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Comparison of Acute Postoperative Pain Between Preemptive Ultrasound-Guided Pectoral Nerve Block and Intraoperative Pectoral Nerve Block in Patients Undergoing Mastectomy

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Abstract

Pectoral nerve block is an effective postoperative pain control strategy for patients undergoing mastectomy. Preemptive analgesia is also recognized as a key component of multimodal pain management strategies. The purpose of this study was to compare the efficacy of preemptive ultrasound-guided pectoral nerve block (PECs block) with intraoperative PECs block. In this study, a randomized controlled trial with 44 patients undergoing mastectomy with general anesthesia was conducted, and the patients were allocated into two groups. The preemptive group received preemptive ultrasound-guided PECs block with 10 ml of 0.25% bupivacaine mixed with 1% lidocaine with epinephrine 1:200,000 for PEC I and 20 ml for PEC II, while the intraoperative group received intraoperative pectoral nerve block with 10 ml of same mixture for PEC I and 20 ml for PEC II. The primary outcome was pain intensity using a visual analogue scale (VAS). The secondary outcomes were cumulative morphine consumption over 72 hr postoperatively, total anesthetic time and complications. The study showed that at 20 hr postoperatively, the mean VAS score in the intraoperative group was 1.41 ± 1.22, which was statistically significantly lower than the 2.22 ± 1.34 observed in the preemptive group ($p = 0.040$). There were no complications reported in either group, and cumulative morphine consumption did not differ significantly between groups at any time point. The total anesthetic time was significantly shorter in the intraoperative group (111 ± 3.54 min) compared with the preemptive group (140 ± 2.84 min, $p < 0.001$). Therefore, the intraoperative PECs block resulted in significantly lower VAS scores at 20 hr postoperatively, although the clinical relevance may be limited. Additionally, the intraoperative approach may offer practical advantages in clinical settings, such as reduced anesthesia time.

Keywords: Pectoral nerve, Nerve block, Mastectomy, Acute postoperative pain

Introduction

Mastectomy is a common surgical procedure for breast cancer treatment (Storm-Dickerson & Sigalove, 2019). Patients undergoing breast surgery often experience moderate to severe postoperative pain, which can contribute to complications such as atelectasis, delayed recovery, and prolonged hospital stays. Therefore, effective postoperative pain control is critical to improving rehabilitation participation and both short- and long-term recovery outcomes (Bell et al., 2019; Diéguez et al., 2016; Hussain et al.,2019; Neethu et al., 2018).

Regional anesthesia, combined with general anesthesia, has been shown to enhance postoperative recovery by reducing pain intensity, opioid consumption, and nausea (Jin et al., 2020; Sherwin & Buggy,2018; Wong et al., 2021). Pectoral nerve blocks (PECs blocks) are recommended as effective strategies for managing postoperative pain in major breast surgeries (Jacobs et al., 2020).

Preemptive PECs block, performed before surgical incision, are hypothesized to reduce postoperative pain by preventing central sensitization, thereby prolonging analgesia and reducing opioid requirements (Ali et al., 2016;

Xuan et al., 2022). Intraoperative PECs block, performed under direct visualization by surgeons, offers an alternative approach with comparable effectiveness and precision (Dsbe et al., 2021; Moon et al., 2022; Thomas et al., 2018). However, direct comparisons between these two techniques remain limited in the current literature.

The purpose of this study was to compare the efficacy of preemptive ultrasound-guided pectoral nerve block (PECs block) with Intraoperative PECs block in patients undergoing mastectomy. The primary outcome was postoperative pain intensity, measured by Visual Analog Scale (VAS) scores, while secondary outcomes included morphine consumption, anesthetic time, and complications. We hypothesized that preemptive PECs block would provide superior pain relief compared to intraoperative PECs block.

Materials and Methods

Study Design and participants

This single-center, prospective, randomized, double-blind controlled trial was conducted at Naresuan University Hospital between October 2022 and October 2024. The study aimed to compare the effectiveness of preemptive ultrasound-guided pectoral nerve block and intraoperative pectoral nerve block for postoperative pain control in patients undergoing elective mastectomy.

Eligible patients were female, aged 20-80 years, classified as American Society of Anesthesiologists (ASA) physical status I-III. All procedures were performed by a single surgeon to standardize surgical technique. Exclusion criteria included a history of ischemic heart disease or ejection fraction <50% on echocardiography, liver cirrhosis or cancer, prior breast or axillary radiation, regular use of NSAIDs or opioids, allergies to paracetamol, NSAIDs, or opioids, an estimated glomerular filtration rate (eGFR) <50 ml/min/1.73m^2, or cognitive impairment.

The study protocol was approved by the Naresuan University Institutional Review Board (IRB) (COA No. 408/2022; IRB No. 0076/2565) on October 7, 2022. The trial was registered with the Thai Clinical Trials Registry (TCTR20241115006) on November 5, 2024 and conducted in compliance with the Declaration of Helsinki, Belmont Report, CIOMS guidelines, and International Conference on Harmonization Good Clinical Practice standards.

Outcomes, measurement, and data collection

The primary outcome was postoperative pain intensity at rest, measured using a 10-cm Visual Analog Scale (VAS) at regular 4-hr intervals for 72 hr postoperatively. Secondary outcomes included total morphine consumption, total anesthetic time, and incidence of complications.

Baseline characteristics, including age, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status classification system, type of mastectomy, side of operation, and comorbidities, were recorded preoperatively. Postoperative data were collected by assessors blinded to the group allocation. The total anesthetic time was defined as the duration from administration of the anesthetic induction agent until removal of the endotracheal tube. Morphine consumption was tracked using a patient-controlled analgesia (PCA) pump. Complications, including pneumothorax, ipsilateral upper extremity motor weakness, seroma, hematoma, infection, and skin flap necrosis, were monitored and documented during routine perioperative care.

Randomization and blinding

A total of 44 patients were recruited and randomized into two groups: the preemptive PECs block group and the intraoperative PECs block group. Randomization was performed using a block design with a block size of four,

generated via a computerized random number generator (www.randomization.com). Group assignments were sealed in opaque envelopes by an independent third party. Both patients and outcome assessors were blinded to the group allocation.

Perioperative anesthesia and intervention

On the day of surgery, intravenous access was established in the nonoperative arm. Standard monitoring, including pulse oximetry, noninvasive blood pressure measurement, and electrocardiography, was applied.

The local anesthetic solution consisted of 15 ml of 0.5% bupivacaine, 15 ml of 2% lidocaine and 0.15 ml of epinephrine (1:1000) prepared under the anesthesiologist's supervision. The total 30 ml volume was divided into two syringes: a 10-ml syringe and a 20-ml syringe.

General anesthesia was induced with intravenous propofol 1.5-2.5 mg/kg, fentanyl 1-2 mcg/kg, and cisatracurium 0.15-0.2 mg/kg. After intubation with a 7.0-7.5 size of endotracheal tube, anesthesia was maintained using sevoflurane 0.8-1.2 MAC. Following intubation, patients received dexamethasone 8 mg, ondansetron 8 mg, and ketorolac 30 mg intravenously. The assigned group was revealed to the anesthesiologist after intubation by opening the opaque envelope.

Patients in the preemptive group were positioned supine with the shoulder abducted and the elbow extended. The operative chest wall was sterilized, and a linear ultrasound probe covered in a sterile sheath was placed over the anterior axillary line at the level between the third and fourth rib with an angled infero-laterally approach on the ipsilateral side of the operative chest wall. The transducer was rotated and tilted to visualize the pectoralis major, pectoralis minor, and serratus anterior muscle layers. (Fig. 1)

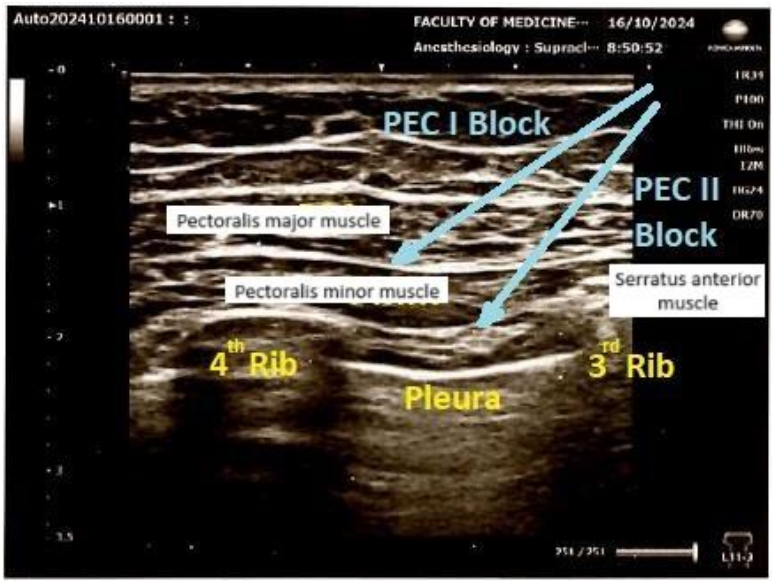

Figure 1 Sonographic anatomy of PECs-I and PECs-II block.

All preemptive PECs group were performed under real-time ultrasound guidance by three anesthesiologists, each with more than two years of experience in performing PECs block and a 22G, 80-mm needle was advanced in-plane to the target site, the plane between the pectoralis minor and serratus anterior muscles. After confirming the appropriate plane with 1-2 ml of normal saline, 20 ml of the local anesthetic solution (0.25% bupivacaine mixed with 1% lidocaine and epinephrine 1:200,000) was injected to perform the PEC II block. The needle was then

repositioned between the pectoralis major and minor muscles, and after verification with normal saline, an additional 10 ml of the local anesthetic solution was injected for the PEC I block. (Fig.1)

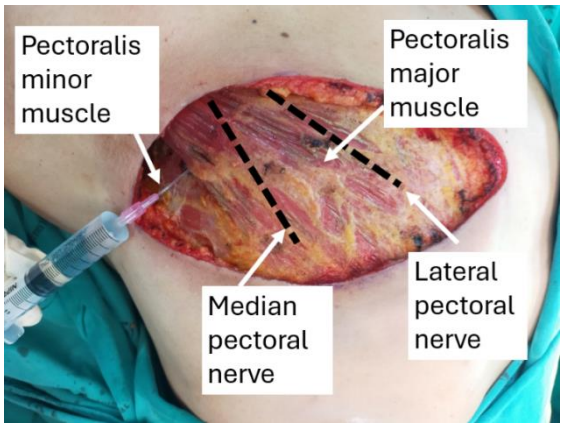

Figure 2 Intraoperative PEC I block: The anesthetic agent was injected between the pectoralis major and pectoralis minor muscles to cover the medial pectoral nerve and lateral pectoral nerve

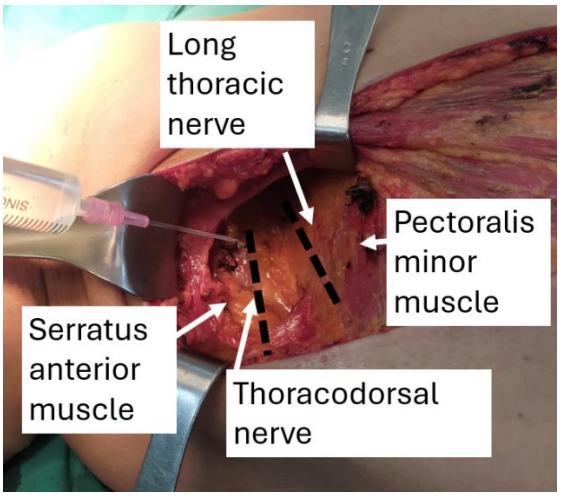

Figure 3 Intraoperative PEC II block: The anesthetic agent was injected between the pectoralis minor and serratus anterior muscles to cover the lateral cutaneous nerve, long thoracic nerve, and thoracodorsal nerve

For the intraoperative group, the PECs block was performed after mastectomy completion and before skin closure. The local anesthetic solution was prepared identically to the preemptive group. The surgeon infiltrated two sites using a 21G intravenous catheter. The first site, located between the pectoralis major and minor muscles, received 10 ml of the anesthetic solution (Fig.2). The second site, between the pectoralis minor and serratus anterior muscles, received 20 ml of the same solution (Fig.3).

Postoperatively, acetaminophen 500 mg was administered orally every 8 hr for pain management. Patient-controlled analgesia (PCA) pumps were provided, programmed to deliver 1 mg boluses of morphine on demand.

VAS pain scores at rest were assessed at 4-hr intervals for 72 hr postoperatively. Cumulative morphine use was recorded at 24-hr, 48-hr, and 72-hr intervals.

Sample size and statistical analysis

The sample size was calculated based on a previous study by Neethu et al. (2018), which reported VAS scores of 1.73 ± 0.78 in the treatment group receiving ultrasound-guided PECs block compared to 3.2 ± 1.51 in the control group that did not receive a PECs block. Thus, the sample size calculated using n4 Studies application (Prince of Songkhla University, Hat Yai, Thailand) (Ngamjarus et al., 2016). Using a power of 90%, a type I error of 0.05 and accounting for a 10% dropout rate, a total of 22 patients per group was required.

Statistical analysis was performed using Stata/MP 16.0 software (Stata Corp, College Station, TX, USA). Continuous variables were expressed as means ± standard deviation (SD), while categorical data were presented as numbers and percentages. Group comparisons were analyzed using the chi-square test for categorical variables and the Shapiro-Wilk test for normality. Postoperative VAS scores were analyzed using a Generalized Estimating Equation (GEE) model: $p < 0.05$ is considered statistically significant.

$$n_{trt} = \frac{(z_{1-\frac{\alpha}{2}} + z_{1-\beta})^2 \left[\sigma_{trt}^2 + \frac{\sigma_{con}^2}{r}\right]}{\Delta^2}$$

$$r = \frac{n_{con}}{n_{trt}}, \Delta = \mu_{trt} - \mu_{con}$$

Mean in a treatment group = **1.73**, SD. in a treatment group = **0.78**

Mean in a control group = **3.20**, SD. in a control group = **1.51**

Ratio (control/treatment) = **1.00**

Alpha (α) = **0.01**, Z(**0.995**) = **2.575829**

Beta (β) = **0.10**, Z(**0.900**) = **1.281552**

Sample size of 20 per group, dropout rate of 10% and sample size of 22 per group, **2** groups and a total sample size of 44 patients

Results

We enrolled 47 patients who underwent elective mastectomy between October 2022 and October 2024. One patient declined to participate; two patients were excluded due to a history of NSAID allergy. The remaining 44 patients were randomly assigned to either the preemptive group (n=22) or the intraoperative group (n=22). All participants completed the study and had fully recorded postoperative pain scores for 72 hr before discharge. Thus, a total of 44 patients were included in the final analysis. (Fig. 4)

Baseline demographic and clinical data are summarized in Table 1. The mean age of patients in the preemptive group was 53 ± 9.94 years, while in the intraoperative group, it was 56 ± 10.34 years. There were no statistically significant differences between the two groups regarding age, BMI, side of surgery, type of surgery, or underlying medical conditions. The study showed that there were significantly statistically lower VAS pain scores at 20 hr postoperatively in the intraoperative group (1.41±1.22) than in the preemptive group (2.22±1.34, P=0.040) (Table 2).

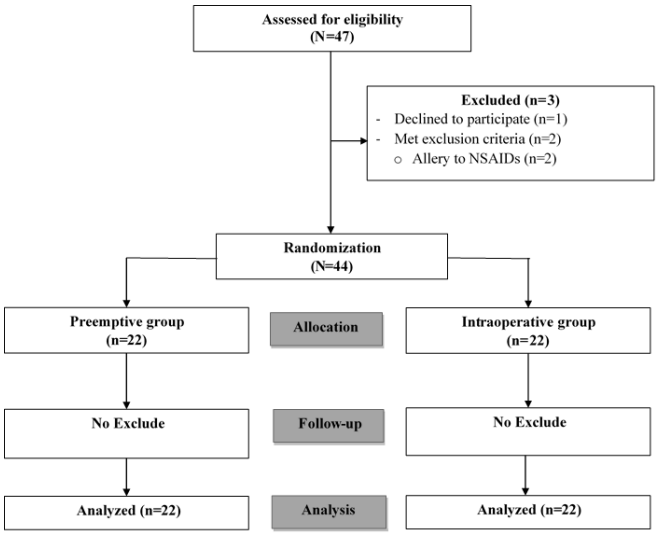

Figure 4 Consolidated Standards of Reporting Trials (CONSORT) diagram showed the flow of patients in the study

Table 1 Demographic characteristics

	Preemptive group (n=22)	Intraoperative group (n=22)	P-valve
Age (mean±sd)	53±9.94	56±10.34	0.213
BMI (mean±sd)	24.09±3.10	24.08±3.47	0.99
ASA physical (mean±sd)			
I	16(73.72%)	14(63.63%)	0.42
II	6(27.27%)	8(36.36%)	
Side of operation, n (%)			
Right	8(36.4%)	11(50.0%)	0.834
Left	14(63.6%)	11(50.0%)	
Operation, n (%)			
Mastectomy	1(4.55%)	2(9.09%)	0.656
Mastectomy with SLNB	13(59.09%)	14(63.64%)	
Modify radical mastectomy	8(36.36%)	6(27.27%)	
Underlying, n(%)			
Type 2 diabetes mellitus	1(4.55%)	4(18.18%)	0.154
Hypertension	5(22.73%)	9(40.91%)	0.195

Table 2 Pain score at various times after post-operative

Pain score	Preemptive group (n=22)	Intraoperative group (n=22)	*p*-valve
	(mean±sd)	(mean±sd)	
At 4 hr.	2.95±1.64	2.86±1.27	0.816
At 8 hr.	2.90±1.94	2.27±1.39	0.219
At 12 hr.	2.250±1.97	2.00±1.45	0.343
At 16 hr.	2.31±1.92	2.00±1.93	0.586
At 20 hr.	2.22±1.34	1.41±1.22	0.040*
At 24 hr.	1.81±1.26	1.36±1.09	0.208
At 28 hr.	1.68±1.43	1.22±1.02	0.231
At 32 hr.	1.81±1.13	1.27±1.35	0.123
At 36 hr.	1.27±1.16	1.14±1.32	0.718
At 40 hr.	1.59±1.05	1.05±0.79	0.058
At 44 hr.	1.77±1.38	1.14±0.83	0.070
At 48 hr.	1.68±1.21	1.09±0.87	0.069
At 52 hr.	1.59±1.18	1.18±1.01	0.223
At 56 hr.	1.50±1.10	1.27±0.94	0.464
At 60 hr.	1.36±0.95	1.09±0.87	0.327
At 64 hr.	1.45±1.14	1.32±1.25	0.707
At 68 hr.	1.18±1.00	0.82±0.59	0.151
At 72 hr.	1.04±0.89	0.82±0.66	0.345

* = statistical significance (P < 0.05)

Table 3 summarizes the anesthetic time, complications, and total morphine consumption. The intraoperative group had a significantly shorter total anesthetic time (113 ± 18.22 min) than the preemptive group (142 ± 12.03 min, $p < 0.001$). However, there were no statistically significant differences between the two groups regarding the complications, including pneumothorax, ipsilateral upper extremity motor weakness, seroma, hematoma, infection and skin flap necrosis or total postoperative morphine consumption ($P > 0.05$).

Table 3 Anesthetic times, Complications, and Morphine used

	Preemptive group (n=22)	Intraoperative group (n=22)	P-valve
Anesthetic time (min) (mean±sd)	142±12.03	113±18.22	<0.001*
Incidence of complication, n (%)	0	0	1.000
Morphine used, (mg)			
Morphine day 1	2.68±4.22	1.22±1.60	0.136
Morphine day 2	1.18±2.28	0.86±1.45	0.584
Morphine day 3	0.50±1.14	0.81±1.59	0.516

* = statistical significance (P < 0.05)

Discussion

Our study found statistically significant lower VAS pain scores at 20 hr postoperatively in intraoperative PECs block (1.41±1.22) than in preemptive ultrasound-guided PECs block (2.22±1.34, P 0.040). Furthermore, intraoperative PECs block offers greater clinical utility due to its association with shorter anesthesia time ($p < 0.001$), is easier to perform, and more cost-effective as a result of avoiding the need for additional ultrasound and block-specific needles. It also avoids the concern of local anesthetic spread into the axilla, which may potentially interfere with the surgical field.

According to the PROSPECT guidelines, thoracic paravertebral block (PVB) is recommended as the first-line regional analgesic technique for major breast surgery, while PECs block may be considered as an alternative (Jacobs et al., 2020). The PECs block is technically easier to perform and avoids potential risks associated with PVB. A systematic review and meta-analysis by Jin et al. demonstrated that PECs block and PVB provide comparable postoperative analgesic efficacy in mastectomy patients, with no significant differences in 24-hr opioid consumption or time to first rescue analgesia (Jin et al., 2020). Based on these findings, we selected the PECs block for our study as a practical and effective regional technique.

In contrast to our result, Elmeligy. et al. conducted a randomized study comparing the preemptive ultrasound-guided PECs block, intraoperative PECs block, and a control group in mastectomy patients. They reported significantly lower pain scores and morphine consumption in the preemptive group than in the intraoperative and control groups in the first 8 hr postoperatively ($p < 0.05$ and $p < 0.001$, respectively) (Elmeligy et al., 2024).

Several factors may explain the discrepancy between our results and Elmeligy. et al. First, preemptive analgesia may not consistently provide superior pain relief compared to intraoperative administration. For instance, Amit Kumar et al. found no significant difference in pain scores between preemptive and preventive IV paracetamol administration in 90 patients undergoing surgery (Amit et al., 2024). Similarly, Shaojuan Chen et al. reported no significant differences in pain scores between preemptive and postoperative intercostal nerve blocks in lobectomy patients (Chen et al., 2023).

Second, multimodal analgesia, including intravenous dexamethasone and ketorolac, may provide sufficient pain control, diminishing the additional benefit of the PECs block. Uribe et al. compared PECs block plus multimodal analgesia to multimodal analgesia alone in mastectomy patients and found no significant reduction in opioid consumption (Uribe et al., 2022). Future studies should include a control group to clarify the true efficacy of the PECs block. Third, intraoperative manipulation of pectoralis muscles may cause local anesthetic leakage in the preemptive group, reducing the duration of analgesic effect.

This study has several strengths. It was designed as a randomized, double-blind, controlled trial with standardized surgical and anesthetic techniques, including the use of a single surgeon and a limited number of anesthesiologists to perform the intervention, thereby minimizing variability and reducing potential bias. Pain assessment was conducted using repeated VAS measurements over 72 hr, and secondary outcomes such as morphine consumption, anesthetic time, and complications were systematically recorded by a single blinded investigator, providing a comprehensive and consistent evaluation of both efficacy and safety.

However, there are also important limitations. First, this was a single-center study, which may limit generalizability. Second, although previous studies have demonstrated the benefit of PECs block compared to placebo, and there are guidelines recommending their use as part of multimodal analgesia, the absence of a true

control group (without PECs block) precludes evaluation of the absolute efficacy of our PECs block technique within multimodal analgesia.

Third, our sample size was calculated based on a previous study comparing the PECs block with a control group, due to the absence, at the time of the study design, of published evidence directly comparing preemptive ultrasound-guided PECs block with an intraoperative PECs block. As a result, the current sample size may not be optimal for detecting differences between two active interventions.

Fourth, this study did not collect or report the total intraoperative fentanyl dose. Fentanyl was administered only during anesthetic induction to suppress the laryngeal reflex, and the dosage was adjusted according to individual patient body weight. Given its short duration of action, fentanyl was expected to have minimal effect on our primary and secondary outcomes (72-hr postoperative pain scores and morphine consumption). However, if there had been a statistically significant difference in total fentanyl administration between groups, it could have influenced our results.

Finally, pain perception is subjective and influenced by psychological factors, particularly in cancer patients (Meretoja et al., 2014; Steegers et al., 2008).

Conclusion and Suggestions

The preemptive ultrasound-guided PECs block does not provide superior postoperative pain control and reduced morphine consumption compared to the intraoperative PECs block. In contrast, the intraoperative block offers a lower VAS pain score at 20 hr postoperatively. Future studies should calculate the sample size using appropriate reference data that directly compares the preemptive and intraoperative PECs blocks to ensure adequate statistical power and valid conclusions. Furthermore, incorporating a three-arm study design that includes a true control group (without the PECs block) would provide a more comprehensive evaluation of the efficacy of the PECs block within the context of multimodal analgesia.

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Author Contributions

Sivaporn Pondeenana: Contributed to conceptualization, study design and methodology; performed data collection, investigation, and validation; participated in data analysis and interpretation; drafted the original manuscript; and contributed to critical review and editing.

Khwanchai Wanjerdkit: Performed data collection, investigation, and validation.

Chawisachon Nonsri: Contributed to conceptualization, study design and methodology; performed data collection, investigation, and validation; participated in data analysis and interpretation; assisted in drafting the manuscript; and contributed to critical review and editing.

Inthiporn Kositanurit: Contributed to conceptualization; performed data collection, investigation, and validation.

Rawee Jongkongkawutthi: Contributed to conceptualization and methodology; participated in data analysis and interpretation; contributed to manuscript drafting; performed critical revision and editing; provided overall scientific guidance; and served as the corresponding author.

All authors have read and approved the final manuscript.

Conflicts of Interest

All authors declare no personal conflicts of interest and no financial support from the companies that produce and/or distribute the drugs, devices, or materials described in this report.

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References

Ali, H., Ali, M., Zanfaly, H. E., & Biomy, T. A. (2016). Pre-emptive analgesia of ultrasound-guided pectoral nerve block II with dexmedetomidine-bupivacaine for controlling chronic pain after modified radical mastectomy. *Research and Opinion in Anesthesia and Intensive Care, 3*(1), 6-13. https://doi.org/10.4103/2356-9115.184078

Amit, K., Mohd, S. N., Sandhya, B. K., & Jitendra, S. (2024). Efficacy of Preemptive and Preventive Analgesia in Reducing Postoperative Rescue Analgesic Requirements in Surgical Patients. *Journal of Population Therapeutics and Clinical Pharmacology, 31*(3), 506-514. https://doi.org/10.53555/jptcp.v31i3.4940

Bell, A., Ali, O., Robinson, A., Aggarwal, A., Blundell, M., Townend, A., & Aspinall, S. (2019). The role of pectoral nerve blocks in a day-case mastectomy service: A prospective cohort study. *Annals of Medicine and surgery, 48*, 65-68. https://doi.org/10.1016/j.amsu.2019.10.019

Chen, S., Guo, Z., Wei, X., Chen, Z., Liu, N., Yin, W., & Lan, L. (2023). Efficacy of preemptive intercostal nerve block on recovery in patients undergoing video-assisted thoracic lobectomy. *Journal Of Cardiothoracic Surgery, 18*(1), 168. https://doi.org/10.1186/s13019-023-02243-z

Diéguez, P., Casas, P., López, S., & Fajardo, M. (2016). Ultrasound guided nerve block for breast surgery. *Revista espanola de anestesiologia y reanimacion, 63*(3), 159-167. https://doi.org/10.1016/j.redar.2015.11.003

Dsbe, M. K., Wu, J., & Sharma, R. D. (2021). The patient-Roported of Intra-operative Direct vision pectoral nerve block for post-operative analgesia for breast surgery. *Surgical Science, 12*, 274-285 http://doi.org/10.4236/ss.2021.128028

Elmeligy, M., Kohaf, N., Bauiomy, H., & Sakaya, A. (2024). Direct versus Ultrasound Guided PECS Block Effect on Controlling Postmastectomy Pain: A Randomized Single-Blind Trial. *Benha Medical Journal, 41*(5), 314-322. https://doi.org/10.21608/bmfj.2024.244677.1938

Hussain, N., Brull, R., McCartney, C. J. L., Wong, P., Kumar, N., Essandoh, M., Sawyer, T., Sullivan, T., & Abdallah, F. W. (2019). Pectoralis-II Myofascial Block and Analgesia in Breast Cancer Surgery: A Systematic Review and Meta-analysis. *Anesthesiology, 131*(3), 630-648. https://doi.org/10.1097/ALN.0000000000002822

Jacobs, A., Lemoine, A., Joshi, G. P., Van de Velde, M., Bonnet, F., & PROSPECT Working Group collaborators# (2020). PROSPECT guideline for oncological breast surgery: a systematic review and procedure-specific postoperative pain management recommendations. *Anaesthesia*, *75*(5), 664-673. https://doi.org/10.1111/anae.14964

Jin, Z., Durrands, T., Li, R., Gan, T. J., & Lin, J. (2020). Pectoral block versus paravertebral block: a systematic review, meta-analysis and trial sequential analysis. *Regional Anesthesia and Pain Medicine*, *45*(9), 727-732. https://doi.org/10.1136/rapm-2020-101512

Meretoja, T. J., Leidenius, M. H. K., Tasmuth, T., Sipilä, R., & Kalso, E. (2014). Pain at 12 months after surgery for breast cancer. *JAMA*, *311*(1), 90-92. https://doi.org/10.1001/jama.2013.278795

Moon, J., Park, H. S., Kim, J. Y., Lee, H. S., Jeon, S., Lee, D., Bai, S. J., & Kim, N. Y. (2022). Analgesic Efficacies of Intraoperative Pectoralis Nerve II Block under Direct Vision in Patients Undergoing Robotic Nipple-Sparing Mastectomy with Immediate Breast Reconstruction: A Prospective, Randomized Controlled Study. *Journal of Personalized Medicine*, *12*(8), 1309. https://doi.org/10.3390/jpm12081309

Neethu M., Pandey, R. K., Sharma, A., Darlong, V., Punj, J., Sinha, R., Singh, P. M., Hamshi, N., Garg, R., Chandralekha, C., & Srivastava, A. (2018). Pectoral nerve blocks to improve analgesia after breast cancer surgery: A prospective, randomized and controlled trial. *Journal of Clinical Anesthesia*, *45*, 12-17. https://doi.org/10.1016/j.jclinane.2017.11.027

Ngamjarus, C., & Chongsuvivatwong, V., (2016). McNeil E. n4Studies: Sample Size Calculation for an Epidemiological Study on a Smart Device. *Siriraj Medical Journal, 68*(3), 160-170. https://he02.tci-thaijo.org/index.php/sirirajmedj/article/view/58342

Sherwin, A., & Buggy, D. J. (2018). Anaesthesia for breast surgery. *BJA Education*, *18*(11), 342-348. https://doi.org/10.1016/j.bjae.2018.08.002

Steegers, M. A., Wolters, B., Evers, A. W., Strobbe, L., & Wilder-Smith, O. H. (2008). Effect of axillary lymph node dissection on prevalence and intensity of chronic and phantom pain after breast cancer surgery. *The Journal of Pain, 9*, 813-822. http://doi.org/10.1016/j.jpain.2008.04.001

Storm-Dickerson, T., & Sigalove, N. M. (2019). The breast surgeons′ approach to mastectomy and prepectoral breast reconstruction. *Gland Surgery*, *8*(1), 27-35. https://doi.org/10.21037/gs.2018.11.06

Thomas, M., Philip, F. A., Mathew, A. P., & Jagathnath Krishna, K. M. (2018). Intraoperative pectoral nerve block (Pec) for breast cancer surgery: A randomized controlled trial. *Journal of Anaesthesiology, Clinical Pharmacology*, *34*(3), 318-323. https://doi.org/10.4103/joacp.JOACP_191_17

Uribe, A. A., Weaver, T. E., Echeverria-Villalobos, M., Periel, L., Pasek, J., Fiorda-Diaz, J., Palettas, M., Skoracki, R. J., Poteet, S. J., & Heard, J. A. (2022). Efficacy of PECS block in addition to multimodal analgesia for postoperative pain management in patients undergoing outpatient elective breast surgery: A retrospective study. *Frontiers in Medicine*, *9*, 975080. https://doi.org/10.3389/fmed.2022.975080

Wong, H. Y., Pilling, R. J., Young, B. W. M., Owolabi, A. A., Onwochei, D. N., & Desai, N. (2021). Corrigendum to: ′Comparison of local and regional anesthesia modalities in breast surgery: A systematic review and network meta-analysis′. *Journal of Clinical Anesthesia*, *75*, 110491. https://doi.org/10.1016/j.jclinane.2021.110491

Xuan, C., Yan, W., Wang, D., Li, C., Ma, H., Mueller, A., Chin, V., Houle, T. T., & Wang, J. (2022). Efficacy of preemptive analgesia treatments for the management of postoperative pain: a network meta-analysis. *British Journal of Anaesthesia*, *129*(6), 946-958. https://doi.org/10.1016/j.bja.2022.08.038