Evaluation of the effect of different block techniques on open-heart surgery in the postoperative period: a prospective observational study

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Abstract

Background: Open-heart surgery is associated with severe postoperative pain. Adequate analgesia after open-heart surgery improves patients' early postoperative recovery, extubation, ambulation and early discharge from hospital. Regional anaesthesia techniques are the new hope for adequate postoperative analgesia after cardiac surgery and are widely used for early pain management in the first six hours.

Methods: A total of 100 patients with the American Society of Anesthesiologists physical status classification I–III, aged 18 years and over, undergoing open-heart surgery with sternotomy for coronary artery bypass grafting or valve replacement under general anaesthesia, were included in this study. For postoperative analgesia, 50 patients with pectoral nerve (PECS II) block and 50 with parasternal (PS) block were consecutively enrolled in one of the groups at the end of the surgery and compared in terms of sedation scores, ventilation duration, pain scores at rest after extubation, block duration, total morphine consumption and complications.

Results: The block duration in the PS group was statistically significantly higher than in the PECS II group ($p = 0.001$, $p < 0.05$, respectively). The visual analogue scale scores at rest in the fourth and sixth hours were statistically significantly higher in the PECS II group than in the PS group ($p = 0.001$, $p = 0.001$, $p < 0.01$). Cumulative morphine consumption in the PECS II group was statistically significantly higher than in the PS group in the fourth, sixth, 12th and 24th hours ($p = 0.001$, $p = 0.001$, $p = 0.001$, $p = 0.001$, $p = 0.001$, $p < 0.01$, respectively).

Conclusion: PS block provided longer block duration with lower postoperative pain and sedation scores than the PECS II block, with lower cumulative morphine consumption.

Keywords: PECS II block, parasternal block, cumulative morphine consumption

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Open-heart surgery is associated with severe postoperative pain.[1] Sternotomy and rib retractions are the primary source of postoperative pain.[2] Adequate analgesia after open-heart surgery improves patients' early postoperative recovery, extubation, ambulation and early discharge from hospital. Inadequate postoperative pain control is strictly associated with decreased pulmonary function, atelectasis and pneumonia, leading to delayed extubation and discharge from the intensive care unit, with a prolonged hospital stay and increased mortality and morbidity rates.[3,4] Postoperative pain management is the main consideration after surgery, and yet there is still a pursuit for the best approach to it.

Regional anaesthesia techniques are the new hope for adequate postoperative analgesia after cardiac surgery and are widely used for early pain management in the first six hours. They are preferable to parenteral systemic opioid treatments because of their side effects and complications; however, opioids are still the first choice in the early postoperative period.[4] Regional anaesthesia techniques also reduce the use of postoperative parenteral analgesics.[5] Paravertebral blocks and thoracal epidural analgesia provide adequate postoperative analgesia but have limited use after cardiac surgery because of anticoagulant drug use, leading to severe complications such as haematomas.[6]

The parasternal (PS) block is safe in anticoagulated patients and provides sufficient postoperative analgesia after cardiac surgery.[5,7] Other alternatives are erector spinae plane and pectoral nerve (PECS) blocks.[8] These blocks are effective on the anterior branches of the thoracic intercostal nerves from T2 to T6 at different anatomical regions, and this is essential for postoperative pain relief associated with sternotomy after open-heart surgery.[1]

PECS blocks were described by Blanco *et al*. for the first time for breast surgery and were used for postoperative pain relief after anterior thoracic wall surgery.[9] PECS blocks are performed under ultrasound guidance with a two-plane approach. The first plane is between the pectoralis muscles (PECS I) and the second plane is between the serratus anterior and the pectoralis minor muscle (PECS II) at the level of the third rib. PECS I blocks the lateral and medial pectoral nerves, whereas PECS II blocks the anterior branches of the thoracic intercostal nerves from T2 to T6, thoracodorsal nerve and long thoracic nerve.

This study aimed to compare the efficacy of ultrasound-guided PECS II block with the PS block in patients undergoing open-heart surgery via a midline sternotomy. We hypothesised that the PECS II block could provide superior postoperative analgesia for patients undergoing cardiac surgery with midline sternotomy than a PS block.

Methods

This prospective observational study was conducted in the Department of Anesthesiology and Reanimation at the Prof Dr Cemil Taşçioğlu City Hospital from 1 May 2019 to 1 May 2020, after obtaining the permission of the ethics committee (date 16.04.2019, number 1249) and the written informed consent of the patients.

A total of 100 patients with the American Society of Anesthesiologists physical status classification I–III, aged 18 years and over, undergoing open-heart surgery with sternotomy for coronary artery bypass grafting or valve replacement under general anaesthesia, were included in this study. For postoperative analgesia, 50 patients with PECS II block and 50 with PS block were consecutively enrolled in one of the groups at the end of the surgery and compared in terms of sedation scores, ventilation duration, pain scores at rest after extubation, which was our first endpoint, block duration and cumulative morphine consumption, which was our second endpoint, and complications such as itching, postoperative vomiting and nausea (POVN). Patient demographics were also recorded and compared.

Patients with symptoms of congestive cardiac failure, allergy to local anaesthetics, haemodynamic instability, pre-existing infection at the block site, psychiatric disorders and those with prolonged ventilatory course in the intensive care unit were excluded from the study.

All patients were pre-medicated with 0.06 mg/kg midazolam as part of the standard anaesthesia care in the study. General anaesthesia was induced after basic monitoring, including pulse oximetry, electrocardiograph, invasive blood pressure and bispectral index with intravenous administration of propofol (2 mg/kg), rocuronium (0.5–1 mg/kg), fentanyl (2 µg/kg) and remifentanil (0.01–0.2 µg/kg/min) in both groups. After tracheal intubation, maintenance of anaesthesia was done with propofol (2–4 µg/ml), rocuronium (0.5–1 mg/kg), remifentanil (2–4 ng/ml) and O_2/air (FiO_2 0.4). The depth of anaesthesia was set by the bispectral index score of 40 to 60 (range 0–100). The remifentanil infusion was titrated to maintain the patient's blood pressure at around 20% of the baseline.

The patients were transferred to the intensive care unit at the end of the surgery. All parameters were screened in the intensive care unit in the first, second, fourth, sixth, 12th and 24th hours. The block administration time in both groups was assumed as the beginning of the study in the postoperative period.

All regional anaesthesia blocks were administered at the end of the surgery by the same anaesthesiologist under general anaesthesia and ultrasound guidance. The PS block was done with 2 ml of 0.25% bupivacaine injected into each parasternal space, 4 cm lateral to the sternal edge, deep to the major pectoral muscle and superficial to the intercostal muscle, bilaterally at the level between the second and sixth intercostal space with a total of 10 injections.

The ultrasound-guided PECS II block was done with 20 ml 0.25% bupivacaine injected into each site. The local anaesthetic was injected between the serratus anterior and the pectoralis minor muscle (PECS II) over the third rib to block the anterior branches of the thoracic intercostal nerves at the level of T2 to T6, thoracodorsal nerve and long thoracic nerve.

The pain scores were assessed with the visual analogue scale (VAS), where 0 means no pain and 10 means the worst pain ever. When the patient's pain score was found to be three or more, intravenous bolus morphine at a dose of 2 mg was administered to the patients and noted. The sedation score was measured with the Richmond agitation–sedation scale (RASS).[10]

Statistical analysis

The Number Cruncher Statistical System (NCSS) program (Kaysville, Utah, 2007, USA) was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, median, frequency, percentage, minimum, maximum) were used when evaluating the study data. The normal distribution conformity of quantitative data was tested with Shapiro–Wilk testing and graphical examinations. Independent groups *t*-test was used to compare two groups of quantitative variables with normal distribution, and the Mann–Whitney *U*-test was used to compare two groups of quantitative variables that did not show a normal distribution. Pearson's chi-squared test was used to compare qualitative data. Statistical significance was set at $p < 0.05$.

Results

The study was conducted with 100 patients divided into two groups (Fig. 1). The groups were compared for gender, age, body mass index (BMI), block and ventilation duration, postoperative pain scores at rest and cumulative morphine consumption.

The block duration in the PS block group was statistically significantly higher than in the PECS II block group ($p = 0.001$, $p < 0.05$, respectively) (Table 1). There were no significant differences in age, gender, BMI and ventilation duration between the groups ($p > 0.05$) (Table 1).

The VAS scores at rest in the fourth and sixth hours were statistically significantly higher in the PECS II block group than in the PS block group ($p = 0.001$, $p = 0.001$, $p < 0.01$, respectively) (Table 2). VAS scores at rest did not differ significantly between the groups ($p > 00.05$) in the first, second, 12th and 24th hours (Table 2).

Cumulative morphine consumption in the PECS II block group was statistically significantly higher than in the PS block group in the fourth, sixth, 12th and 24th hours ($p = 0.001$, $p = 0.001$, $p = 0.001$, $p = 0.001$, $p = 0.001$, $p < 0.01$, respectively) (Table 3). Fifteen patients in the PECS II block group and six in the PS block group had POVN.

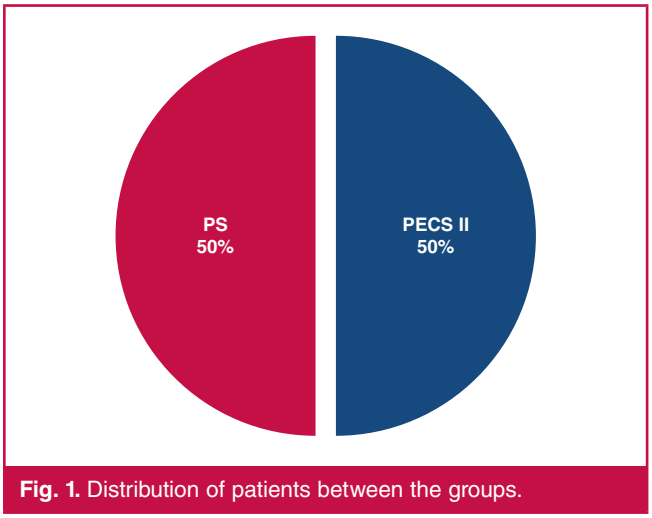

Fig. 1. Distribution of patients between the groups.

Table 1. Comparison of characteristics between the groups

Characteristics	*Groups*		p-*value*
	PECS II	*PS*	
Gender			
Male	36 (72.0)	39 (78.0)	0.488[b]
Female	14 (28.0)	11 (22.0)	
Age			
Mean ± SD	56.90 ± 4.08	56.88 ± 4.35	0.849[a]
Median (min–max)	57 (48–67)	57 (45–64)	
BMI			
Mean ± SD	30.14 ± 4.19	30.78 ± 2.44	0.336[a]
Median (min–max)	30.5 (18–39)	31 (23–35)	
Block duration (h)			
Mean ± SD	2.18 ± 0.56	5.26 ± 0.78	0.001[a*]
Median (min–max)	2 (1–3)	5 (4–6)	
Ventilation duration (min)			
Mean ± SD	99.56 ± 15.2	97.32 ± 15.36	0.426[a]
Median (min–max)	100 (75–135)	90 (75–135)	

[a]Mann–Whitney *U*-test, [b]Chi-squared test, $*p < 0.05$.
BMI: body mass index.

The RASS scores in the PECS II block group were statistically significantly higher than in the PS block group in the fourth hour ($p = 0.001$, $p < 0.01$, respectively) (Table 4). The RASS scores of the two groups did not differ significantly in the sixth, 12th and 24th hours ($p > 0.05$) (Table 4).

Discussion

The current analgesic regimens are far from providing uncomplicated and adequate postoperative analgesia after open-heart surgery with sternotomy. Opioids are the first choice for postoperative analgesia after cardiac surgery as part of a multimodal analgesia and are frequently associated with sedation, inadequate respiratory function and delayed extubation, causing prolonged length of stay in the intensive care unit.[4] Very few of these regimens provide the desired sufficient postoperative analgesia with minimal side effects.

Table 3. Comparison of cumulative morphine consumption between the groups

Cumulative morphine consumption	*Groups*		p-*value*
	PECS II	*PS*	
1st hour			
Mean ± SD	0 ± 0	0 ± 0	–
Median (min–max)	0 (0–0)	0 (0–0)	
2nd hour			
Mean ± SD	0 ± 0	0 ± 0	–
Median (min–max)	0 (0–0)	0 (0–0)	
4th hour			
Mean ± SD	2.36 ± 0.78	0 ± 0	0.001[a**]
Median (min–max)	2 (2–4)	0 (0–0)	
6th hour			
Mean ± SD	4.72 ± 1.05	1.68 ± 0.74	0.001[a**]
Median (min–max)	4 (4–8)	2 (0–2)	
12th hour			
Mean ± SD	7.32 ± 1.19	3.84 ± 0.89	0.001[a**]
Median (min–max)	8 (6–10)	4 (2–6)	
24th hour			
Mean ± SD	9.04 ± 1.09	5.4 ± 1.01	0.001[a**]
Median (min-max)	9 (8–12)	6 (4–8)	

[a]Mann–Whitney *U*-test, $**p < 0.01$.

Blocking nerves in different regions with different block techniques effectively provides postoperative analgesia and reduces the use of opioids.[11,12] However systemic heparinisation limits the number of methods used for postoperative analgesia after open-heart surgery with sternotomy.[2,6] Based on this, our study evaluated the effectiveness of two block techniques that provide adequate postoperative analgesia after open-heart surgery.

According to their study protocols, previous studies compared one of the blocks with multimodal analgesia after sternotomy in the postoperative period. In a research article conducted in India, the PECS II block was compared with multimodal analgesia after cardiac surgery for ventilation support. Pain scores, flow rates and rescue analgesia were compared. The

Table 2. Comparison of VAS score at rest between the groups

VAS-R	*Groups*		p-*value*
	PECS II	*PS*	
1st hour			
Mean ± SD	1.4 ± 0.61	1.24 ± 0.62	0.194[a]
Median (min–max)	1 (0–2)	1 (0–2)	
2nd hour			
Mean ± SD	1.06 ± 0.65	0.88 ± 0.48	0.126[a]
Median (min–max)	1 (0–2)	1 (0–2)	
4th hour			
Mean ± SD	4.08 ± 1.19	1.38 ± 0.73	0.001[a**]
Median (min–max)	4 (2–6)	2 (0–2)	
6th hour			
Mean ± SD	5.36 ± 1.24	3.62 ± 0.78	0.001[a**]
Median (min–max)	6 (2–7)	4 (2–5)	
12th hour			
Mean ± SD	3.86 ± 1.09	3.8 ± 1.03	0.679[a]
Median (min–max)	4 (2–6)	4 (2–6)	
24th hour			
Mean ± SD	0.78 ± 0.95	0.86 ± 0.78	0.469[a]
Median (min–max)	0 (0–2)	1 (0–2)	

[a]Mann–Whitney *U*-test, $**p < 0.01$.
VAS-R: VAS score at rest.

Table 4. Comparison of the RASS scores between the groups

RASS scores	*Groups*		p-*value*
	PECS II	*PS*	
1st hour			
Mean ± SD	0 ± 0	0 ± 0	–
Median (min–max)	0 (0–0)	0 (0–0)	
2nd hour			
Mean ± SD	0 ± 0	0 ± 0	–
Median (min–max)	0 (0–0)	0 (0–0)	
4th hour			
Mean ± SD	1.42 ± 0.5	0.42 ± 0.5	0.001[a**]
Median (min–max)	1 (1–2)	0 (0–1)	
6th hour			
Mean ± SD	1.08 ± 0.72	1.02 ± 0.62	0.632[a]
Median (min–max)	1 (0–2)	1 (0–2)	
12th hour			
Mean ± SD	0.2 ± 0.4	0.28 ± 0.45	0.351[a]
Median (min–max)	0 (0–1)	0 (0–1)	
24th hour			
Mean ± SD	0.38 ± 0.49	0.28 ± 0.45	0.290[a]
Median (min–max)	0 (0–1)	0 (0–1)	

[a]Mann–Whitney *U*-test, $**p < 0.01$.
RASS: Richmond agitation–sedation scale.

PECS block was more effective in reducing postoperative pain, ventilation support and demand for rescue analgesia.[2] The PS block was compared with controls in another study and was found to be more effective in reducing postoperative pain scores and morphine consumption.[13]

We have conducted the first study with two blocks in two groups after open-heart surgery with sternotomy. We compared the PS block with the PECS II block in terms of age, gender, BMI, block and ventilation duration, postoperative pain scores at rest and cumulative morphine consumption.

In our study, the VAS scores at rest were higher in the PECS II block group in the first six hours than in the PS group. It was associated with the block duration, which lasted longer in the PS block group. Cumulative morphine consumption and RASS scores in the PECS II block group were also higher than in the PS block group in the first six hours.

There was no difference in ventilation duration between two block groups in our study. There was also no difference in block duration, or pain and sedation scores in the first two hours. The difference in block duration between the groups led to the differences in the fourth and sixth hours in cumulative morphine consumption, sedation and pain scores, which were higher in the PECS II group.

In an article by McDonald *et al.*, the PS block was combined with local anaesthetic infiltration after sternotomy. This was associated with early extubation and shorter ventilation duration in the intensive care unit than each alone.[7] In our study, we did not determine the length of stay in the intensive care unit. This is one of the limitations of our study. On the other hand, our study is the first comparing the two different blocks that are safe for use in anticoagulated patients after cardiac surgery.

Conclusion

The PS block provided longer block duration with lower postoperative pain and sedation scores than the PECS II block, as well as lower cumulative morphine consumption. Further studies are required to confirm our findings.

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