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Additional intraoperative subpectoral plane block vs conventional pain control: A comparison of shoulder movement in patients with mastectomy

Sivaporn Pondeenana [a,*], Chao Saenghirunvattana [b], Patcharin Intarakhao [c], Sorasit Inchan [a], Panuwat Chuemor [a], Atthakorn Jarusriwanna [d]

[a] Department of Surgery, Faculty of Medicine, Naresuan University, Phitsanulok, Thailand
[b] Department of Anesthesiology, Hua Chiew Hospital, Bangkok, Thailand
[c] Department of Anesthesiology, Faculty of Medicine, Naresuan University, Phitsanulok, Thailand
[d] Department of Orthopaedics, Faculty of Medicine, Naresuan University, Phitsanulok, Thailand

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ABSTRACT

Purpose: Shoulder pain is common among mastectomy patients, with limiting shoulder mobility and negatively affecting their quality of life. Pectoral nerve blocks (PECs) have demonstrated efficacy in providing postoperative analgesia. We hypothesized that these nerve blocks could improve shoulder movement in patients undergoing mastectomy.

Methods: This prospective, randomized, double-blind controlled trial enrolled female participants diagnosed with breast cancer and scheduled for mastectomy. Participants were randomly assigned to either the conventional analgesia group or the intervention group. In the intervention group, a PECs II block was applied prior to skin closure following a mastectomy. This study's primary outcome was the assessment of shoulder movement ratios in 5 different positions (forward elevation, external rotation, arm abduction, internal rotation, and cross-body adduction), which were recorded before surgery, at 24-h, 48-h, and 72-h intervals postoperatively, with follow-up at 1 month, 2 months, 3 months, and 6 months.

Results: A total of 59 participants were included in the final analysis. Patients who underwent mastectomy with PECs II block exhibited better shoulder movement in terms of external rotation and arm abduction from the early post-surgery up to 6 months postoperatively. Shoulder forward elevation also showed superior gains during the early postoperative period, with statistical significance observed after 1 month following the surgery. However, no significant differences were found between the two groups in terms of internal rotation and adduction movements of the shoulder.

Conclusions: Compared to conventional analgesia, intraoperative pectoral nerve block under direct vision enhances shoulder mobility in forward elevation, external rotation, and arm abduction after mastectomy in breast cancer patients.

1. Introduction

Mastectomy is a common procedure for the treatment of breast cancer [1]. Extensive resection during surgery could provide nerve damage and inflammatory stimulation, resulting in post-mastectomy pain syndrome (PMPS), which is estimated to affect around 20–50% of patients [2]. Among patients who underwent mastectomy, shoulder pain is a prevalent issue that restricts shoulder joint mobility and significantly impacts their quality of life [3,4]. Additionally, limited range of motion of the shoulder joint might potentially be a contributing factor in the onset of lymphedema [5]. Therefore, perioperative pain management plays an important role in enhancing mobility and reducing the risk of complications including shoulder stiffness and lymphedema.

Peripheral nerve blocks have been increasingly used for post-operative pain management following mastectomy [6–8]. Pectoral nerve blocks (PECs) are a type of regional anesthesia used to provide perioperative pain control in breast surgery. PECs involve the injection

* Corresponding author. Department of Surgery, Faculty of Medicine, Naresuan University, 99 Moo 9, Phitsanulok-Nakhon Sawan Road, Tha Pho, Mueang Phitsanulok, Phitsanulok, 65000, Thailand.
E-mail address: tivasha39@gmail.com (S. Pondeenana).

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of local anesthesia into the fascial plane between the pectoralis major and minor muscles, targeting the lateral and medial pectoral nerves. This technique also blocks the lateral cutaneous branches of the intercostal nerves. Several studies have demonstrated the efficacy of PECs including reduction of postoperative pain intensity and opioids consumption. Nevertheless, complications of PECs such as infection or bleeding around the injection site, as well as nerve injury and systemic toxicity, have been reported [9–11].

Recently, there was limited data about the effect of PECs on shoulder movement in mastectomy patients, which we hypothesized that intraoperative PECs could enhance shoulder motion in these patients after surgery. The aim of this study was to evaluate and compare the efficacy of PECs block on shoulder movement in breast cancer patients who underwent mastectomy.

2. Methods

2.1. Study design and participants

We performed a prospective randomized double-blind controlled trial between May 2020 and June 2022. The study protocol was approved by the Research Ethical Committee of Naresuan University Institutional Review Board (IRB) on November 13, 2019 (COA No. 604/2019; IRB No.0694/62) and registered in the Thai Clinical Trials Registry (registration no. TCTR20230628001), in compliance with the Declaration of Helsinki, the Belmont Report, CIOMS and International Conference on Harmonization Good Clinical Practice guidelines. All participants provided written informed consent. Females aged between 20 and 80 years old who diagnosed with breast cancer and scheduled for mastectomy were recruited. Patients with history of ischemic heart disease or ejection fraction <50% from echocardiogram, history of liver disease with aspartate aminotransferase (AST) or alanine aminotransferase (ALT) more than the upper limit of normal range, history of shoulder pain or limited range of motion prior to mastectomy, allergies to bupivacaine, anesthetic drugs, opioids, or acetaminophen, and history of NSAIDs or steroid use before surgery were excluded from the study.

2.2. Outcomes, measurement, and data collection

The assessors determined goniometric measurements of each patient's shoulder range of motion in 5 positions: 1) forward elevation 2) external rotation 3) arm abduction 4) internal rotation, and 5) cross-body adduction [12]. Baseline characteristics including age, site of operation (right or left), body mass index (BMI), type of surgery, and intraoperative intravenous fentanyl use were collected.

The primary outcome of the study was the ratio of shoulder movement (RSM) angles, which recorded at various time intervals as follows: before surgery, 24 h, 48 h, 72 h after surgery, and follow-up period at postoperative 1-month, 2-month, 3-month, and 6-month. RSM was calculated as the ratio of post-mastectomy measurements (at different time points) and the measurements taken before mastectomy. The other outcomes including the intensity of early postoperative pain which was assessed by 10-cm visual analogue scale (VAS) and any complications after surgery were recorded.

2.3. Randomization and blinding

Randomization was performed prior to skin closure, using sequentially numbered concealed envelopes administered by a third party. The patients were divided into two groups: the control group and the intervention group. The surgical team was not blinded during the perioperative period, but both the patients and the assessors were blinded throughout the study, ensuring that they were unaware of the specific group assignments and minimizing potential biases.

2.4. Perioperative anesthesia and intervention

Patients were placed under standard monitoring and received general anesthesia. Intravenous fentanyl 1 mcg/kg, parecoxib 40 mg, dexamethasone 8 mg, and ondansetron 8 mg were given to all patients prior to skin incision. Following mastectomy and before skin closure, the intervention group received a solution prepared by an anesthesiologist, consisting of 0.25% bupivacaine 20 ml and 1:1000 adrenaline 0.1 ml. Subsequently, the PECs II block was performed by a single surgeon. This technique involved injection of 10 ml of local anesthetic into the plane between the pectoris major and minor muscles to block the medial and lateral pectoral nerves. An additional injection of 10 ml of local anesthetic was administered in the plane between the pectoralis minor and serratus anterior muscles to block the lateral cutaneous nerve, long thoracic nerve, and thoracodorsal nerve [13]. Nevertheless, participants in the control group were not administered with the placebo and all patients had not been performed breast reconstruction after surgery.

After surgical intervention, patients were closely monitored for pain levels in a 4-h interval and received a similar pain management protocol including the injection of intravenous 3 mg of morphine sulfate as needed for breakthrough pain every 4 h if VAS score was above 3, and administering 500 mg of acetaminophen orally every 6 h for postoperative 72 h. Similar physiotherapy and shoulder exercise programs were introduced to all patients postoperatively.

2.5. Sample size and statistical analysis

The sample size was calculated using n4Studies application (Prince of Songkla University, Hat Yai, Thailand) [14], based on mean and standard deviation (SD) of the shoulder movement in post-mastectomy patients with/without lymphedema in the previous study by Haddad et al. [5]. A sample size of 27 patients in each group would have 80% statistical power to detect a significance level of 0.05. To compensate for a possible 10% dropout rate for any reason, the target enrollment number for each group was 30 patients. Categorical data including site, type of surgery, complication, and intraoperative intravenous fentanyl use were compared between groups using the chi-square test. Shapiro-Wilk W test was employed to test the normality distribution of continuous data. Age and intraoperative intravenous fentanyl use were displayed as mean ± SD. Mean RSM in 5 positions at various time points were analyzed using an independent *t*-test. Statistical significance was set at p-value <0.05. Pain scores from post-operation up to 72 h were analyzed using the Generalized Estimating Equation (GEE). All statistical analyses were performed using Stata/MP 15.0 software (StataCorp, College Station, TX, USA).

3. Results

We enrolled 65 patients who underwent elective mastectomy between May 2020 and June 2022. Among them, 5 patients were excluded (2 patients declined to participate in the study, 1 patient had previous history of ischemic heart disease, 1 patient had a liver disease, and another patient had allergy to opioid). The remaining 60 patients were randomly assigned to either the control group or the intervention group. However, one patient in the intervention group was subsequently excluded due to loss to follow-up. Thus, a total of 59 patients (control group, n = 30; intervention group, n = 29) were included in the final analysis (Fig. 1).

The baseline demographic data were presented in Table 1. The mean age of patients in the control and intervention group was 53.3 ± 11.4 and 58.4 ± 9.7 years, respectively. There was no significant difference between groups in terms of age, site, BMI, and type of surgery. The baseline degrees of shoulder movement angles of the study subjects found no significant differences in all directions. The mean intraoperative intravenous fentanyl use was 95.8 ± 30.9 mcg in the control group and 90.7 ± 30.8 mcg in the intervention group (p = 0.53). There

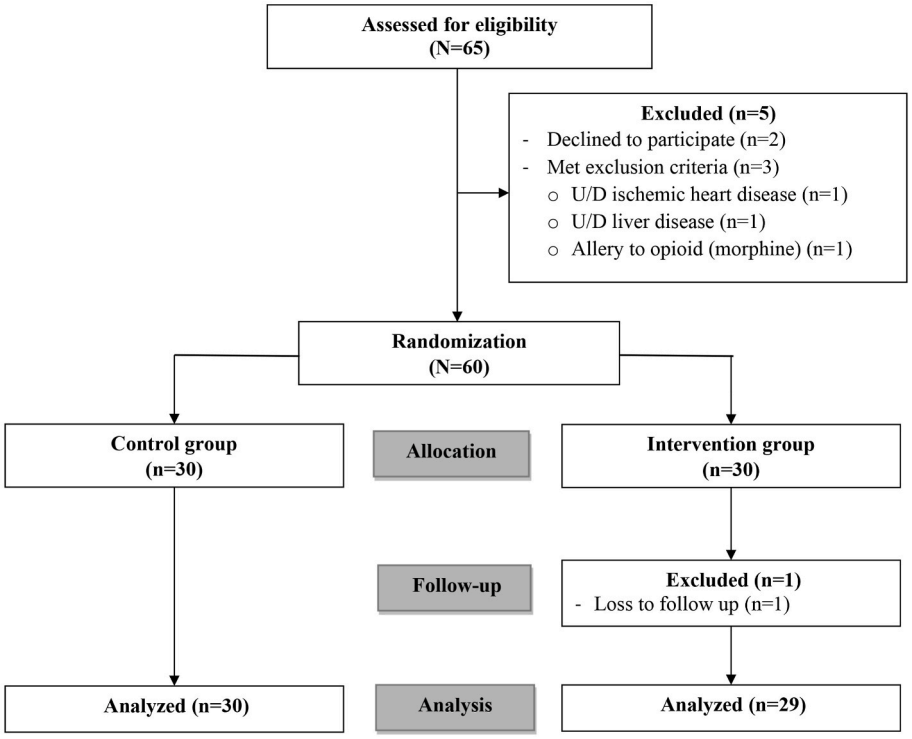

Fig. 1. Consolidated Standards of Reporting Trials (CONSORT) diagram showed the flow of patients in the study.

Table 1
Demographic characteristics of study subjects.

Characteristics	Control group (n = 30)	Intervention group (n = 29)	*p*-value
Age (years), mean (SD)	53.3 (11.4)	58.4 (9.7)	0.07
Site, n (%)			0.54
• Right	19 (63.3)	16 (55.2)	
• Left	11 (36.7)	13 (44.8)	
BMI (kg/m^2), mean (SD)	26.9 (5.5)	24.5 (5.4)	0.67
Type of surgery, n (%)			
• Mastectomy	4 (15.3)	2 (6.9)	0.65
• Mastectomy with sentinel lymph node biopsy (SLNB)	15 (50)	14 (42.3)	
• Modified radical mastectomy	11 (36.7)	13 (44.8)	
Baseline shoulder movement angles (degrees), mean (SD)			
• Forward elevation	175.0 (8.5)	174.1 (10.0)	0.72
• External rotation	174.1 (9.2)	169.0 (17.1)	0.17
• Arm abduction	88.2 (5.0)	85.0 (9.8)	0.12
• Internal rotation	88.8 (4.1)	88.9 (4.5)	0.97
• Cross-body adduction	44.5 (1.5)	44.8 (0.9)	0.33
Intraoperative intravenous fentanyl use (mcg), mean (SD)	95.8 (30.9)	90.7 (30.8)	0.53
Patients with radiotherapy after surgery, n (%)	12 (40)	12 (41.4)	0.94

were 12 patients in both the control and the intervention group being received radiotherapy during the study period ($p = 0.94$).

The mean RSM in 5 positions of the two groups were shown in Figs. 2–6. The RSM in external rotation, arm abduction, and forward elevation position were significantly greater in the intervention group than the control group beyond the 24-h, 48-h, and 1-month after surgery until follow-up at 6 months, respectively (Figs. 2–4). There was no significant difference between groups in the RSM in internal rotation and cross-body adduction (Figs. 5 and 6). The mean shoulder movement declination angles of the patients between groups were shown in Table 2, which significant differences were found in the same way as the mean RSM. The VAS pain score showed no significant difference

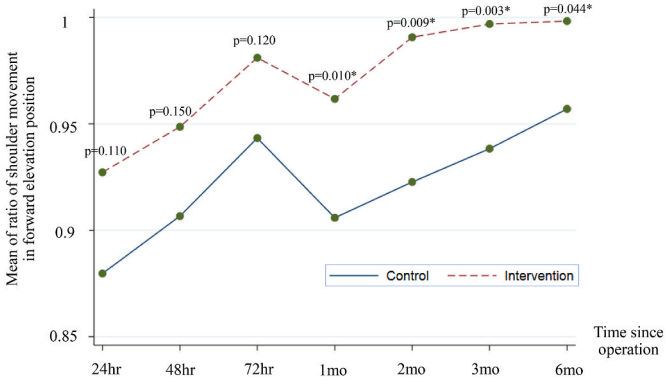

Fig. 2. A graph showed mean RSM in forward elevation position of the two groups. *Statistically significant difference ($p < 0.05$).

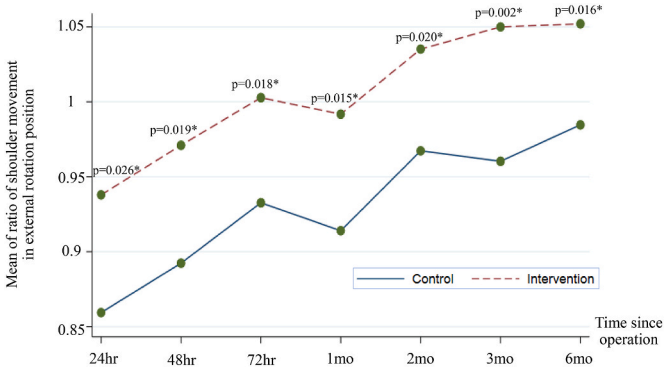

Fig. 3. A graph showed mean RSM in external rotation position of the two groups. *Statistically significant difference ($p < 0.05$).

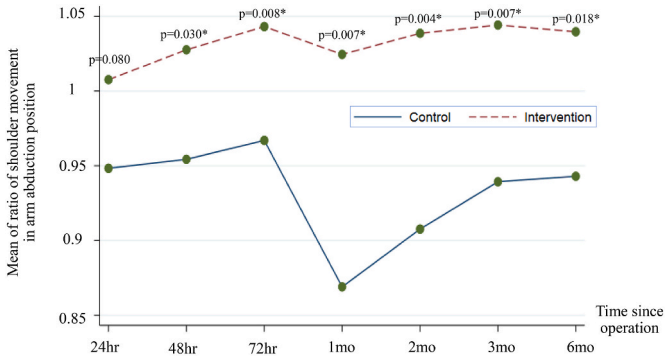

Fig. 4. A graph showed mean RSM in arm abduction position of the two groups. *Statistically significant difference ($p < 0.05$).

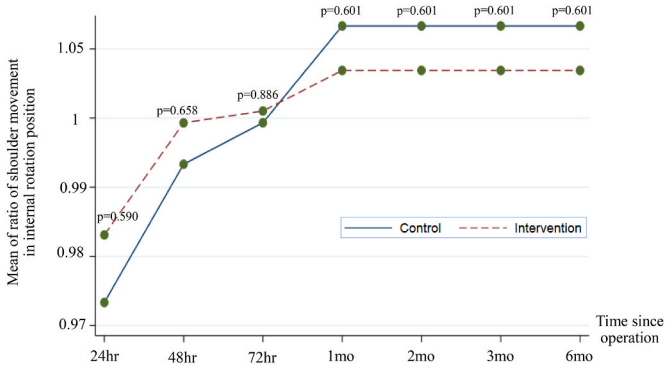

Fig. 5. A graph showed mean RSM in internal rotation position of the two groups. No significant difference was observed at all timeframes.

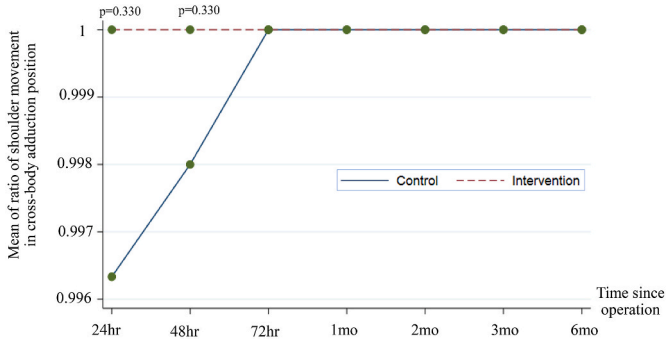

Fig. 6. A graph showed mean RSM in cross-body adduction position of the two groups. No significant difference was observed at all timeframes.

between groups in all timeframes (Fig. 7). Three complications were reported in 5 patients in the intervention group (1 wound infection, 1 skin necrosis, 3 seromas) and 4 patients in the control group (1 wound infection, 1 skin necrosis with wound dehiscence, 2 seromas).

4. Discussion

Adequate postoperative pain control around the shoulder after mastectomy is necessary to prevent further complications like joint movement restriction, shoulder rigidity, and functional impairment [15,16]. The previous study by Arsh and Ullah found that over 67% of patients who underwent breast cancer surgery experienced shoulder pain and mobility difficulties, which were associated with connective tissue fibrosis in the shoulder joint [3]. Kim et al. further confirmed the presence of adhesive capsulitis, biceps tenosynovitis, and thickening of

Table 2
The mean shoulder movement declination angles of patients between the control and the intervention group.

Position	Control group (n = 30)	Intervention group (n = 29)	*p*-value
Forward elevation, degrees (SD)			
24 h	21.7 (22.9)	13.6 (15.2)	0.12
48 h	17.3 (23.7)	9.8 (11.7)	0.13
72 h	12.3 (18.0)	6.6 (7.7)	0.12
1 mo	16.7 (12.3)	8.9 (9.8)	0.01
2 mo	14.4 (12.1)	5.0 (6.3)	0.005
3 mo	11.2 (11.7)	4.3 (6.0)	0.01
6 mo	8.8 (10.4)	4.3 (7.9)	0.05
External rotation, degrees (SD)			
24 h	24.7 (23.9)	14.0 (16.5)	0.05
48 h	18.7 (21.3)	9.7 (14.3)	0.03
72 h	13.2 (17.5)	7.0 (9.2)	0.05
1 mo	15.3 (14.2)	8.1 (13.3)	0.05
2 mo	14.2 (28.4)	3.3 (8.2)	0.05
3 mo	9.7 (12.2)	1.9 (5.9)	0.002
6 mo	6.4 (9.7)	2.1 (6.3)	0.04
Arm abduction, degrees (SD)			
24 h	5.4 (7.7)	2.2 (8.2)	0.13
48 h	4.0 (6.5)	1.9 (7.6)	0.26
72 h	2.7 (5.2)	0.5 (2.0)	0.04
1 mo	11.7 (13.0)	1.9 (4.7)	0.003
2 mo	9.3 (12.2)	1.2 (4.2)	0.001
3 mo	6.0 (8.6)	0.7 (2.2)	0.002
6 mo	5.3 (8.5)	1.6 (5.8)	0.05
Internal rotation, degrees (SD)			
24 h	2.2 (4.3)	0.7 (2.9)	0.13
48 h	1.3 (4.1)	0.7 (2.6)	0.48
72 h	1.0 (3.3)	0.5 (2.1)	0.50
1 mo	0 (0)	0 (0)	–
2 mo	0.7 (3.7)	0 (0)	0.33
3 mo	0.3 (1.8)	0 (0)	0.33
6 mo	0 (0)	0 (0)	–
Cross-body adduction, degrees (SD)			
24 h	0.2 (0.9)	0.2 (0.9)	0.98
48 h	0.3 (1.3)	0 (0)	0.16
72 h	0 (0)	0 (0)	–
1 mo	0 (0)	0 (0)	–
2 mo	0 (0)	0 (0)	–
3 mo	0 (0)	0 (0)	–
6 mo	0 (0)	0 (0)	–

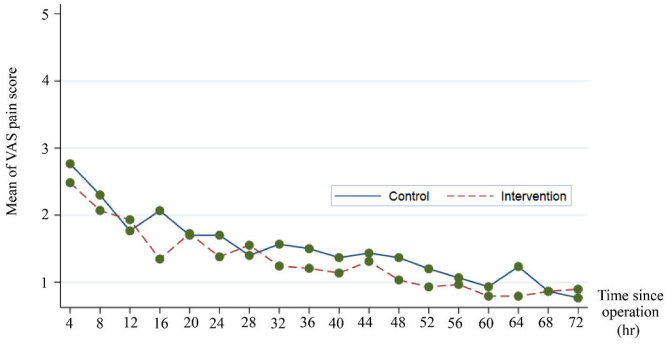

Fig. 7. A graph showed mean postoperative VAS between the two groups from 4 to 72 h after surgery. No significant difference was observed at all timeframes.

coracohumeral ligament in post-mastectomy patients with chronic shoulder pain by ultrasonography [17]. In addition to conventional post-surgery pain control through medication, any intervention to minimize pain around the shoulder can be beneficial in preventing complications and enhancing shoulder mobility [2]. The decline of shoulder movement also impacts the activities of daily living. A study by Gates et al. demonstrated the range of motion requirements for upper-limb activities. If the shoulder movement in each direction declined below the required degrees, it could impact the daily life of the patient [18].

Ultrasound-guided PECs have been found to be effective for patients who underwent mastectomy. This perioperative procedure not only reduces pain during motion after surgery, but also decreases opioid consumption, and improves patient satisfaction in the early postoperative period [10,19,20]. PECs with sedation could be a viable alternative to general anesthesia for patients with severe medical comorbidities [21]. Dube et al. conducted a prospective observational study and showed that intraoperative direct vision PECs could reduce the operative time significantly with good efficacy when compared to preoperative ultrasound guidance PECs [13]. However, a study by Desroches et al. reported that PECs caused a significant motor blockage in the pectoralis muscles, which affected the adductor strength of the patients [22].

Our study revealed that patients who underwent mastectomy with additional PECs exhibited improvement in shoulder external rotation and abduction from the early post-surgery period up to postoperative six months. In addition, there was a progressive improvement in shoulder forward elevation in the early postoperative period, with statistical significance observed at one month after surgery. However, internal rotation and cross-body adduction of the shoulder showed no significant differences between the two groups. The PECs II intervention involved blocking the medial and lateral pectoral nerves, which are motor nerves that primarily innervate the pectoralis minor and major muscles, respectively [23]. A second injection was performed to block the lateral cutaneous nerve, long thoracic nerve, and thoracodorsal nerve. The blockade of the lateral cutaneous nerve reduced pain perception in the lateral chest wall, the medial aspect of the upper arm, and the axilla, as this nerve carries sensory information from these areas [24]. The long thoracic and thoracodorsal nerves support the motor function of serratus anterior and latissimus dorsi muscles, respectively [25,26].

Different shoulder movements are facilitated by distinct muscle groups, with each motion requiring coordinated muscular activity. During shoulder abduction, the deltoid and supraspinatus muscles are primarily contracted, while the infraspinatus and teres minor muscles are primarily involved in shoulder external rotation [27]. In shoulder forward elevation, the deltoid, supraspinatus, and subscapularis muscles perform important functions [28]. The primary adductors, namely the latissimus dorsi, pectoralis major, and teres major, play important roles in internal rotation and adduction of the shoulder [27]. The PECs intervention specifically targets the motor nerve that innervates the adductors and internal rotators of the shoulder, which might decrease the motion of these positions and result in a non-significant difference between the control and the intervention group. In the other positions (forward elevation, abduction, and external rotation), PECs only affected the sensation, but no motor was involved in those muscle groups. This would help explain a significant improvement in shoulder movement in only those 3 positions.

The period after PECs might be a factor affecting the functional outcome. During the early postoperative period, most of the motions were found to have no statistical differences, which aligns with the findings of pain scores that also exhibited no significant variation between the two groups. However, in later periods, patients usually develop fibrosis and tenosynovitis with chronic shoulder pain and movement limitation [29]. PECs intervention may help improve shoulder motion by reducing the incidence of chronic pain. A prospective study by De Cassai et al. demonstrated that PECs could decrease chronic pain up to three months after breast surgery [30].

There were some limitations in this study. First, the PECs in this study was performed before skin closure. Nerve blockage before operation or as early as possible may pretreat postoperative pain and minimize the nervous system response [31]. Second, the pain score obtained in this study was the pain at rest, which might result differently from the pain during motion. However, a self-administered questionnaire of pain section of shoulder pain and disability index (SPADI) in the previous study by Arsh and Ullah demonstrated the similar result of pain score in each activity [3]. Third, one enrolled patient was not included in the final analysis due to loss to follow-up. However, the remaining number of participants included in the final analysis would achieve the statistical power. Finally, the pain score was collected only in the early postoperative period. The pain data at the longer postoperative period might be associated to the outcome of shoulder movement of the patients.

5. Conclusions

Intraoperative direct vision pectoral nerve block can be performed easily, safely, and effectively with no increase in complications after mastectomy in breast cancer patients. This technique improves shoulder movement in forward elevation, external rotation, and arm abduction compared to the control group.

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Declaration of competing interest

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