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Evaluation of erector spinae plane block in cardiac surgery patients in terms of acute and chronic pain scores

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Abstract. – OBJECTIVE: Pain after cardiac surgery is a frequently encountered morbidity associated with poor quality of life and postoperative recovery. There have been several regional anesthesia modalities for this purpose. We aimed to investigate acute and chronic postoperative analgesic effects of erector spinae plane block (ESPB) after cardiac surgery.

PATIENTS AND METHODS: We retrospectively evaluated patients who underwent cardiac surgery between December 2019 and December 2020. According to regional anesthesia management, there were two groups: ESPB and control groups. Patient demographic data, surgical outcomes, and Numerical Rating Scale (NRS) and Prince Henry Hospital Pain Scores (PHHPS) were recorded.

RESULTS: Patients in the ESPB group were significantly younger than those in the control group (p=0.023). The duration of surgery was significantly shorter in the ESPB group (p=0.009). Patients in the ESPB group had significantly lower NRS and PHHPS pain scores assessed at the 48th hour after extubation (p=0.001 for both cases) and three months after discharge (p<0.001 and p=0.025, respectively). Significance remained after adjustment for age (p=0.029 and p<0.001, respectively) and duration of surgery (p=0.003 and p=0.041, respectively).

CONCLUSIONS: ESPB might benefit patients with cardiac surgery by reducing acute and chronic postoperative pain.

Key Words:
Cardiac surgery, Erector spina plane block, Acute pain, Chronic pain.

Introduction

Acute or chronic pain after cardiac surgery is a common problem that adversely impacts the quality of life[1]. The incidence of moderate to severe acute pain after cardiac surgery reported in the literature ranged between <5% and >80%[2]. Severe postoperative pain after a median sternotomy could be due to various factors, including vasospasm, increased inflammatory response, soft tissue and bone injury during the dissection, and chest tube placement[3].

The postoperative pain begins to alleviate after the first 24 hours. Nonetheless, inadequate analgesic treatment may prolong this painful period. The incidence of chronic post-sternotomy pain syndrome in open-heart surgery patients reported in the literature ranged between 7% and 66%[4].

Neuraxial anesthesia techniques, which primarily include thoracic epidural or thoracic paravertebral blocks, have been proposed as the postoperative pain control following minimally invasive cardiac surgery; there was controversy considering the technique- and patient-related drawbacks such as procedure-related difficulties, coagulation disorders, full heparinization, hemodynamic instability, and pneumothorax[5,6]. Nevertheless, fascial plane chest wall blocks, including the serratus anterior and erector spinae planes, have gained popularity for managing postoperative pain after minimally invasive cardiac surgery and thoracotomy/sternotomy, specifically in patients who receive antiplatelet and anticoagulant therapy[5,6].

As an alternative novel approach, ultrasonography (USG)-guided erector spinae plane block (ESPB) was first introduced in 2016 by Forero et al[7] for treating thoracic neuropathic pain. A recent prospective observational study[5] reported that continuous ESPB provided adequate analgesia with low opioid consumption during the

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first 24 hours following mini-thoracotomy mitral valve surgery. Moreover, ESPB reduced the need for using nonsteroidal anti-inflammatory drugs (NSAID) and antiemetics postoperatively[5,8,9]. Several studies reported[10,11] better pain control and lower morphine consumption with the use of ESPB in addition to multimodal analgesia during the early postoperative period following cardiac surgery. Although ESPB reportedly provides better pain control in the acute postoperative period compared to analgesic treatment, there is still not enough evidence in the literature on the benefits of ESPB on chronic pain control and surgical outcomes.

In view of the foregoing, this study was carried out to investigate the acute and chronic postoperative analgesic effects of ESPB in cardiac surgery patients using pain scores.

Patients and Methods

Study Design

The population of this retrospective study consisted of patients who underwent cardiac surgery at the Anesthesiology and Reanimation Clinic of Necmettin Erbakan University Meram Faculty of Medicine between December 2019 and December 2020. The study protocol was approved by the Ethics Committee of Necmettin Erbakan University Meram Faculty of Medicine prior to the conduct of the study (Approval Number: 2020/2961).

The sample of the study consisted of patients aged 18 to 80, whose physical statuses were assessed as III or IV according to the American Association of Anesthesiologists (ASA) criteria, and who had undergone elective open-heart surgery. Patients with coagulopathy, hepatic and renal insufficiency, left ventricular ejection fraction <40%, who concurrently underwent other surgical procedures, had reoperation and emergency operation, have been using a cardiac mechanical support device preoperatively, required pre- and intraoperative inotropic/vasoactive treatment, and had incomplete data were excluded from the study. Patients were categorized by the form of analgesia administered. Patients who underwent the ESPB procedure were thus included in the experimental group. Patients without fascial plane chest wall block, including ESPB, comprised the control group. The request for ESPB was determined at the discretion of the primary attending cardiovascular surgeon. All patients were informed about the ESPB procedure. Written and verbal consent were obtained from the patients who agreed to undergo the ESPB procedure. The ESPB was administered to the patients in the experimental group who were scheduled for open heart surgery within the scope of multimodal analgesia half an hour before the surgery.

Data Collection

Patients' demographic and clinical characteristics, such as gender, age, comorbidities, body mass index (BMI), ejection fraction, and pulmonary artery pressure values, were recorded. The analgesic needs of all patients were monitored with the surgical plethysmographic index. The remifentanil infusion dose to be administered was adjusted, and the total intraoperative remifentanil consumption was recorded. Additionally, the duration of surgery, total perfusion time, aortic occlusion time, number of drains, type of surgery (coronary artery bypass graft surgery, heart valve replacement), the extubation time, oral intake time, length of stay (LoS) in the intensive care unit (ICU), and time to discharge were recorded.

ESPB Procedure

The patients who were scheduled to receive ESPB were first administered 1-2 mg of midazolam in the operating room. Skin sterilization was performed using a 10% povidone-iodine/chlorhexidine solution while the patients were sitting. The T5 spinous process was visualized in the midline horizontal plane using a convex probe covered with a sterile drape under the guidance of USG. The probe was then rotated to the longitudinal plane, and the transverse process and erector spinae muscle were visualized approximately 2-2.5 cm from the right and left lateral midline. The 22-gauge, 80-mm needle was inserted in the cauda-cranial direction to contact the transverse process. After it was confirmed by hydro dissection that it was between the erector spinae muscle group and the transverse process, the needle was slightly withdrawn, and 20 ml (0.125% bupivacaine hydrochloride + 0.5% lidocaine hydrochloride + 4 mg dexamethasone) local anesthetic and adjuvant drug were injected into the interfacial plane (Figure 1). The simultaneous volume expansion was visualized by ultrasonography. The same procedure was applied to the opposite side at the T5 level, and then ESPB was performed bilaterally.

Anesthesia Management

The same surgical team operated on all open-heart surgery patients with or without ESPB un-

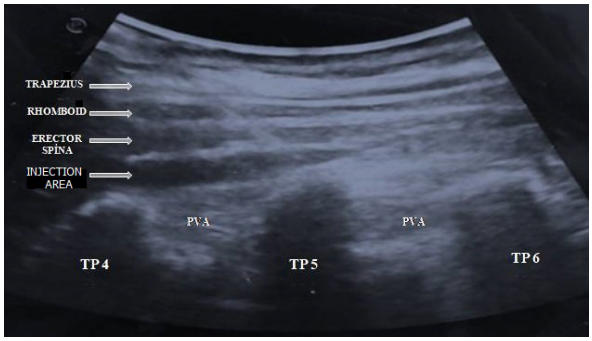

Figure 1. Ultrasonographic image for ESPB. Please note to the injection area (white arrow) of the local anesthetics to the interfacial planes under the muscles of the chest wall (the trapezius, rhomboid, and erector spinae).

der general anesthesia. The anesthesia induction was conducted as described in the literature[10]. All patients were transferred to ICU after the surgery and extubated, taking the blood gas and clinical parameters into consideration.

Assessment of the Pain Scores

Two different tools, the Numerical Rating Scale (NRS) and Prince Henry Hospital Pain Score (PHHPS) were used to assess the pain in the post-extubation period. PHHPS allows assessing the pain not only during rest and sleep but also under dynamic conditions[12,13]. Based on the pain scores assessed during follow-up, 50 mg tramadol was administered as rescue analgesia to patients with NRS>4 and PHHPS>2 in the cardiovascular surgery ICU. In addition, patients were asked about their NRS and PHHPS pain scores over the phone in the 3rd month after discharge.

Statistical Analysis

The descriptive statistics obtained from the collected data were presented as mean±standard deviation or median, and minimum-maximum values in the case of continuous (numerical) variables determined to conform or not to conform to the normal distribution, respectively, and as numbers and percentage values in the case of categorical variables. Normal distribution characteristics of the numerical variables were analyzed using Shapiro-Wilk, Kolmogorov-Smirnov, and Anderson-Darling tests.

Pearson's Chi-squared test was used in 2x2 tables with expected cells 5 and above. Fisher's exact test was used in tables with expected cells less than 5, and the Fisher-Freeman-Halton test was used in RxC tables with expected cells below 5 in comparing the differences between categorical variables according to study groups.

In the comparisons of two independent groups, independent samples *t*-test and Mann-Whitney Utest were used in the case of numerical variables determined to conform or not to conform to the normal distribution, respectively.

The effects of age and duration of surgery on NRS and PHHPS scores were compared between the groups by nonparametric covariance analysis using the "sm.ancova" package in R software[14]. Jamovi project 2.2.5.0 (Jamovi, version 2.2.5.0, 2022, retrieved from https://www.jamovi.org), JASP 0.16.1 (Jeffreys' Amazing Statistics Program, version 0.16.1, 2022, retrieved from https://jasp-stats.org) and R (version 4.2) software packages were used in the statistical analyses. The probability p-value ≤ 0.05 was deemed to indicate statistical significance for all comparisons.

Results

fThe median age was 61 (min 42, max 79) years in the experimental group and 68.5 (min 45, max 79) years in the control group. The patients in the experimental group were significantly younger than those in the control group (p=0.023). There was no significant difference between the study groups in gender, BMI, body surface area, ejection fraction, pulmonary artery pressure, and type of surgery.

The duration of surgery was significantly higher in the control group than in the experimental group (257 min *vs.* 221.5 min, p=0.009). There was no significant difference between the groups in perfusion time, aortic clamping time, and the number of total drains (Table I).

There was no significant difference between the groups in NRS and PHHPS scores assessed during the first 24 hours after the surgery (Figure 2, Figure 3). On the other hand, the NRS and PHHPS scores assessed at the 48th hour after extubation (p=0.001 for both cases) and 3 months after discharge were significantly lower in the experimental group than in the control group (p<0.001 and p=0.025, respectively)

This significant difference in favor of the experimental group remained even after the NRS and PHHPS scores assessed at the 48th hour after extubationand 3 months after discharge were adjusted for age (p=0.029 and p<0.001, respectively) and duration of surgery (p=0.003 and p=0.041,

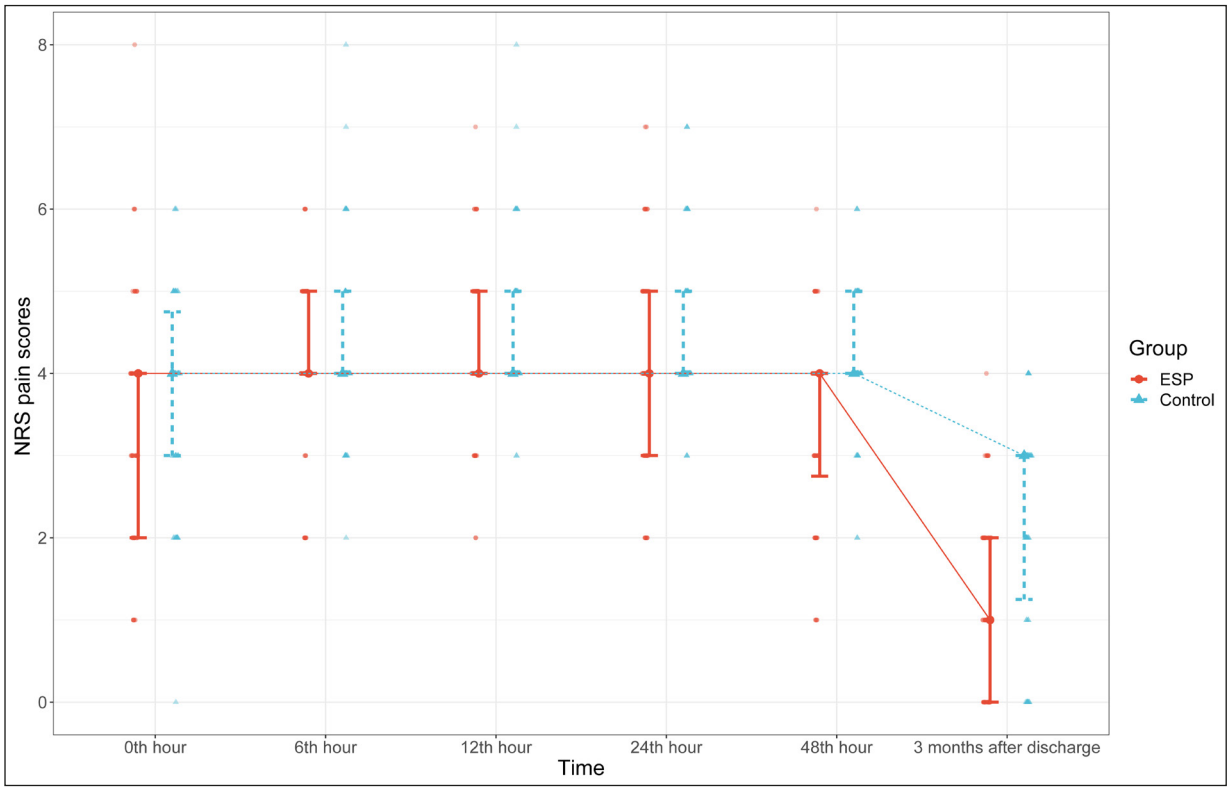

Figure 2. The figure depicts NRS pain scores at the immediate, 6h, 12h, 24h, 48h after extubation and 3 months after discharge.

respectively) using nonparametric covariance analysis (Table II).

Lastly, there was no significant difference between the groups in early postoperative follow-up parameters, i.e., the required dose of rescue analgesic, oral intake time, LoS in ICU, and time to discharge (Table III). Besides, there was no procedure-related complications in the ESPB group.

Discussion

This study revealed that ESPB reduced the NRS and PHHPS pain scores assessed at the 48th hour after extubation and 3 months after discharge compared to the control group in cardiac surgery patients. This finding is compatible with the recent findings reported in the literature, which revealed that using USG-guided regional anesthesia techniques reduced pain and dose-dependent side effects of opioids after major cardiac surgeries[5-7,15].

It has been reported that ESPB, one of the USG-guided regional anesthesia techniques, can be used in cardiac surgeries with high efficiency and a high safety margin[16,17]. In a prospective randomized study[11] on the acute effect of ESPB, the visual analogue scale (VAS) scores of 54 cardiac surgery patients with bilateral ESPB and multimodal analgesia were found to be significantly lower than those with only multimodal analgesia at the postoperative 6th hour, yet comparable to those with only multimodal analgesia at the postoperative 12th and 24th hours. In another study[5] conducted with 85 consecutive mitral valve surgery patients, there was no significant difference between the patients who received serratus anterior plane block (SAPB) and ESPB in median NRS pain scores assessed at the 12th, 24th, and 48th hour postoperatively. Toscano et al[18] showed similar efficacy of SABP and ESPB in patients undergoing cardiac surgery while receiving anticoagulant and antiplatelet drugs. There were no adverse effects directly related to the procedures. So, they thought both procedures could be used in patients with a high risk of bleeding secondary to anticoagulation. Kodali et al[19] reported that bilateral ESPB reduced the pain scores assessed at the 4th and 12th hour after off-pump coronary artery bypass graft surgery. In comparison, the pain scores of the cardiac surgery patients included in

Table I. The comparison of baseline characteristic and intra/postoperative surgical outcomes of the study groups.

	ESPB (n=52)	Control (n=58)	*p*
Age (years)	61.0 [42.0-79.0]	68.5 [45.0-79.0]	**0.023****
Gender‡			
Female	16 (30.8)	25 (43.1)	0.255***
Male	36 (69.2)	33 (56.9)	
Height (cm)†	170.1±8.9	168.7±10.2	0.460*
Weight (kg)†	82.4±11.1	79.6±13.3	0.231*
Body mass index (kg/m^2)†	28.4±2.6	27.9±3.5	0.368*
Body surface area (m^2)†	1.9±0.2	1.9±0.2	0.250*
Ejection Fraction (%)§	50.0 [40.0-60.0]	50.0 [40.0-60.0]	0.925**
Pulmonary Artery Pressure (mmHg)§	30.0 [20.0-57.0]	30.0 [18.0-45.0]	0.325**
Type of surgery‡			
Coronary artery bypass graft surgery	35 (67.3)	30 (51.7)	0.294***
Isolated valve surgery	5 (9.6)	14 (24.1)	
Beating coronary artery bypass graft surgery	6 (11.5)	6 (10.3)	
Combined surgery	3 (5.8)	5 (8.6)	
Others	3 (5.8)	3 (5.2)	
Duration of surgery (min)§	221.5 [175.0-323.0]	257.0 [181.0-342.0]	**0.009****
Duration of perfusion (min)†	104.3±18.8	100.8±14.0	0.275*
Duration of aortic cross clamp (min)†	70.9±13.9	66.7±14.3	0.127*
Number of total drains§	2.0 [1.0-3.0]	2.0 [1.0-3.0]	0.978**
Intraoperative remifentanil consumption (mcg/min)†	10.0±1.1	9.8±0.8	0.419**

‡: n (%), †: mean ± standard deviation, §: median [min-max]. *: Independent Samples *t*-test. **: Mann-Whitney U test. ***: Pearson Chi-Square, Fisher's Exact/Fisher Freeman Halton test. ESPB: Erector spinae plane block.

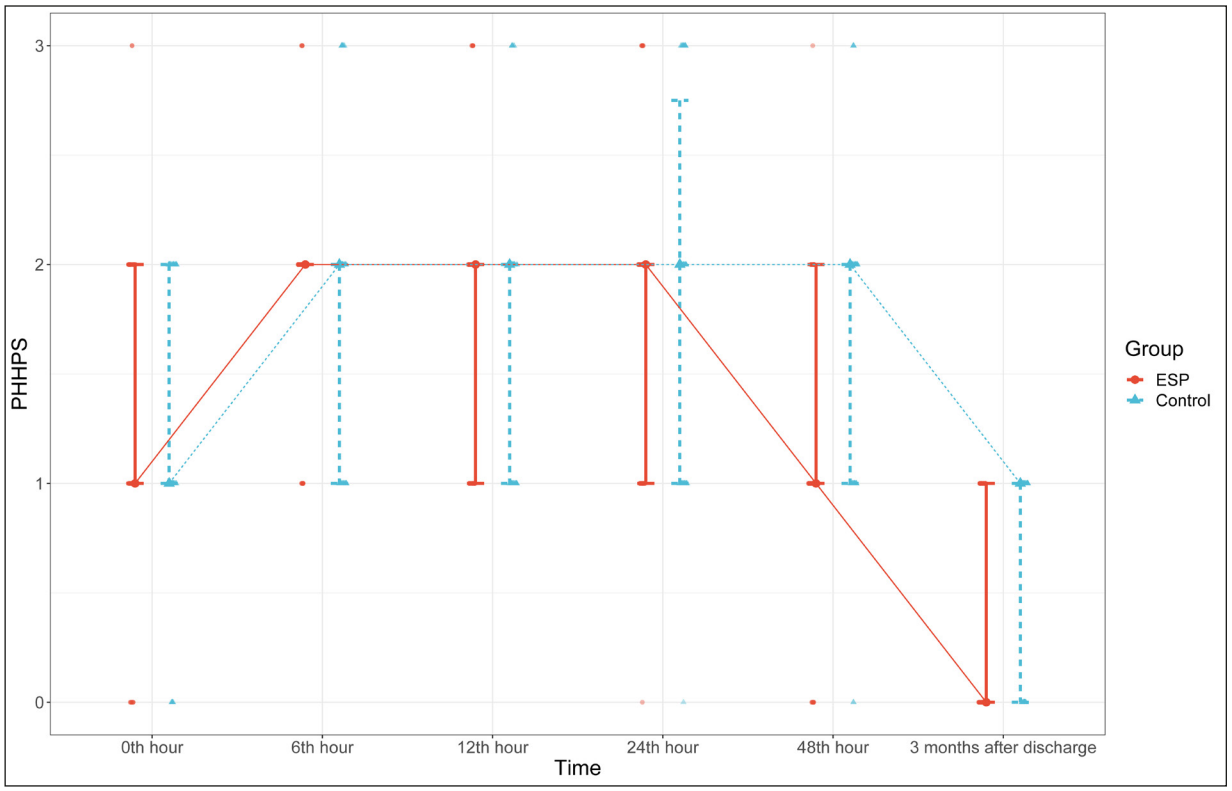

Figure 3. The figure depicts PHHPS pain scores at the immediate, 6 h, 12 h, 24 h, 48 h after extubation and 3 months after discharge.

Table II. The comparison of NRS and PHHPS of the study groups.

	ESP (n=52)	Control (n=58)	*p*-value *p****	Covariate (age) *p****	Covariate (duration of surgery)
NRS§					
Immediate after extubation (0th hour)	4.0 [1.0-8.0]	4.0 [0.0-6.0]	0.345*	-	-
6th hour	4.0 [2.0-6.0]	4.0 [2.0-8.0]	0.916*	-	-
12th hour	4.0 [2.0-7.0]	4.0 [3.0-8.0]	0.208*	-	-
24th hour	4.0 [2.0-7.0]	4.0 [3.0-7.0]	0.098*	-	-
48th hour	4.0 [1.0-6.0]	4.0 [2.0-6.0]	**0.001***	**0.029**	**<0.001**
3 months after discharge	1.0 [0.0-4.0]	3.0 [0.0-4.0]	**<0.001***	**0.003**	**0.041**
PHHPS§					
Immediate after extubation (0th hour)	1.0 [0.0-3.0]	1.0 [0.0-2.0]	0.716*	-	-
6th hour	2.0 [1.0-3.0]	2.0 [1.0-3.0]	0.262*	-	-
12th hour	2.0 [1.0-3.0]	2.0 [1.0-3.0]	0.822*	-	-
24th hour	2.0 [0.0-3.0]	2.0 [0.0-3.0]	0.929*	-	-
48th hour	1.0 [0.0-3.0]	2.0 [0.0-3.0]	**0.001***	**0.035**	**<0.001**
3 months after discharge	0.0 [0.0-1.0]	1.0 [0.0-1.0]	**0.025***	0.1761	**0.015**

‡: n (%), †: mean ± standard deviation, §: median [min-max]. *: Independent Samples *t*-test. **: Mann-Whitney U test. ***: Pearson Chi-Square, Fisher's Exact/Fisher Freeman Halton test. ESPB: Erector spinae plane block.

Table III. The comparison of postoperative outcomes of the study groups.

	ESPB (n=52)	Control (n=58)	*p*
Nausea/vomiting‡	37 (71.2)	33 (56.9)	0.176**
Oral intake time (min)§	320.0 [180.0-505.0]	355.0 [180.0-520.0]	0.886*
ICU stay (day)§	3.0 [2.0-7.0]	3.0 [2.0-8.0]	0.820*
Discharge (day)§	9.0 [6.0-15.0]	9.0 [6.0-15.0]	0.379*
Requirement for rescue analgesics‡			
2nd hour	4 (7.7)	7 (12.1)	0.656**
4th hour	7 (13.5)	8 (13.8)	0.999**
6th hour	3 (5.8)	9 (15.5)	0.183**
12th hour	9 (17.3)	10 (17.2)	0.999**
24th hour	10 (19.2)	17 (29.3)	0.315**
48th hour	4 (7.7)	9 (15.5)	0.330**

‡: n (%), §: median [min-max]. *: Mann-Whitney U test. **: Pearson Chi-Square or Fisher's Exact test. ESPB: Erector spinae plane block.

this study were assessed at the 0th, 6th, 12th,24th, and 48th hour after extubation. Consequently, NRS and PHHPS pain scores were found to be lower, albeit not significant, in the ESPB group than in the control group during the first 24 hours after extubation, and this difference reached a significant level in the case of pain scores assessed at the 48th hour after extubation. The absence of a significant difference between the groups in pain scores during the first 24 hours after extubation might be attributed to the routine analgesia protocols and single-dose administration of ESPB. Then again, the significantly lower pain scores assessed at the 48th hour after extubation could be attributed to the regimen that was used, which comprised bupivacaine, lidocaine, and dexamethasone. It is possible that this regimen provided analgesia along with less edema contributing to lower pain scores at the 48th hour postoperatively.

In a study[20] that assessed the quality of life and chronic postsurgical pain six months after mini-thoracotomy mitral valve surgery according to the type of analgesia patients received for postoperative pain control, Toscano et al[20] reported no significant difference in the chronic pain scores assessed at the 6-month follow-up, between the 26 patients who received morphine, an opioid, 37 patients who received continuous SAPB and 37 patients who re-

ceived ESPB. Wiechet al[21] reported that EPSB lowered chronic postsurgical pain at the 1st, 3rd, and 6th months postoperatively in patients who underwent coronary artery bypass grafting compared to control subjects. Similarly, in this study, a significant decrease was observed in the 3rd-month NRS and PHHPS scores in the ESPB group compared to control, suggesting that better pain control could be achieved in a chronic state with better acute phase pain control and better recovery.

In a prospective randomized controlled study[22] conducted with 106 open heart surgery patients, of whom 53 received USG-guided bilateral ESPB (experimental group) and 53 received 1 g of paracetamol every 6 hours and 50 mg of tramadol every 8 hours (control group), Krishna et al[22] reported that fentanyl requirement, extubation time, oral intake time, ambulation time, and LoS in ICU were significantly lower in the experimental group than in the control group. In another study, Oğur et al[23] found that bilateral preoperative ESPB reduced opioid requirement compared to stand-alone use of intravenous morphine, providing better pain control and postoperative recovery. In contrast, there was no significant difference between the experimental and control groups included in this study in terms of the total dose of remifentanil, oral intake time, and LoS in the ICU. The differences between our analysis and those studies[22,23] might be attributed to the type of surgery, the fundamental characteristics of the patients, and the clinical management policy.

Potential risk factors for chronic pain after cardiac surgery include type and duration of surgery and the technique used in the surgery as well as young age, female gender, obesity, the presence of preoperative pain, and reoperation[24,25]. The ESPB group was younger than the control group. However, the postoperative pain scores in the ESPB group were significantly lower than those in the control group after these scores were adjusted for age and duration of surgery. These findings indicated that ESPB has a positive effect on postoperative pain scores irrespective of patients' age and the duration of surgery.

Limitations of the Study

Apart from the fact that NRS and PHHPS were used for chronic pain assessment at the postoperative 3rd month, which might be deemed a strength of this study, the study's retrospective design and the heterogeneity of the surgery types might be deemed the study's primary limitations. The fact that the duration of the surgery was different between the groups due to the resident training carried out in the tertiary hospital where this study was conducted could be considered another limitation of the study if covariate adjustment analysis had not revealed that the duration of surgery did not have a significant effect on pain scores.

Conclusions

In conclusion, although ESPB provided no significant difference on postoperative clinical course, it seems beneficial on reducing postoperative 48 h pain scores and also could decrease chronic pain after cardiac surgeries.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Acknowledgements

None.

Ethics Approval

The study protocol was approved by the Ethics Committee of Necmettin Erbakan University Meram Faculty of Medicine prior to the conduct of the study (Approval Number: 2020/2961).

Informed Consent

Informed consent was obtained from each patient included in the study.

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Authors' Contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by MSYüce and G Sarkılar. The first draft of the manuscript was written by MSYüce. G Sarkılar, A Kılıçarslan, Y Dereli, Ş Özyürek and A Tavlan reviewed and edited previous versions of the manuscript. All authors read and approved the final manuscript.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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