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Original Article

Comparison of bilateral pectoral nerve block 2 and local anesthetic infiltration for pain control in cardiac surgery

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Abstract

Aim: We aimed to compare the effect on postoperative pain of pre-emptive bilateral Pectoral Nerve Block 2 by ultrasound with local anesthetic infiltration on the sternotomy line and drain insertion points in cardiac surgery.

Materials and Methods: The study included 40 patients with open heart surgery under general anesthesia aged over 18 years. Patients were randomly divided into 2 groups. Group 1(bilateral Pectoral Nerve Block 2 (PECS 2) performed with ultrasound) and Group 2 (local anesthesia infiltration). Patients had intraoperative and postoperative opioid consumption amounts, duration on ventilator, visual analog scale (VAS) scores when moving (cough) and at rest, inspiratory flow rates and hospitalization duration recorded.

Results: Group 1 was identified to have lower intraoperative and postoperative opioid consumption amounts (p<0.001). The rescue opioid requirements in the postoperative period were lower in Group 1 (p=0.002). The postoperative analgesia duration was longer in Group 1 (p=0.000). The duration on ventilator in the postoperative period was shorter for those with PECS 2 administration (p=0.010). The VAS score at rest was lower in Group 1 in the 48th hour (p=0.033). VAS score when moving was lower in Group 1 in the 24th and 48th hours (p=0.015, 0.001, respectively) After extubation, peak inspiratory flow rates were found to be statistically significantly higher in Group 1 in the 12th, 16th, 24th, 48th and 72nd hours.

Conclusion: PECS 2 may be a part of Enhanced recovery after surgery protocols in cardiovascular surgery because of its contribution to lower VAS scores, less opioid consumption, and less pulmonary complications during the perioperative period.

Keywords: Cardiac surgery; local infiltration; opioid consumption; pain control; pectoral nerve block

INTRODUCTION

In the world in general, more than one third of deaths are due to cardiovascular diseases (1). Additionally, nearly 1.5 million people have surgery annually due to cardiovascular diseases (2). One of the most significant problems encountered with these surgical operations is postoperative pain. This pain, perceived by the intercostal nerves originating in the T2-T6 thoracic nerve roots, may be due to sternotomy, sternal retraction, internal mammary artery bed resection, metal materials used, inflammatory processes developing in tissue linked to surgery and drain sites (3,4). If sufficient analgesia is not provided in the postoperative period, pulmonary problems like ineffective coughing, inadequate secretion clearance, lengthened weaning and acute respiratory failure; cardiac problems like increased oxygen consumption and tachycardia; and systemic complications like hyperglycemia and muscle weakness may occur. Effective pain control is necessary to reduce all these complications including postoperative mortality and morbidity (5-7).

The basic method used for postoperative pain control is analgesia strategies based on systemic high-dose opioids. The effects of use of high-dose opioids on lengthened intubation durations, ventilator-associated pneumonia, increased incidence of nausea-vomiting and lengthened intensive care, and hospitalization durations resulting in mortality increase are well-known (8,9).

Additionally, in the last 20 years, Enhanced recovery after surgery (ERAS) programs have gained popularity in surgical branches and begun to be applied for cardiovascular surgery patients. The ERAS protocol for cardiovascular surgery is an approach to postoperative analgesia as part of a multimodal approach. It is necessary to ensure successful pain control to reduce mortality and complication rates and for rapid normalization of vital functions in patients (10,11). ERAS protocols are based on the principle of postoperative analgesia, minimal amounts of opioids necessary along with co-adjuvant agents and regional anesthesia techniques. Thoracic epidural or paravertebral blockage may provide successful pain

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control; however, the increased risk of spinal hematoma linked to heparinization of patients has directed clinicians toward other analgesic methods (12). With the widespread use of ultrasonography (USG), regional block techniques have begun to come to the agenda.

Regional techniques chosen for postoperative pain control include paravertebral blocks, erector spina plane block, pectoral interfascial plane block, serratus anterior plane block, parasternal block and transversus thoracic plane blocks (13,14). Additionally, with the aim of preventing pain observed on the surgical incision line and drain entry sites, one of the basic factors in pain formation, infiltration with local anesthetic agents by the surgical team contributes to pain control and was shown to cause lower opioid use in many studies (15,16).

In our study, we aimed to research the effects of pre-emptive bilateral pectoral interfascial plane block performed with USG and administration of local anesthetic agents on the sternotomy line and drain entry points on postoperative pain, opioid consumption, extubation time, intensive care and discharge durations and postoperative respiratory peak flow measurements.

MATERIALS and METHODS

This study was planned as a prospective randomized study in Health Sciences University Gazi Yaşargil Education and Research Hospital from 15 March 2020-15 September 2020. Permission was granted by the hospital ethics committee (13.03.2020-439). The study included 46 patients with cardiac surgery with sternotomy performed, American Society of Anesthesiologist (ASA) II-III and aged over 18 years. Patients who did not accept participation, with presence of infection in the area of administration, coagulopathy, morbid obesity (Body mass index(BMI) >35), medication allergy history, chronic pain history, long-term opioid use history, psychiatric disease history, tumor and surgical history in the block administration spread area, repeated surgical history and emergency surgery were excluded from the study. Due to morbid obesity in 2 patients, coagulopathy in 1 patient and for postoperative re-exploration in 3 patients, they were excluded from the study. The study was completed with 40 patients (Figure 1).

Patients were assessed in the ward by an experienced anesthesiologist in the preoperative period. Detailed information was given about the surgical procedure and block administration. All patients provided informed written consent. Patients were given information about the visual analogue scale (VAS) (0 =no pain, 10= the worst pain imaginable) used to assess postoperative pain. Patients were randomly assigned to two groups with the envelope method. The intervention technique was placed in the envelope as a result of randomization. Immediately before the intervention, the researcher opened the envelope. Patients in Group 1 had bilateral PECS 2 block and patients in Group 2 had local anesthetic agent infiltration performed.

Procedures

Patients were taken to the operating room on the day of surgery after 6-8 hours fasting. Monitoring was provided according to the ASA standards (electrocardiography, peripheral oxygen saturation and non-invasive blood pressure monitoring). Thirty minutes before surgery, patients had 2 venous routes opened in the antecubital region with a 20 G cannula. For anesthesia induction, patients were administered 0.1 mg/kg midazolam, 2-3 mg/kg propofol, 2 mcg/kg fentanyl and 0.6 mg/kg rocuronium by the intravenous (iv.) route. After ensuring sufficient muscle relaxation, patients were intubated. After intubation, patients had anesthesia maintenance provided by 50% air and 50% air with 1 minimal alveolar concentration sevoflurane. Patients were monitored in volume-controlled mode with end-tidal carbon dioxide values fixed to 30-35. All patients had a 7 F central venous catheter and radial artery catheter inserted before surgery began and invasive arterial monitoring was used.

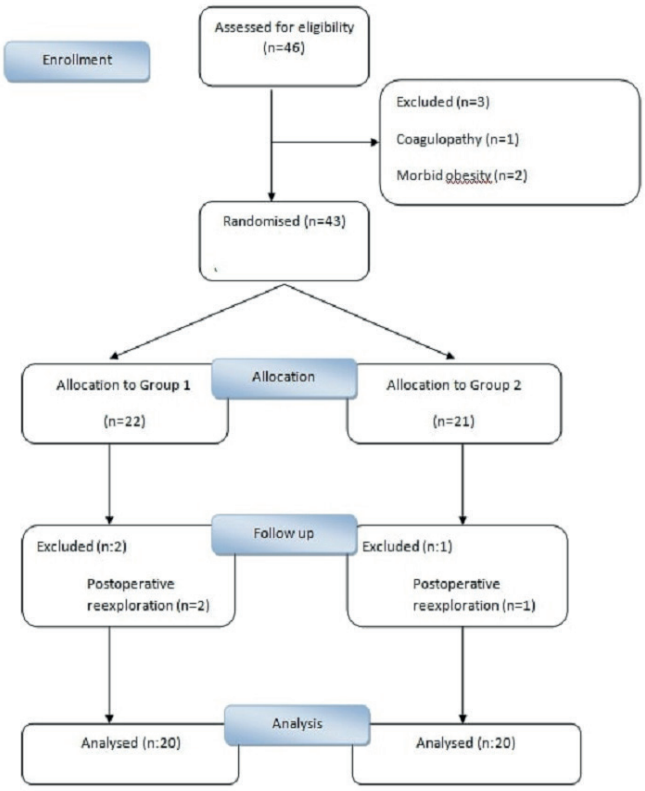
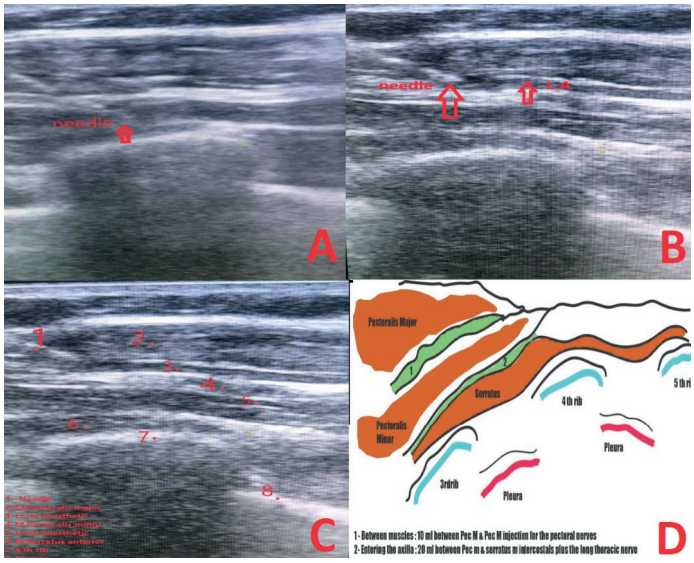


Figure 1. Flow diagram

After general anesthesia induction for patients in Group 1, bilateral PECS 2 block was performed by a linear USG probe (5-12 MHz, Mindray DP-50). During block administration, firstly the musculus pectoralis major and minor were determined on the mid-clavicular line. Then the probe was directed inferolateral and the axillary artery was imaged. At this level the 2nd rib was determined and progression was inferolateral. Using a 100 mm block need with the in-plane technique at the 3rd and 4th rib level (Braun peripheral nerve block needle stimplex 22 gauge), the skin and subdermal tissue was passed. Distribution of the anesthetic agent was checked and 10 cc 0.25% mg/ml bupivacaine was given between the musculus pectoris major and minor. Afterwards, the needle was advanced

deeper, and 20 cc of 0.25% mg/ml bupivacaine was administered between the musculus pectoralis minor and serratus anterior muscles (Figure 2). PECS 2 block was performed bilaterally. All blocks were administered by the same anesthesiologist with experience of using USG.



A: Needle insertion between musculus serratus anterior and musculus pectoralis minor. B: Needle insertion between musculus pectoralis minor and musculus pectoralis major.C: View of completed PECS 2 block D: Illustration of completed PECS 2 block

Figure 2. View of ultrasound guided PECS 2 block

Before incision in the patients in Group 2, 30 ml 0.25% bupivacaine was given along the incision line determined by the surgical team. Also, 15 ml 0.25% bupivacaine was given for right and 15 ml 0.25% bupivacaine was given for left port entry points. Total of 60 ml 0.25% bupivacaine was given for each patient. No patient exceeded the toxic dose of 3 mg/kg bupivacaine.

Patient's age, sex, BMI, surgery type, anesthesia duration, surgery duration, aortic cross clamp duration, by-pass duration, hospitalization, and intensive care durations were recorded.

During surgery, when mean arterial pressure increased 20% compared to basal values 1 mcg/kg iv. fentanyl was administered and intraoperative opioid consumption amounts were recorded.

After surgery, patients were taken to intensive care and connected to a ventilator in volume-guaranteed pressure supported synchronous mode. When patients were sufficiently awake and met all criteria for extubation, they were weaned from the mechanical ventilator. Weaning time from the mechanical ventilator, postoperative respiratory complications and re-intubation was recorded.

In the postoperative period 0 (at extubation), 2nd, 4th, 8th, 12th, 24th, 48th and 72nd hours VAS scores were recorded at rest and when coughing. Patients with VAS ≥4 had 1 mcg/kg fentanyl administered by the iv. route and recorded. If VAS was ≥4 within 30 minutes in spite of this, 1 mcg/kg additional fentanyl was administered (17). Patients administered rescue opioids and administration times were recorded. The mean opioid amounts used were calculated. Simultaneous to VAS scores, all patients had incentive spirometry (tri-flow) tested and recorded with inspiratory flow rate calculated according to the number of balls raised (1 ball=600 ml, 2 balls=900 ml, 3 balls=1200 ml).

After extubation patients had postoperative nausea and vomiting (PONV) assessed with a 3-point scale (0=none, 1=mild, 2=severe) (18). Patients with PONV score of 1 and above were administered 0.15 mg/kg iv. ondansetron. After extubation, sedation scores were recorded in the 1st, 2nd, 4th, 8th, 12th, 16th and 24th hour with a 3-point scale (awake=0, sleepy=1, deep sleep=2) (18).

Sample Size

G-Power software (version 3.1.9.4;University of Kiel, Kiel, Germany) was used to calculate the required sample size based on a previous study (19). The minimum number of patients required was 40, assuming two –tailed alpha error of 0.05, power (1-β err prob) 0.80, allocation ratio of N2/N1= 1, number of groups 2, effect size 0.8 (Actual power: 0.816878).

Statistical Analyses

Statistical analyses used the SPSS 16.0 for Windows program. Normal distribution of data was assessed with the Kolmogorov Smirnov test. Descriptive statistics included the mean with standard deviation or proportions depending on the characteristics of the data. Continuous variables are expressed as mean ±standard deviation (SD) or median (25th-75th percentiles). The groups were compared using the t test for independent variables. The Mann Whitney U test was used for the abnormally distributed data. Nominal variables were compared using the x2 test. A p value of less than 0.05 was considered statistically significant.

RESULTS

During the study, 46 patients were investigated. Two patients were excluded due to morbid obesity (BMI >35) and 1 patient was excluded due to coagulopathy. A total of 43 patients were randomized into 2 groups. Later, 3 patients with postoperative exploration performed were excluded from the study and 40 patients were analyzed (Figure 1).

The demographic and clinical features of patients are shown in Table 1. There were no statistically significant differences identified between the groups in terms of demographic and clinical features.

In Group 1, the intraoperative and postoperative opioid consumption amount was identified to be low by a statistically significant degree (p=0.000, p=0.010, respectively). In the postoperative period, the number of patients with rescue opioid requirements was identified to be statistically significantly low in Group 1 (p=0.002). The postoperative analgesia duration in Group 1 was statistically significantly longer (p=0.000).

Table 1. Demographic and clinical characteristics of patients

	Group 1 (n=20) (Mean±(SD)	Group 2 (n=20) (Mean±(SD)	P value
Age (years)	52.55±10.75	56.00±13.85	0.383
BMI	27.70±4.24	25.30±4.25	0.165
EF(%)	54.50±7.41	52.75±10.06	0.659
Sex (male/female)	12/8	16/4	0.289
Type of surgery			
CABG	8	15	
AVR	3	1	
MVR	3	4	
Aortic aneurysm	6	0	
Anaesthesia time(min.)	201.5±35.4	212.7±46.6	0.301
Surgery time(min.)	177.0±37.2	184.5±48.1	0.461
Aortic cross-clamp time	54.4±21.1	52.2±17.2	0.620
Cardiopulmonary bypass time	75.0±24.1	78.45±24.5	0.602

SD, Standard deviation; BMI, body mass index; EF, ejection fraction; CABG, coronary artery bypass grafting; AVR, aortic valve replacement; MVR, mitral valve replacement

In the postoperative period, the duration on ventilator was shorter by a statistically significant degree in Group 1 (p=0.010). There was no difference between the groups in terms of the number of patients re-intubated in the postoperative period. The duration in intensive care and duration of hospitalization were similar in the groups (Table 2).

The VAS values measured at rest and when moving(cough) significantly reduced in both groups at postoperative measurement times, especially from the 16th hour.(Figure 3)The VAS score at rest was found to be statistically significantly lower in Group 1 in the 48th hour (p=0.033). The VAS scores when moving (cough) were found to be low by a statistically significant degree in Group 1 in the 24th and 48th hours (p=0.015, p=0.001, respectively) (Figure 4).

The peak inspiratory flow rates assessed with tri-flow spirometry were identified to be statistically significantly higher in Group 1 in the 12th, 16th, 24th, 48th and 72nd hours after extubation (p=0.007, 0.021, 0.012, 0.012 and 0.018, respectively) (Table 3).

There were no statistical differences between the postoperative sedation score and nausea-vomiting scores between the groups. Two patients in Group 1 and 3 patients in Group 2 had nausea; however, no patient was observed to have opioid-related side effects like vomiting, rash or respiratory depression. Mortality was not encountered in any patient.

Table 2. Opioid consumption, duration on ventilator, in intensive care and hospitalization

	Group 1 (n=20) (Mean±(SD)	Group 2 (n=20) (Mean±(SD)	P value
Intraoperative opioid consumption (mcg)	415±108	782±219	<0.001*
Postoperative opioid consumption (mcg)	15±48	130±155	0.010*
Postoperative analgesia time (min)	1347±294	666±637	<0.001*
Rescue analgesia (yes/no)	2/18	11/9	0.002*
Extubation time (min)	339±93	459±237	0.010*
ICU discharge time (hour)	48.1±33.0	60.8±36.3	0.201
Hospitalisation duration (day)	5.1±1.8	5.70±2.0	0.414

SD, Standard deviation; ICU, Intensive care unit, *statistically significant

Table 3. Incentive spirometry (inspiratory flow rate)

Time (hour)	Group 1 (n=20)	Group 2 (n=20)	P value
1st hour	0 (0-450)	0 (0-600)	1.000
2nd hour	0 (0-600)	0 (0-600)	0.560
4th hour	600 (0-600)	300 (0-600)	0.385
8th hour	600 (150-600)	600 (600-600)	0.867
12th hour	600 (600-825)	600 (600-600)	0.007*
16th hour	600 (600-825)	600 (600-600)	0.021*
24th hour	600 (600-825)	600 (600-600)	0.012*
48th hour	600 (600-825)	600 (600-600)	0.012*
72nd hour	600 (600-825)	600 (600-600)	0.018*

Values are presented as median (25%-75%). * Statistically significant

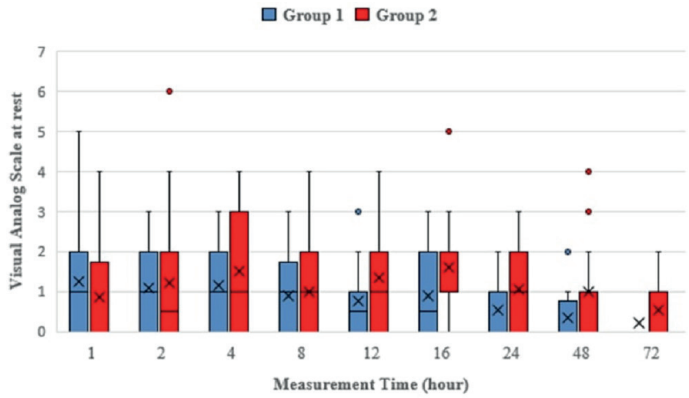


Figure 3. Visual analog scale scores at rest

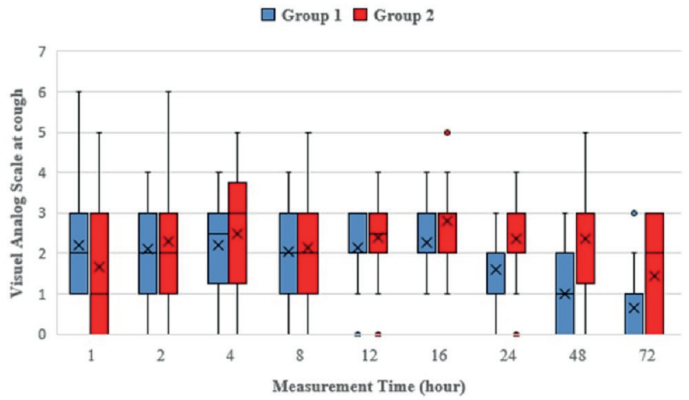


Figure 4. Visual analog scale scores at cough

DISCUSSION

In our study, pre-emptive bilateral PECS 2 block accompanied by USG in patients undergoing cardiovascular surgery was identified to significantly reduce opioid consumption in the intraoperative and postoperative periods, the number of patients with rescue opioid requirements and weaning from ventilator time compared to local anesthetic agent administration to the sternal incision line and drain entry points.

Postoperative pain in cardiovascular surgery is one of the factors causing severe morbidity and mortality in patients and is observed most severely in the first 24-48 hours (20-22). Along with opioids, non-steroidal anti-inflammatory agents and regional anesthesia techniques come to the forefront for postoperative pain management (6,7).

One of the regional applications of local anesthetics of PECS 2 block began to be used safely with USG by Blanco et al. for the first time due to lowering postoperative pain scores and reducing opioid consumption of patients with chest wall operations and breast surgeries (23). Currently, it is commonly chosen for minor and major breast surgeries due to positive effect on postoperative opioid consumption and VAS scores (24). In our study comparing pre-emptively administered techniques, the group with PECS 2 block performed with USG were found to have statistically significantly lower intraoperative opioid consumption compared to the group with local anesthetic administered. The importance and benefit of pre-emptive analgesic agent administration is known from studies performed in other surgical branches (25). For this reason, we applied all analgesia techniques pre-emptively and aimed to increase the analgesic effect.

A study by Kumar et al. researched the effect of PECS 2 block administration on postoperative analgesic consumption in patients undergoing cardiovascular surgery. They found the rescue opioid requirements and VAS scores were significantly lower in the PECS 2 group compared to the control group. In fact, they emphasised that even during coughing patients in the PECS 2 group had less pain and had higher inspiratory peak flow on spirometry measurements (19). In our study, patients in the PECS 2 group had statistically significant outcomes for VAS scores and inspiratory flow rates compared to the patient group administered local anesthetic, supporting this study.

Local anesthetic infiltration in the incision region with the aim of multimodal analgesia inhibits pain conduction from nociceptive receptors on the wound surface and the local inflammatory response to injury. Thus, secretions of inflammatory mediators like neutrophils are reduced, oedema formation is prevented and analgesia is provided. There are studies reporting local anesthetic agent administration to the wound site in many surgical operation types reduces analgesic requirements and pain scores (26). Though wound site infiltration with local anesthetics is not as common in cardiac surgery as in other surgical branches, there are studies related to the topic (27). Kocabas et al. stated that local anesthetic agent infiltration of the median sternotomy and mediastinal tube insertion site reduced morphine consumption during a 24-hour period in a study using 0.25% levobupivacaine as local anesthetic agent.

Aydın et al. found the extubation time was 6±2 hours in a study administering thoracic muscle plane block accompanied by USG with postoperative analgesia purposes for patients undergoing cardiovascular surgery (28). Berthoud et al. found the mean extubation time was 5 hours in studies administering serratus plane block accompanied by USG with postoperative analgesia purposes for patients undergoing minimally invasive cardiac surgery (29). While Berthoud et al. administered continuous local anesthetic infiltration to the incision line, in our study we administered a single dose pre-emptively. We determined that patients with PECS 2 block administered in our study group were extubated in earlier periods compared to those with local administration. We think the higher intraoperative and postoperative opioid use amounts in the local infiltration group compared to the PECS 2 group may have affected this duration.

VAS scores are among commonly-used methods to assess postoperative pain. For this reason, we chose VAS scoring to assess pain in our study (30). Our study results show that VAS sores in the postoperative period were lower while coughing and at rest in patients with PECS 2 block. This outcome supports the view that PECS 2 block

administration is a more effective analgesic method for postoperative pain control in cardiovascular surgery and is consistent with the literature (17,19,31).

Kumar et al. found that those administered PECS 2 block had lower VAS scores in addition to higher peak inspiratory flow values in a study performed with the aim of assessing pain and postoperative pulmonary functions in patients undergoing cardiac surgery (19). In our study, the peak inspiratory flow measurement values were higher for patients with PECS 2 block compatible with the literature. Lower VAS scores and higher inspiratory flow measurement values ensure patients in the PECS 2 group can cough better and more strongly in the postoperative period which provides advantages in terms of postoperative pulmonary functions.

There were no differences between the groups of our patients in terms of intensive care duration and discharge duration. Additionally, no patient development wound site infection or complications related to the procedure.

LIMITATIONS

Limitations of our study are the low number of cases and the lack of a control group.

CONCLUSION

PECS 2 block administration with USG is a simple and reliable method when administered pre-emptively as a part of multimodal analgesia for cardiovascular surgery. Due to the lower VAS scores in the perioperative period, it contributes to patients consuming lower amounts of opioids and development of fewer pulmonary complications. For this reason, we think PECS 2 block administration should be a part of ERAS protocols due to the positive contribution to pulmonary functions.

Competing Interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports.

Ethical Approval: This study was approved by the Local Ethics Committee of the Health Sciences University Gazi Yasargil Education and Research Hospital (Approval date and number 13.03.2020-439).

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