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ORIGINAL ARTICLE

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Ultrasound-guided modified pectoral plane (PECS II) block versus erector spinae plane (ESP) block for perioperative analgesia of surgical treatment of gynecomastia

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Abstract

Background: Nerve block reduces anesthetics requirement, allows faster recovery, and reduces postoperative pain. The modified pectoral plane block (PECS II) and the erector spinae plane block (ESP) have been proposed for nerve block in men undergoing breast surgery for gynecomastia.

This study aimed to compare the efficacy of PECS II and ESP for perioperative analgesia in men undergoing surgical treatment of gynecomastia.

We conducted a randomized clinical trial on 46 males (with ASA I and II, age range from 18 to 25 years) undergoing surgical gynecomastia treatment in a tertiary medical center. Patients were randomly allocated to receive nerve blocks with either PECS II or ESP in addition to the general anesthesia. The postoperative opioid requirement, analgesic doses, pain intensity on the VAS score, hemodynamic parameters throughout the operation, and complications were recorded and compared for both groups.

Results: PECS II group had more favorable outcomes compared to the ESP group, evident by the significantly less total morphine consumption in 24 h (6.09 vs. 14.26 mg, $P \leq 0.001$) and the significantly higher effective analgesic time (6.57 vs. 4.91 h, $P \leq 0.001$). In addition, there were no intraoperative or postoperative complications recorded in both groups.

Conclusions: For men undergoing elective surgical treatment of gynecomastia, the ultrasound-guided modified PECS II is superior to the ESP in terms of opioid requirement, analgesic doses, and pain intensity.

Keywords: Analgesia, Erector spinae block, Gynecomastia, Pectoral nerve block, Ultrasound, Surgery, Pain, Postoperative opioid consumption

Background

Gynecomastia is a prevalent male breast glandular tissue benign proliferation that affects 90% of neonates, 60% of boys in the adolescence period, and about 30 to 70% of men as a transient condition in the adulthood period, with higher incidence among older men, especially those with medical illness (Bailey et al. 2016; Longheu 2016). Some cases are treated medically; however, others require surgical resection, which provides better cosmetic improvement and might be necessary if carcinoma is suspected. Surgical treatment of gynecomastia includes either liposuction, gland excision, or both (Bailey et al. 2016; Sollie 2018).

Owing to the nature and location of surgery in the chest, the pain of breast surgery is usually due to chest

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wall scar or nerve injury. The pain is usually neuropathic or nociceptive, and the severity depends on the extent of surgery; also, initial reports suggested that local nerve block improves postoperative pain and chronic neuropathic pain (Niraj and Rowbotham 2011). Moreover, combined general and regional blocks are accompanied by many advantages like nociceptive pathways blocking, decreasing general anesthetic requirements, faster recovery, reducing postoperative pain, and so analgesic requirements and their side effects (Kaufman et al. 2005).

Many techniques can be used to achieve regional anesthesia for breast surgery, including thoracic epidural anesthesia, thoracic spinal anesthesia, the paravertebral block, the intrapleural block, and the multiple intercostal blocks (Sherwin and Buggy 2018). However, some of these procedures have a major limitation; they carry the risk of pneumothorax (Senapathi et al. 2019). Recently, the ultrasound-guided pectoral plane block (PECS II) with general anesthesia reduced intra- and postoperative pain in breast surgery patients (Senapathi et al. 2019). Other studies showed that another technique, the ultrasound-guided erector spinae plane block (ESP), effectively reduces the postoperative pain of breast surgeries (Jain et al. 2018).

Until the moment, evidence on the superiority of either of the two procedures is scarce, particularly in terms of the opioid requirement, effective analgesia time, and pain intensity scores. Therefore, we conducted this randomized clinical trial to compare the ultrasound-guided PECS II block and ESP block for perioperative analgesia in surgical treatment for gynecomastia patients under general anesthesia.

Methods

Trial registration

This clinical trial was approved by the Institutional Review Board of Zagazig University Hospitals in Egypt (ZU-IRB#5851/8-1-2020) and was registered at Clinicaltrials.gov (NCT04221074). Registered 9 January 2020, https://clinicaltrials.gov/ct2/show/NCT04221074.

The study was conducted following the ethical principles of the Declaration of Helsinki, and all patients gave informed consent. This manuscript is reported according to the CONSORT statement guidelines for randomized clinical trials.

Trial design

We conducted a single randomized clinical trial in a tertiary medical center in Egypt from February 2020 to July 2020.

Participants

Patients meeting the following criteria were eligible for inclusion in the study as follows:

1. Male patients with gynecomastia who are undergoing surgical resection
2. Aged from 18 to 25 years old
3. ASA classes 1 and 2
4. BMI ≤ 30 kg/m^2

We excluded patients with a history of opioid abuse or chronic analgesic use, coagulopathy, anticoagulants, infection at the injection sites, or allergy to the study drugs.

Anesthesia protocol

Before the operation, the following precautions were done: (1) all patients underwent routine investigation, (2) all patients were fasting 8 h preoperatively, (3) all patients educated well about the VAS scale for pain measurement, and (4) all patients educated well to be familiar with patient-controlled analgesia (PCA) machine.

Standard monitors were used inside the operating room, including electrocardiograms, automated noninvasive blood pressure, and pulse oximeter. A20-gauge intravenous cannula was inserted in the holding area, ringer lactated solution started at a rate of 10 ml per kg/h, and midazolam was given intravenously (0.05 mg/kg) for sedation 10 min before operation.

Preoxygenation started by asking the patient to take three deep breathes of 100% oxygen, and then anesthesia was induced by 1 ug/kg fentanyl and 2–2.5 mg/kg propofol. Next, endotracheal intubation was facilitated by 0.15 mg/kg cisatracurium. Finally, bispectral index monitoring (BIS) and capnography were attached, and all measures were recorded at baseline and every 5 min after general anesthesia up to extubation.

Anesthesia was maintained by minimum alveolar concentration (MAC) of sevoflurane keeps BIS between 40 and 60 in 60% oxygen/air mixture, cisatracurium given as intermittent doses 0.03 mg/kg judged by Train of Four (TOF) of the nerve stimulator to maintain muscle relaxation (the goal was complete disappearance of T1 twitch). In addition, the ventilation parameters were adjusted to keep end-tidal CO2 between 35 and 45 mmHg. Anesthesia management during the operation and data collection was done by the same anesthetist who implemented the intervention.

Interventions

For the group of patients who underwent modified pectoral plane block (PECS II group), the procedure was done

after induction of general anesthesia in supine position of the patient with his arm of the operated side abducted 90° and the ultrasound probe (general electric ultrasound machine Logiq e made in the USA linear probe frequency 8–12 MHZ) placed at the midclavicular level and angled infero-laterally, the axillary artery, and the vein, and the second rib was identified. Then, the probe moved laterally until the pectoralis minor and serratus anterior were identified; the local anesthetic was injected at two points using (echoplext gauge 20, length = 50 mm) needle. The first injection includes 10 ml of 0.25% bupivacaine (Bucaine, Hikma Parmaceuticals, Amman-Jordan 0.25% 50 mg per 20 ml) and 4 mg dexamethasone injected between the pectoralis major and minor muscles. In comparison, the second injection includes 20 ml of 0.25% bupivacaine and 4 mg dexamethasone between the pectoralis minor and serratus anterior muscles (Fig. 1).

For the group of patients who underwent erector spinae plane block (ESP group), the procedure was done after induction of general anesthesia, and then the patient was turned to the lateral position where the surgical site is up. First, at the T4 level, the probe (General Electric ultrasound machine Logiq e made in the USA linear probe frequency 8–12 MHZ) was placed lateral to the spine by 3 cm. Then, in the parasagittal plane, the needle (echoplext gauge 20 length 50 mm) was advanced between the transverse process and the erector spinae muscle. At that level, 20 ml of 0.25% bupivacaine (Bucaine, Hikma Pharmaceuticals, Amman-Jordan 0.25% 50 mg per 20 ml) and 8 mg dexamethasone were injected (Fig. 1).

Both blocks were done by the same investigator.

Electrocardiogram, automated noninvasive blood pressure, and pulse oximeter were attached and recorded every 15 min in the postanesthesia care unit (PACU) for 1 h. Blood pressure and pulse were recorded hourly for 24 h in the ward. VAS pain score was assessed for every patient once in the PACU and then every 6 h in the ward for 24 h postoperatively.

Outcomes

The primary outcome measure for this study was the postoperative opioid requirement.

The secondary outcome measures for this study were as follows:

1. Intraoperative analgesic doses
2. VAS pain score, assessed for every patient once in PACU and every 6 h in the ward for 24 h
3. Hemodynamic parameters throughout the operation including the mean arterial blood pressure, heart rate, and bispectral index
4. Complications

Data variables

For each patient, the following data items were collected as follows:

- Demographic data (age, physical state ASA I & II, BMI)
- Duration of surgery (60–120 min)

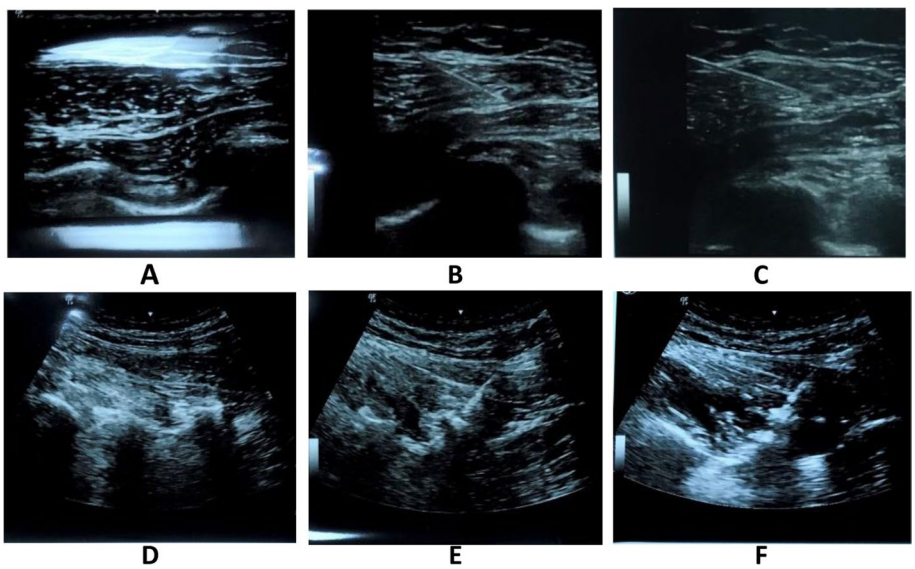

Fig. 1 It was added separately due to size**. Figure shows both interventions: First, the ultrasound-guidedPECS II block (**A**) Pre- injection, (**B**) Needling, and (**C**) Injection of the local anesthetic, then the ultrasound-guided ESP block (**D**) pre-injection, (**E**) Needling, and (**F**) Injection of the local anesthetic

- Hemodynamic (heart rate, mean blood pressure) and oxygen saturation
- Intraoperative fentanyl needs in micrograms after the induction dose as it was given in a dose of 0.5 ug/kg if hemodynamics of the patient (mean arterial blood pressure and heart rate) increased more than 20% of the basal measurements and the level of the bispectral index if increased above 60.
- Effective analgesia time postoperatively: The time from the block to the first dose of patient-controlled analgesia (PCA) (MedimaSp machine type S-PCA made in Poland).
- Visual analogue scale (VAS) using a ruler graded from 0 to 100 mm, where 0 = no pain and 100 = the worst imaginable pain measured in postanesthesia care unit once and every 6 h for 24 h postoperative
- Total postoperative opioid (morphine) needs (mg) in 24 h postoperative as patients used patient-controlled analgesia machine (medima S-PCA) with no basal infusion only bolus doses of 2 mg morphine with a 10 min lockout interval was allowed and maximum 30 mg/6hours.
- Complications (failure of the block, pneumothorax, hematoma, hypotension, etc.).

Sample size

The sample size was calculated based on the primary endpoint, the postoperative opioid requirement. We assumed a mean postoperative opioid requirement of 16.7 mg (±7.21) and 11.6 mg (±4.9) for the ESP and PECS II groups, respectively, as reported by a previous study (Gad et al. 2019). Assuming a 5% margin of error and 80% statistical power, a minimum sample size of 46 patients was required for the study ($n = 23$ patients). The sample size was calculated using the SampSize app for Android according to Negida et al. (Negida et al. 2019).

Randomization

Sequence generation

Patients were randomly assigned to the treatment groups using a computer-generated random sequence generated by Microsoft Excel software (Microsoft Corporation, USA). The random sequence was generated in advance and was kept secure throughout the study.

Allocation concealment and implementation

Allocation was done by the trial nurses who had no further involvement in the study. In addition, one consultant anesthesiologist (AAA) did all the nerve blocks for all patients.

Blinding

There was no blinding in this RCT. Therefore, both the investigators and the patients were aware of the nerve block used in operation.

Statistical methods

Qualitative data as complications were expressed as absolute frequencies (number) and relative frequencies (percentage). Quantitative variables as the opioid requirement and effective analgesia time were expressed as the mean and standard deviations if normally distributed or median and interquartile ranges if not normally distributed.

We used the Student *t*-test to compare the means of two groups when the data are normally distributed, while the Mann Whitney *U*-test when the data are not normally distributed. All tests were two sided. A *P*-value < 0.05 was considered statistically significant.

Results

Characteristics of the study participants

Forty-six male patients met the inclusion criteria and were included in the study and the final analysis ($n = 23$ patients per group); both groups undergone surgical gland excision .The CONSORT flow diagram of the patient numbers at the stages of this study is shown in Fig. 2. The study groups were comparable in the demographic data and duration of surgery (Table 1). In addition, the mean arterial blood pressure, heart rate, and bispectral index throughout the operations were comparable between the two groups.

None of the patients in both groups needed additional fentanyl intraoperatively (supplementary file 1).

Opioid requirement and effective analgesic time

Patients in the PECS II group required significantly fewer doses of morphine compared with those in the ESP group (6.09 vs. 14.26 mg, $P < 0.001$, Table 2). In addition, the effective analgesic time was significantly higher in the PECS II group than in the ESP group (6.57 vs. 4.91 h, $P < 0.001$, Table 2).

Pain intensity on the VAS score

There were no statistically significant differences between the study groups regarding the pain intensity measured on the VAS score at 0 and 24 h postoperatively (Table 3). However, at 6, 12, and 18 h, patients in the PECS II group reported significantly less pain intensity on the VAS score than those in the ESP group (Table 3).

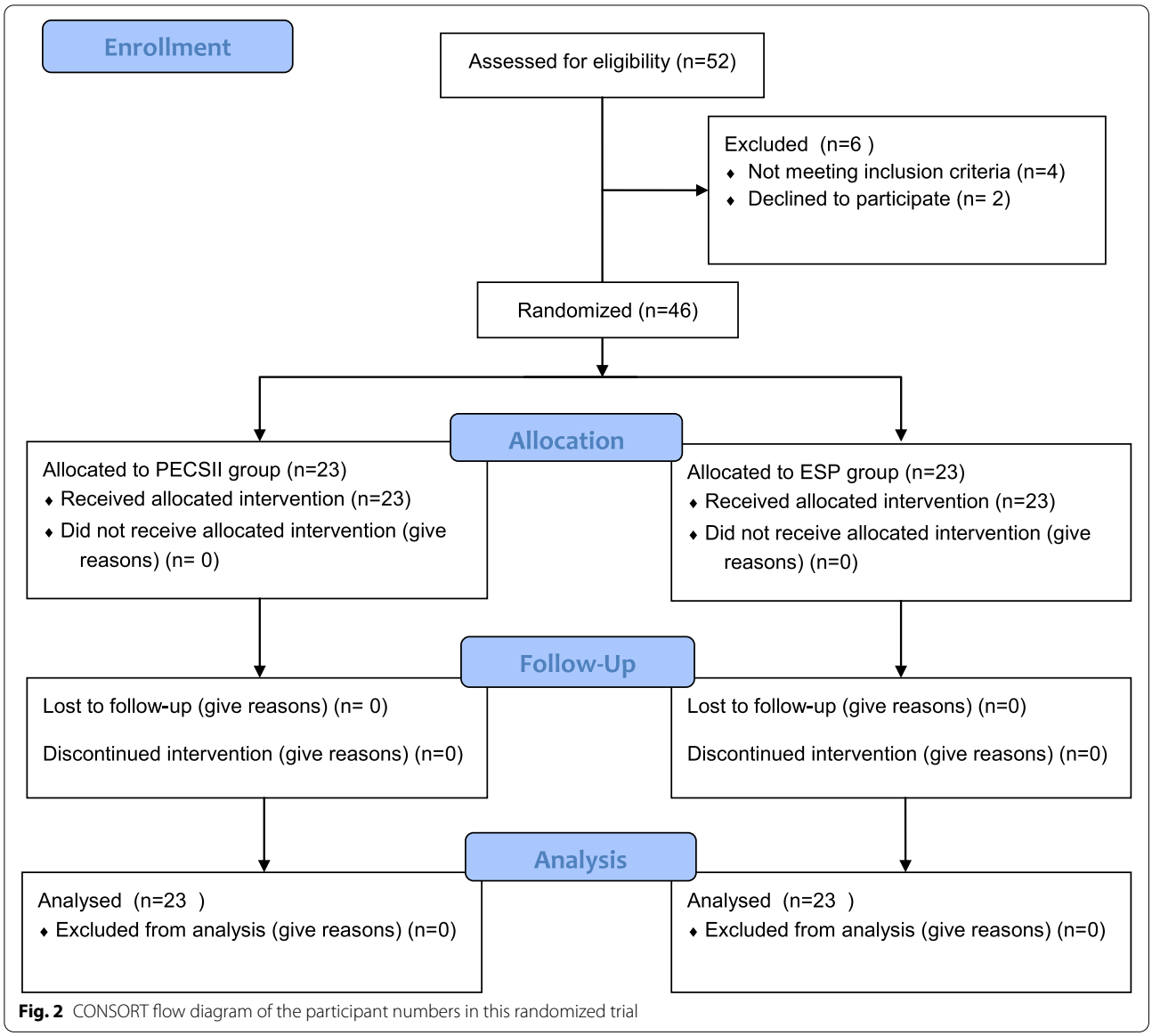

Fig. 2 CONSORT flow diagram of the participant numbers in this randomized trial

Table 1 The demographic data and the duration of surgery of the study groups

Characteristics	Studied groups		*T*	*p*-Value
	PECSII group ($n = 23$)	ESP group ($n = 23$)		
Age (years)	21.52 ± 2.44	21.83 ± 2.06	0.456	0.65
BMI (kg/m^2)	26.75 ± 2.47	26.29 ± 2.29	0.649	0.52
Duration of surgery (min)	73.35 ± 8.57	76.52 ± 6.98	0.943	0.351

Data were expressed as mean ± SD. *SD*, standard deviation. *t*, *t*-test. $P < 0.05$ statistically is significant. *BMI* body mass index. *PECSII* modified pectoral plane block. *ESP* erector spinae plane block

Hemodynamic parameters and complications

There were no statistically significant differences between the two groups in terms of the hemodynamic parameters throughout the operation time, including the mean arterial blood pressure (Fig. 3), heart rate (Fig. 4), and BIS (Fig. 5). In addition, there were no intraoperative or postoperative complications recorded in both groups from the block procedures.

Table 2 Total postoperative morphine dose (mg) and the effective analgesic time in studied groups

	Studied groups		*U*	*p*-Value
	PECSII group (*n* = 23)	ESP group (*n* = 23)		
Total postoperative morphine dose (mg)	6.09 ± 2.13	14.26 ± 4.61	5.4	< 0.001*
Effective postoperative analgesic time (h)	6.57 ± 1.02	4.91 ± 0.79	4.6	< 0.001*

Data were expressed in mean ± SD. $P < 0.01$ statistically is significant.
*Significant for ESP compared to PECSII. *U* Mann-Whitney test, *SD* standard deviation, *PECSII* modified pectoral plane block, *ESP* erector spinae plane block

Table 3 Postoperative visual analog scale of the studied groups at different points of time

	Studied groups		*U*	*p*-Value
	PECSII group (*n* = 23)	ESP group (*n* = 23)		
0 h	0 (0–20)	0 (0–20)	0.761	0.44
6 h	10 (10–20)	20 (10–40)	2.292	0.022*
12 h	20 (10–30)	20 (10–40)	2.021	0.043*
18 h	20 (10–30)	20 (20–30)	3.109	0.002*
24 h	10 (0–30)	10 (0–30)	0.491	0.623

Data were expressed in median (range). *$P < 0.05$ statistically is significant. *U* Mann-Whitney test. *PECSII* modified pectoral plane block, *ESP* erector spinae plane block

Discussion

Summary of the study findings

This randomized clinical trial showed that PECS II is superior to the ESP for men undergoing surgical resection of gynecomastia. Patients who underwent PECS II had significantly less postoperative opioid requirement, more effective analgesia time, and less pain intensity than those who underwent the ESP technique. There were no differences between the two techniques in terms of hemodynamics or complications.

Explanation of the study findings

In PECS II, the block is done by a first injection between the pectoralis major and minor muscles in the fascial plane to block the medial (C8, T1) and the lateral (C5-C7) pectoral nerves, which innervate pectoralis muscles. Then, the other injection is given in the plane between the pectoralis minor and serratus anterior muscles to block the cutaneous branches of the upper intercostal nerves (T2-T6), thus providing anesthesia to the chest wall and the long thoracic nerve (C5-C7) (Gad et al. 2019).

On the other hand, ESP block is done by single injection at the level of T4, allowing the local anesthetic to spread craniocaudally in multiple levels and anteriorly through the costotransverse foramina reaching the thoracic paravertebral space blocking dorsal and ventral rami of spinal nerves with communicants (Altıparmak et al. 2019). Although studies proved that ESP block is a good alternative to paravertebral block as it is safer and its craniocaudal spread of the local anesthetic is better (Veiga et al. 2018; Naja and Lonnqvist 2001), studies using radiocontrast dye mixture in cadaveric models showed that the dye might not spread to the paravertebral space anteriorly to the origins of the dorsal and ventral thoracic spinal nerves branches but stained the dorsal rami behind the costotransverse foramen (Ivanusic et al. 2018). This limitation in the ESP block explains our findings that ESP was associated with less effective analgesia time, higher postoperative opioid dose, and less pain control when compared to the PECS II block.

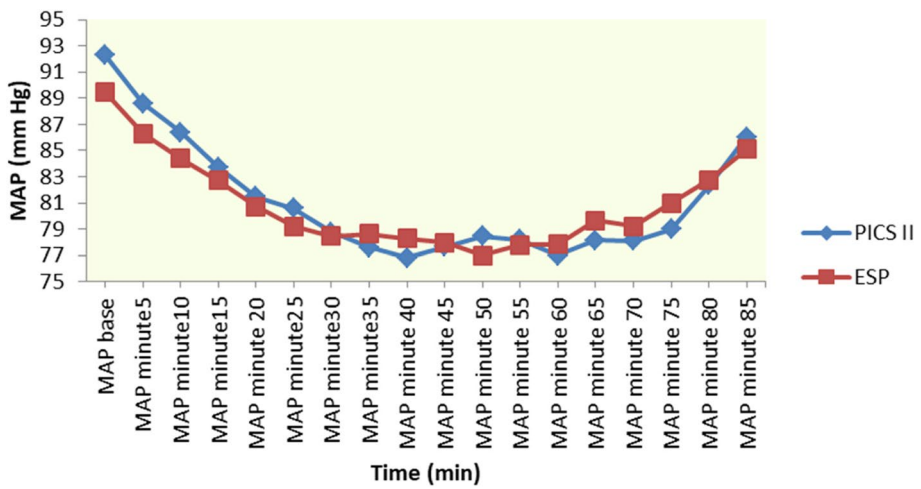

Fig. 3 The mean arterial blood pressure (MAP) throughout the operation time in both the study groups (no significant difference, $P > 0.05$)

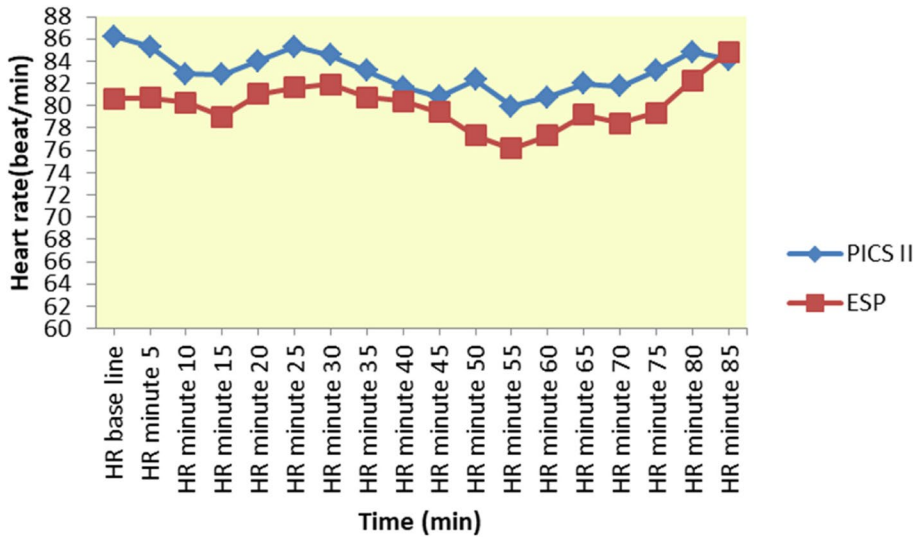

Fig. 4 The heart rate throughout the operation time in both the study groups (no significant difference, $P > 0.05$)

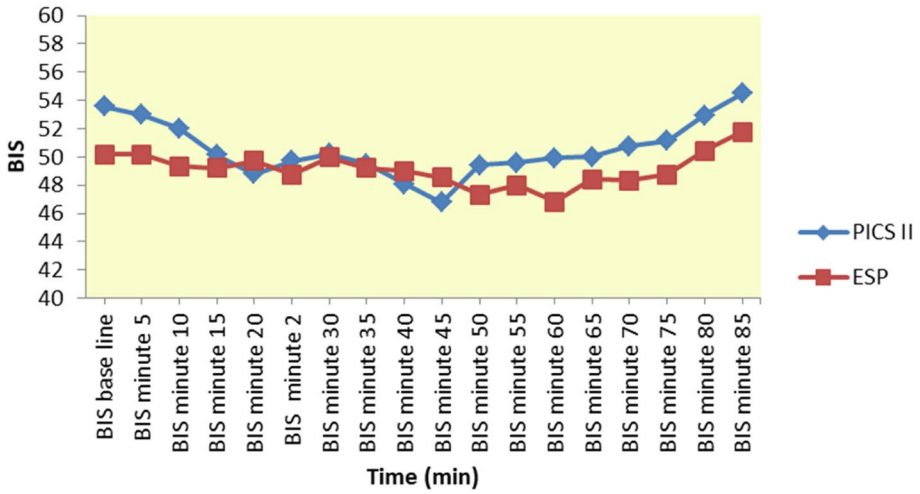

Fig. 5 The bispectral index (BIS) throughout the *operation time in both the study groups (no significant difference*, $P > 0.05$)

In both PECS II and ESP groups, we added dexamethasone to the local anesthetic since previous studies showed that dexamethasone perineurally enhances the sensory block and improves the postoperative analgesia.

Agreement and disagreement with the previous studies

In our study, patients undergoing the ESP block consumed significantly less postoperative morphine doses than the PECS II group, consistent with the two previous RCTs reporting more reductions in tramadol and morphine doses in the ESP group to patients in the PECS II group (Gad et al. 2019; Altıparmak et al. 2019). However, both studies reported higher local anesthetics in the PECS II block than the ESP block.

In our study, patients in the PECS II group had significantly lower VAS pain scores at 6, 12, and 18 hours but were similar at 24 h postoperatively. These results are consistent with the previous studies where patients in the ESP block reported higher levels of pain in the first 24 h postoperatively ($P < 0.05$) (Gad et al. 2019; Altıparmak et al. 2019).

A Bayesian network meta-analysis by Hong et al. (Hong et al. 2021) found that PECS II appeared to have more favorable analgesic effects than the ESP block. In line with this, our results showed higher effective analgesia time in the PECS II group compared to the ESP.

In our study, both blocks were done after general anesthesia to alleviate patients' stress effects. The PECS II block was done in the supine position, while the ESP block was done in the lateral position, and then we returned the patient to the supine position for surgery. Therefore, we agree with Bashandy and Abbas that the PECS II block is easier to position under general anesthesia. Moreover, it is fast and simple (Bashandy and Abbas 2015).

Significance of the study and findings

Breast surgery is associated with severe postoperative pain in more than 50% of cases, in addition to the risk of chronic postsurgical pain (Na et al. 2016). Therefore, effective pain control is important for this type of surgery. The study expands the literature by providing evidence that PECS II block is superior to ESP block for men undergoing breast surgery for gynecomastia. In addition, the study provides evidence that PECS II decreases postoperative opioid consumption, increases the effective analgesia time, and provides better pain control in the first 24 h compared with the ESP block.

Strength points and limitations

The study has several strength points. First, the study design is a randomized clinical trial with patients being randomly allocated to the two types of nerve block, which increased the study's internal validity and made these differences between the two groups attributable to the interventions. Second, the sample size of this study is adequate and provides 80% statistical power to achieve the primary endpoint. However, the study has limitations; all our patients were anesthetized, so we could not evaluate the blocked sensory areas after both procedures. Finally, the study is also limited by the lack of long-term follow-up to assess chronic postsurgical pain.

Recommendations for practice and future research

According to the findings of this study, we recommend the use of PECS II for nerve block in men undergoing surgical treatment of gynecomastia. Future research might look at the role of the block when conducted before anesthesia to allow evaluation of the sensory block. Future studies also should include long-term follow-up to evaluate the incidence of chronic postsurgical pain in both techniques.

Conclusions

For men undergoing elective surgical treatment of gynecomastia, the ultrasound-guided PECS II is superior to the ESP in terms of opioid requirement, analgesic doses, and pain intensity scores.

Abbreviations

PECS II: Modified pectoral plane block; ESP: Erector spinae plane; BIS: Bispectral index; MAC: Minimum alveolar concentration; TOF: Train of four; PACU: Postanesthesia care unit; VAS: Visual analogue scale; MAP: Mean arterial pressure; HR: Heart rate.

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Authors' contributions

The corresponding author MMR was a major contributor in writing the manuscript, and the author AAA performed all the nerve blocks involved in the study. The authors read and approved the final manuscript.

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Availability of data and materials

Not applicable

Declarations

Ethics approval and consent to participate

The IRB approved this study of Zagazig University Hospitals. All patients gave an informed consent. The study was conducted following the Declaration of Helsinki

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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