the block area. Thus, they were blinded to the group allocated.

In the procedural area, the patient was connected to standard monitoring equipment (electrocardiogram, non-invasive blood pressure, and pulse oximetry), then placed in the lateral position with the affected side up, followed by intravenous (IV) fentanyl 50 μg and IV midazolam 1–2 mg for sedation. An experienced anesthesiologist performed all the blocks under ultrasound (US) guidance (SONIMAGE HS1, Konica Minolta, Japan) using a high-frequency (15–6 MHz) linear transducer. For all patients, 20 ml of 0.5% levobupivacaine and a 22 G-80 mm nerve block needle were used.

The PVB was performed using the intercostal approach [13]. After aseptic preparation of skin and covering the transducer with the sterile sleeve, the transducer was initially placed on the patient's back in the parasagittal plane over the 1st rib, then moved caudally until it reached the 4th rib. At this point, the transducer was turned clock-wisely while keeping the medial edge in contact with the transverse process (TP) until the horizontal view of the rib was visualized as a hyperechoic line with the posterior acoustic shadow. The transducer was then moved further caudally into the space between the adjacent ribs. Once the rib shadow disappeared, the paravertebral space (PVS) was visualized as a wedge-shaped space. A block needle was advanced with an in-plane approach from the lateral to medial direction until its tip pierced the internal intercostal membrane and reached the PVS (Fig. 1A). A small volume of normal saline solution (NSS) was injected to confirm the PVS by observing the anterior displacement of the pleura. After negative aspiration of blood, the local anesthetic drug (LA) was then incrementally injected.

Regarding the ESPB, the 4th rib was first identified with the same prior steps. Then the transducer was moved medially to identify the tip of the TP and the three back muscles (trapezius, rhomboid major, and erector spinae muscle; ESM). Then the needle was advanced with an in-plane approach from caudad to cephalad until its tip contacted the TP (Fig. 1B). Then, NSS was injected to confirm the target by observing the fluid spread under the ESM, followed by incrementally injecting the LA. After performing the block, patients were then turned to the supine position. Fifteen minutes later, a blinded observer used an alcohol-soaked cotton ball to assess the dermatome of the sensory blockade on the anterior chest wall. The absence of any sensory blockade at the time of assessment was defined as a failed block, and the patient would be withdrawn from the study.

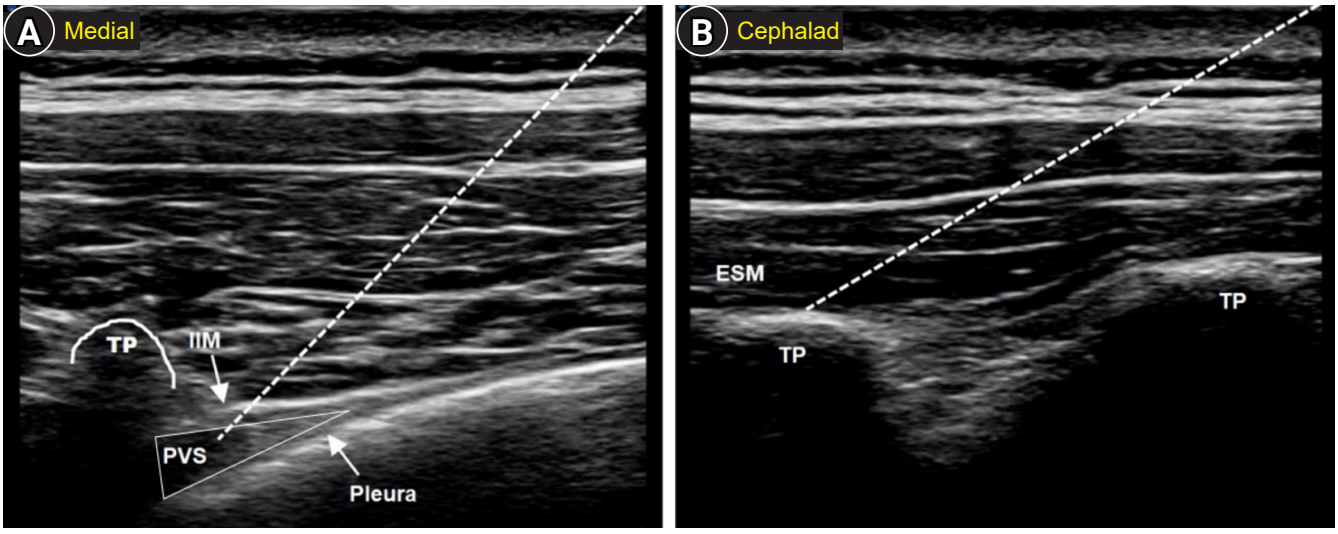

Fig. 1. Ultrasound images of PVB (A) and ESPB (B). PVB: thoracic paravertebral block, ESPB: erector spinae plane block, ESM: erector spinae muscle, IIM: internal intercostal membrane, PVS: paravertebral space (a wedge shape), TP: transverse process, white dash-line represented needle trajectory.

All patients underwent the same institutionally standardized operation and the same general anesthesia protocol. Anesthesia was induced with IV propofol 2–3 mg/kg and IV fentanyl 1.5–2 μg/kg. Tracheal intubation was facilitated with IV cisatracurium 0.1–0.2 mg/kg. For maintenance of anesthesia, patients received a mixture of air-oxygen (FiO_2 0.4) and sevoflurane to keep the bispectral index between 40–60. In addition, intraoperative IV fentanyl could be administered in increments of 25 μg at the discretion of the blinded anesthesia team to maintain the hemodynamic parameters within 20% of baseline.

All patients received IV dexamethasone 8 mg and IV ondansetron 4 mg according to the institutional guidelines for postoperative nausea and vomiting (PONV) prophylaxis. At the end of the surgery, IV morphine (3 mg) was administered, except for those who were over 70 years of age, in which case 2 mg would be given. In addition, when the operation was finished, IV neostigmine 0.05 mg/kg and atropine 0.02 mg/kg were given for reversal of neuromuscular blockade. Patients were extubated according to the institutional protocol.

Patients were transferred to the post-anesthetic care unit (PACU) and cared for by a nurse blinded to their group allocation. According to our PACU protocol, patients received IV morphine 3 mg boluses whenever their NRS was greater than 3. The total morphine consumption in PACU was recorded. The same pain management protocol was applied in the ward, including oral acetaminophen of 1,000 mg every 6 h and IV morphine 2 mg boluses on-demand or whenever their NRS was greater than 3 for rescue analgesia.

The primary outcome was postoperative morphine requirements in the first 24 h after surgery. Secondary outcomes included morphine requirements in the first 48 h after surgery, the number of patients requiring rescue morphine, the frequency of rescue morphine requirements, time to first morphine request, NRS both at rest and on movement at PACU, and at 6, 12, 24, and 48 h postoperatively, dermatome of sensory blockade, and patient satisfaction (assessed by a 5-point scale from 0 = very dissatisfied to 4 = very satisfied). Block-related complications and adverse events such as pneumothorax, local anaesthetic systemic toxicity, respiratory depression (respiratory rate < 8 times/min), oversedation (Ramsay scale > level 4), and moderate to severe PONV (nausea or vomit that requires treatment and beyond) were also recorded.

Sample size was calculated using the program on the website (https://clincalc.com/stats/samplesize.aspx). A pilot study (n = 10) conducted at our institution revealed that patients undergoing PVB for unilateral mastectomy reported a mean 24-h morphine consumption of 6.5 mg, with a standard deviation of 1.5 mg (unpublished data). The difference in morphine consumption of less than 20% (1.3 mg of morphine consumption) in the ESPB group was accepted for assuming the same efficacy to PVB. Thus, a calculated sample size of 21 patients in each group was required for a statistical power of 80% and an alpha error of 0.05. We enrolled 44 patients to account for possible dropouts.

Statistical analyses were performed using STATA version

10.1 (StataCorp LP, USA). Normality of data distribution was tested by the Shapiro–Wilk test. Continuous variables were reported as mean ± SD or median (1Q, 3Q). Categorical variables were presented as absolute numbers and percentages. Normally distributed continuous variables, including age, weight, and BMI were compared using independent Student's *t*-test. The Mann–Whitney *U* test was used to analyse the other continuous variables which were not normally distributed. The NRS which was measured repeatedly were analysed by generalized estimating equations model. Categorical variables including the American Society of Anesthesiologist physical status, frequency of requiring rescue morphine, and PONV incidence were compared using Fisher's exact test, whereas type of surgery, number of patients requiring rescue morphine, and patient satisfaction were compared using chi-square test. A two-tailed P value of < 0.05 was considered statistically significant.

RESULTS

Fifty patients met the eligibility criteria, three refused to participate, and three others did not meet the inclusion criteria. Thus, 44 patients were enrolled and randomly divided into two groups (22 for each). The blocks were all successful, and all the participants were followed up and assessed on an intention-to-treat basis (Fig. 2). The demographic and operative data were comparable between groups (Table 1). Morphine requirements in 24 h were significantly lower in the PVB group (3.5 ± 3.3 mg vs. 8.6 ± 3.8 mg, $P < 0.001$), rescue morphine was required by all patients in the ESPB group, but only by 14 patients in the PVB group ($P = 0.004$). The frequency of requiring rescue morphine was significantly lower in the PVB group ($P < 0.001$), but the time to first morphine request was not different between groups ($P = 0.532$) (Table 2).

In terms of pain score, NRS at rest and on movement at PACU were significantly lower in the PVB group ($P = 0.002$ and < 0.001, respectively). Moreover, the overall NRS was also lower in the PVB group ($P < 0.001$) (Table 3). Wide ranges of sensory blockade from T1–T10 occurred in both groups. However, the PVB group demonstrated a higher blockade percentage in all dermatomes; especially at the T3–T6 levels, in which over 80% blockade was observed (Fig. 3). The dermatome of sensory blockade was substan-

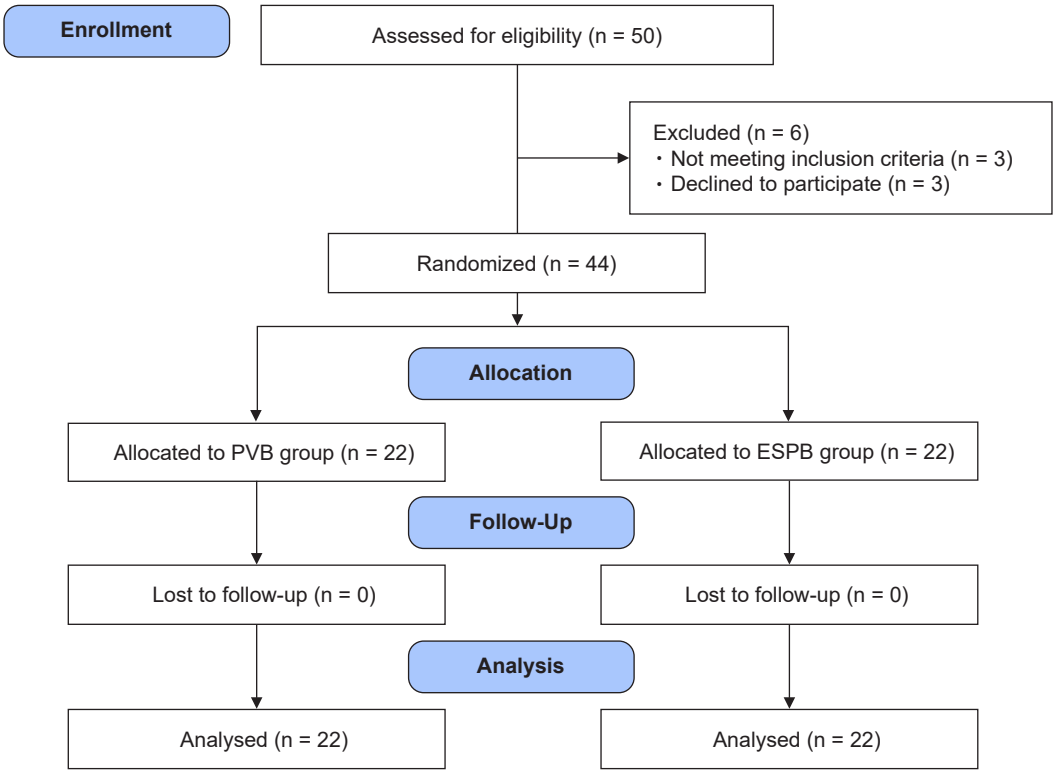

Fig. 2. CONSORT flow diagram for the study. CONSORT: Consolidated Standards for Reporting of Trials, PVB: thoracic paravertebral block, ESPB: erector spinae plane block.

Table 1. Demographic and Operative Data

Variable	PVB (n = 22)	ESPB (n = 22)	P value
Female	22 (100)	22 (100)	NA
Age (yr)	54.2 ± 9.8	56.1 ± 9.1	0.526
Weight (kg)	59.7 ± 8.9	61.1 ± 10.5	0.645
Body mass index (kg/m^2)	24.5 ± 3.4	24.3 ± 3.8	0.878
ASA PS (I/II)	5 (22.7)/17 (77.3)	4 (18.2)/18 (81.8)	< 0.999
Type of surgical procedure			0.361
Simple mastectomy	11 (50.0)	14 (63.6)	
Modified radical mastectomy	11 (50.0)	8 (36.4)	
Operative time (min)	181.6 ± 78.1	156.6 ± 56.0	0.228
Intraoperative blood loss (ml)	59.3 ± 60.1	72.5 ± 68.6	0.318

Values are presented as mean ± SD or number (%). PVB: thoracic paravertebral block, ESPB: erector spinae plane block, ASA PS: American Society of Anesthesiologists physical status, NA: not applicable. Independent Student's *t*-test was used for statistical comparison of age, weight, and body mass index. Mann–Whitney *U* test was used for statistical comparison of operative time and intraoperative blood loss. Fisher's exact test was used for statistical comparison of ASA PS and the chi-square test was used for statistical comparison of type of surgical procedure.

Table 2. Perioperative Opioid Consumption

Variable	PVB (n = 22)	ESPB (n = 22)	MD (95% CI)	P value
Intraoperative fentanyl consumption (μg)	158.0 ± 49.0	177.3 ± 51.7	−19.3 (−49.9 to 11.3)	0.212
Total morphine consumption in 24 h (mg)	3.5 ± 3.3	8.6 ± 3.8	−5.1 (−7.3 to −2.9)	< 0.001*
Time to first analgesic request (min)	209.1 ± 61.1	197.4 ± 49.5	11.8 (−25.9 to 49.4)	0.532
Number of patients requiring rescue morphine	14 (63.6)	22 (100.0)	NA	0.004*
Frequency of rescue morphine requirements (time)	1 (0, 2)	3 (2, 4)	NA	< 0.001*

Values are presented as mean ± SD, number (%), or median (1Q, 3Q). PVB: thoracic paravertebral block, ESPB: erector spinae plane block, MD: mean difference, CI: confidence interval, NA: not applicable. Mann–Whitney *U* test was used for statistical comparison of intraoperative fentanyl consumption, total morphine consumption in 24 h and time to first analgesic request. Chi-square test was used for statistical comparison of number of patients requiring rescue morphine and Fisher's exact test was used for statistical comparison of frequency of rescue morphine requirements. *P < 0.05 was considered statistically significant.

tially wider in the PVB than in the ESPB group, with 7 (5, 8) levels and 4 (1, 7) levels, respectively (P = 0.019). Moderate to severe PONV was found without statistical significance in three patients from the ESPB group. Severe complications did not occur in any group. Most of the patients rated as "very satisfied" followed by "satisfied" the pain relief method they had received (Table 4).

DISCUSSION

This randomized double-blind control trial (RCT) compared the analgesic effects after mastectomy between PVB and ESPB.

Regarding the PVB group in this study, patients required lower postoperative opioids, had lower postoperative pain score, and had wider dermatome of sensory blockade compared to the ESPB group. Also, fewer patients in the PVB group required rescue morphine, and required it less frequently, compared to the ESPB group.

To date, trials that compared the analgesic efficacy between PVB and ESPB after breast surgery are sparse [9–12]. The first RCT conducted by El Ghamry and Amer [9] demonstrated that single-shot PVB and ESPB at T5 level with 20 ml of 0.25% bupivacaine provided comparable 24 h in terms of total postoperative morphine consumption and pain score. These results corresponded to the two following studies. Gürkan et al. [10] compared single-shot PVB and ESPB against control (no block) for breast surgery. In that study, both the PVB and ESPB groups showed a similarly low dose of 24 h morphine consumption of 5.6 mg, which decreased by 62% compared to the control group, while there was no difference between the block groups. Furthermore, Moustafa et al. [11] reported no significant differences between single-shot PVB and single-shot ESPB after modified radical mastectomy surgery in terms of 24-h morphine consumption (6.2 mg) and the time to the first analgesic requirement (approximately 11 h).

These findings contrast with our study, which suggests

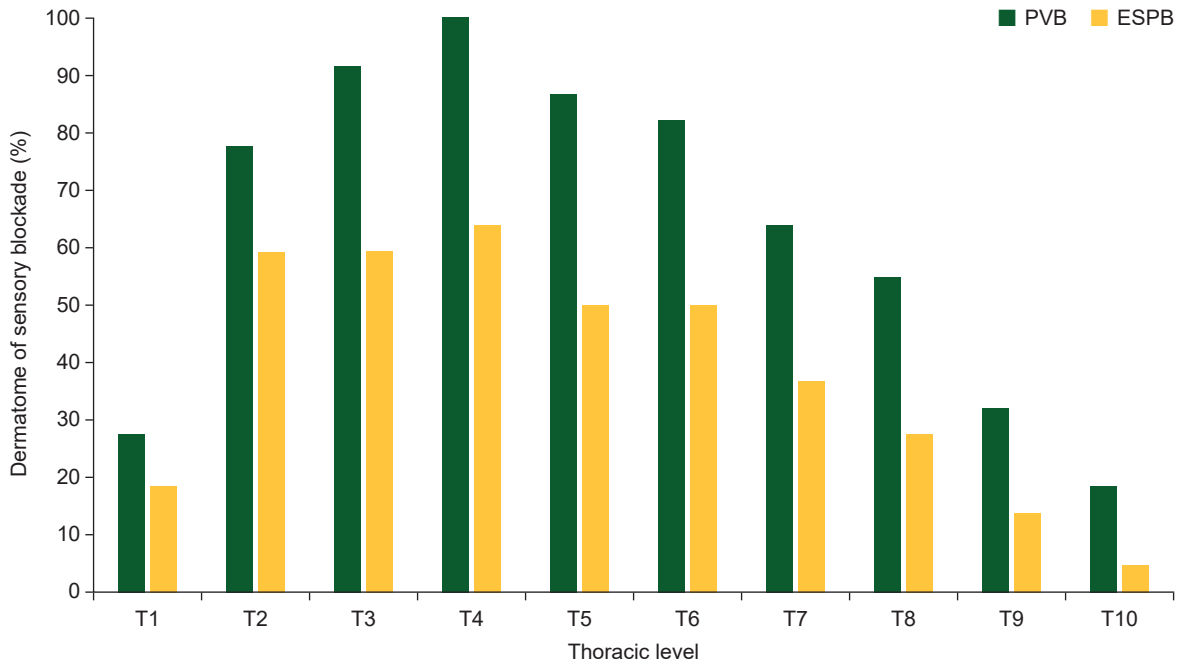

Fig. 3. Dermatome of sensory blockade following PVB and ESPB. PVB: thoracic paravertebral block, ESPB: erector spinae plane block, T: thoracic level.

Table 3. Postoperative Pain Score

Variable	PVB (n = 22)	ESPB (n = 22)	MD (95% CI)	P value
Pain score at rest				
Overall pain score at rest			1.68 (0.74 to 2.63)	< 0.001*,†
At PACU	2.73 ± 1.78	4.41 ± 1.44	1.68 (0.44 to 2.92)	0.002*,‡
At 6 h	1.32 ± 1.17	2.09 ± 1.72	0.77 (−0.35 to 1.90)	0.387‡
At 12 h	0.68 ± 0.95	1.23 ± 1.11	0.55 (−0.25 to 1.34)	0.379‡
At 24 h	0.50 ± 0.86	0.68 ± 0.95	0.18 (−0.51 to 0.88)	> 0.999‡
At 48 h	0.41 ± 0.73	0.59 ± 0.91	0.18 (−0.45 to 0.82)	> 0.999‡
Pain score on movement				
Overall pain score on movement			2.50 (1.28 to 3.72)	< 0.001*,†
At PACU	3.55 ± 2.22	6.05 ± 1.94	2.50 (0.90 to 4.10)	< 0.001*,‡
At 6 h	2.91 ± 1.27	3.41 ± 1.18	0.50 (−0.44 to 1.44)	0.856‡
At 12 h	2.50 ± 1.10	2.64 ± 1.29	0.14 (−0.79 to 1.06)	> 0.999‡
At 24 h	2.09 ± 1.23	2.09 ± 1.02	0.00 (−0.87 to 0.87)	> 0.999‡
At 48 h	1.73 ± 1.24	1.86 ± 1.36	0.14 (−0.86 to 1.13)	> 0.999‡

Values are presented as mean ± SD. PVB: thoracic paravertebral block, ESPB: erector spinae plane block, MD: mean difference, CI: confidence interval, PACU: post anesthesia care unit. *P < 0.05 was considered statistically significant. †Analysed by generalized estimating equations model. ‡Compared pain score between ESPB vs. PVB at PACU, 6, 12, 24, and 48 h.

that PVB had superior analgesia over ESPB. The reason for this could be that we observed a wider dermatome of sensory blockade (7 vs. 4 levels) in the PVB group and a higher blockade percentage. In addition, intense blockade of over 80% at the T3–T6 dermatomes has occurred only in the PVB group, which was necessary for breast surgery analgesia that did not involve the axillary region, such as simple mastectomy, which was the majority of the cases in our study [14].

The precise sensory blockade provided by PVB in this study also resulted in lower postoperative pain scores and morphine consumptions, as well as lower requirements and frequency of rescue morphine. According to Swisher et al. [12], PVB had better immediate analgesic effects than ESPB after non-mastectomy breast surgery in terms of pain score

Table 4. Dermatome of Sensory Blockade, Adverse Events, Complications and Patient Satisfaction

Variable	PVB (n = 22)	ESPB (n = 22)	P value
Dermatome of sensory blockade (levels)	7 (5, 8)	4 (1, 7)	0.019*
Adverse events and complications			
Moderate to severe PONV	0	3 (13.6)	0.351
Oversedation	0	0	NA
Respiratory depression	0	0	NA
Local anaesthetic systemic toxicity	0	0	NA
Pneumothorax	0	0	NA
Patient satisfaction			0.531
Vary satisfied	15 (68.2)	13 (59.1)	
Satisfied	7 (31.8)	9 (40.9)	

Values are presented as median (1Q, 3Q) or number (%). PVB: thoracic paravertebral block, ESPB: erector spinae plane block, PONV: postoperative nausea and vomiting, NA: not applicable. Mann–Whitney *U* test was used for statistical comparison of dermatome of sensory blockade. Fisher's exact test and chi-square test was used for statistical comparison of PONV incidence, and patient satisfaction, respectively. *P < 0.05 was considered statistically significant.

and opioid consumption in the PACU. In addition, PVB also reduced the discharge time from PACU by 15% compared to ESPB (105 min vs. 124 min).

PVB is an RA technique of injecting LA into the PVS, allowing direct contact with the proximal spinal nerves and rami communicant of sympathetic fibers, resulting in a precise ipsilateral somatic and sympathetic blockade. A relatively new technique, ESPB was first introduced as a regional block to treat thoracic neuropathic and acute pain [15]. This block may share the exact mechanism with PVB by allowing LA to spread to PVS through the costotransverse foramen [8,15]. However, two previous cadaveric studies did not support this hypothesis. In those studies, the dye mainly spread underneath the muscle plane in a longitudinal and especially lateral direction but with limited or no anterior spread to the PVS [16,17]. In addition, Ivanusic et al. [16] showed that the dye was most observed at or lateral to the angle of the ribs. Hence, they speculated that the mechanism of ESPB was from the blockade of the lateral cutaneous branches of the spinal nerves at the level in which they pierced the intercostal muscles and left the intercostal space.

How LA spread in cadavers may not represent the proper LA spread in living humans because negative intrathoracic pressure during respiration, ESM contraction, and patient positioning can all enhance LA shift towards the PVS. Thus, examining the contrast dye with X-ray or magnetic resonance imaging (MRI) is more appropriate for evaluating the spread in humans [18,19]. A recent MRI study by Schwartzmann et al. [18] showed the ESPB injectate spreading consistently into the intercostal space and neural foramina. Thus, this appeared to be the mechanism of ESPB in their study. In addition, they found the extent of the longitudinal spread whereas the anterior chest walls blockade was highly variable.

In addition, a recent volunteer study reported a widespread area of decreased sensory sensation in the posterior thorax without any evidence of sensory blockade of the anterior and lateral chest walls following the ESPB with a 20 ml injection of 0.5% ropivacaine. As a result, only the dorsal rami of the spinal nerve were assumed to have been blocked [20]. Furthermore, a clinical study comparing the analgesic efficacy between ESPB and PVB by Aoyama et al. [6] found that although the two blocks were comparable with regards to opioid consumption and pain score, ESPB did not produce sensory blockade as consistently as PVB did. We found a very similar result. In our study, ESPB had a narrower and more variable dermatome of sensory blockade than PVB (4 (1, 7) vs. 7 (5, 8) levels, respectively). Overall, from currently available evidence, ESPB seems to produce high variability in block intensity and the extent of analgesia, its LA spread was unpredictable, and its mechanism of action remains unclear [6,17,21].

In our study, a single-level injection of PVB at T4 was performed, and with the same technique and volume of LA, we found a wide sensory blockade, similar to a previous study (6 dermatomes, range, 5–6) [22]. This may be because using the US-guidance allowed precise needle tip placement and deposited the LA within the PVS. In addition to this, evidence shows that an US-guidance single injection PVB provides an equivalent dermatomal coverage to the multiple injection technique [23].

The incidence of moderate to severe PONV was higher in

the ESPB group but not significantly different. This might be an effect of our PONV prophylaxis regimen, which was administered to all participants. Pneumothorax did not occur in our study, similar to previous studies, which might be because all blocks were performed by the expert and under US-guidance [6,10,12]. According to the report from a meta-analysis, the incidence of pneumothorax after PVB was rarely observed at 0.5% [24]. Most of the patients in our study were very satisfied with their pain management; one possible reason was that they did not suffer from severe complications or severe pain throughout the postoperative period.

Notably, even though postoperative morphine consumption and pain score are important considering factors when selecting an appropriate block technique, there remain essential elements that must be included in the decision-making process, such as the clinician's proficiency, the technical difficulty, the invasiveness, the pain intensity created by the procedure, and the patient's pain experience and expectations [25,26]. Giving adequate attention to weighing all these factors is crucial in reaching the optimal decision for each circumstance.

The present study had some limitations. First, we did not apply a sham or no-block group in our protocol as there was adequate evidence to support the analgesic effects of these two regional blocks without the need to compare them with a control group. Second, the evaluation period of the sensory blockade in this study might be relatively short for the demonstration of actual blockade in fascia plane blocks like ESPB. We chose 15 min after block to evaluate the sensory blockade as we were concerned about the busy operating room schedule. Ultimately, we believe that this decision did not interfere with our primary outcome, which was the morphine consumption within 24 h. Lastly, our participants were not followed up long-term, hence we could not assess the impact of the blocks on long-term outcomes such as post-surgical pain syndrome or the recurrent cancer rate.

In conclusion, compared to ESPB, PVB provided lower postoperative opioid requirements and decreased postoperative pain score with broader dermatome of sensory blockade after mastectomy surgery.

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

Conceptualization: Aumjit Wittayapairoj, Nattanan Sinthuchao. Data curation: Aumjit Wittayapairoj, Nattanan Sinthuchao, Ongart Somintara, Viriya Thincheelong, Wilawan Somdee. Formal analysis: Aumjit Wittayapairoj, Ongart Somintara. Funding acquisition: Aumjit Wittayapairoj. Methodology: Aumjit Wittayapairoj, Nattanan Sinthuchao. Project administration: Aumjit Wittayapairoj, Nattanan Sinthuchao, Ongart Somintara. Writing - original draft: Aumjit Wittayapairoj, Nattanan Sinthuchao. Writing - review & editing: Aumjit Wittayapairoj, Nattanan Sinthuchao, Ongart Somintara. Investigation: Aumjit Wittayapairoj, Nattanan Sinthuchao, Viriya Thincheelong, Wilawan Somdee. Resources: Viriya Thincheelong, Wilawan Somdee. Supervision: Aumjit Wittayapairoj. Validation: Aumjit Wittayapairoj, Ongart Somintara.

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