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Analgesic effects of thoracic fascial plane blocks in postoperative pain management following cardiac surgery with sternotomy: a retrospective study

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ABSTRACT

Aims: Acute poststernotomy pain is very severe and causes adverse hemodynamic disturbances. Various thoracic fascial plane blocks are used in the management of this pain. This study aimed to compare the analgesic effects of conventional analgesic methods and thoracic fascial plane blocks in the treatment of post-sternotomy pain.

Methods: Patients aged over than 18 years and with American Society of Anesthesiologists (ASA) physical status I-II-III who underwent elective cardiac surgery with sternotomy in 2022-2023 were included in this retrospective study. Patient records were categorized into groups based on the regional analgesia preferences applied. The groups are as follows: Group I: Patients without any blocks. Group II: Patients who received parasternal block (PSB). Group III: Patients who received serratus anterior plane block (SAPB). Group IV: Patients who received erector spinae plane block (ESPB). Then, the patients' demographic data, laboratory data, Behavioral Pain Score (BPS) values, Visual Analog Scale (VAS) values, and additional analgesia needs were recorded and compared.

Results: The files of 128 patients were included in the study. The patients are statistically similar in terms of demographic data and surgical characteristics. Remifentanil consumption, BPS values, VAS values, and the need for additional analgesia were statistically lower in the groups in which thoracic fascial plane blocks were applied compared to the group in which conventional analgesia was applied.

Conclusion: As a result, thoracic fascial plane blocks, which have been used increasingly frequently in recent years, can provide more effective analgesia than conventional analgesia methods in cardiac surgery. Additionally, considering enhanced recovery after surgery protocols, these blocks may reduce undesirable side effects by limiting the need for opioids in the perioperative period. Since PSB and SAPB can be applied in the supine position, they may be more advantageous than ESPB in terms of ease of application.

Keywords: Acute pain, cardiac surgery, erector spinae plane block, parasternal block, serratus anterior plane block, thoracic fascial plane blocks

INTRODUCTION

Acute postoperative pain following sternotomy in cardiac surgery should be appropriately treated to prevent adverse hemodynamic outcomes and pulmonary complications. In the era of fast-track management, an adequate and effective postoperative analgesic technique facilitates early extubation, mobilization, and discharge from the intensive care unit.[1] Additionally, if postoperative acute pain is not adequately addressed, chronic pain may develop after sternotomy, hindering patients from recovering their normal activities for an extended period.[2]

After sternotomy, various thoracic fascial plane blocks can be employed in the treatment of acute pain. One of these blocks, Erector Spinae Plane Block (ESPB), was described by Forero et al.[3] in 2016. ESPB involves the administration of a local anesthetic solution, which not only blocks the dorsal branches of the spinal nerve but also disperses into the paravertebral and epidural spaces.[4] Moreover, the targeted point is distant from the pleura and neuroaxial plane, reducing the risk of complications.[5] Another thoracic fascial plane block used in the treatment of acute pain after sternotomy is the Serratus Anterior

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Plane Block (SAPB).[6] Although there is no randomized controlled study on SAPB application in adults due to the lack of innervation of the sternum, SAPB can have an analgesic effect on surrounding tissues related to drain pain and sternal retraction.[7] As a result, it may reduce patients' pain levels and limit morphine consumption.[7] SAPB can be performed below, above, or both below and above the serratus anterior muscle.[8,9] Another block used in the treatment of acute pain after sternotomy is the parasternal block application.[10] For PSB application, a local anesthetic solution is administered into the interfascial space between the pectoralis major and intercostal muscles at the second and fourth intercostal space levels.[11] Despite all these regional methods, in some cases (such as patient consent or infection in the block area), patients are treated solely with intravenous analgesics.

The hypothesis of this study is that effective postoperative analgesia can be provided with thoracic fascial plane blocks applied before cardiac surgery. This study aims to compare the postoperative analgesic effects of different analgesic preferences applied to patients undergoing cardiac surgery at our clinic.

METHODS

This study was retrospectively designed and received approval from the Bilkent City Hospital Ethics Committee (Date: 13.12.2023, Decision No: E.Kurul-E1-23-4389). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki. Patients aged 18 and over, with American Society of Anesthesiologists (ASA) physical status of I-II-III, who underwent elective cardiac surgery with sternotomy in 2022 and 2023, were included in the study. Patients under 18 years of age, those with ASA scores of IV and above, those who did not undergo sternotomy, those who underwent emergency interventions, and those with missing data in their medical records were excluded from the study.

Patient records were categorized into groups based on the regional analgesia preferences applied. The groups are as follows:

- Group I: Patients without any blocks.
- Group II: Patients who received PSB
- Group III: Patients who received SAPB.
- Group IV: Patients who received ESPB.

The age, body mass index (BMI), sex, ASA physical status, type of surgery performed, smoking status, preoperative White blood cells (WBC), Neutrophil-Lymphocyte ratio (N/L) values, anesthesia duration, intraoperative remifentanil consumption, preoperative arterial lactate value, postoperative arterial lactate value, intraoperative maximum glucose values, extubation durations, postoperative side effect incidents of the patients, and first and second postoperative day Behavioral Pain Score (BPS) values, Visual Analog Scale (VAS) values, and additional analgesia needs, were recorded and compared.

According to the protocol implemented in our department, anesthesia induction involved propofol (1.5-2 mg kg^{-1}), fentanyl (1-2 µg kg^{-1}), and rocuronium (0.5-1 mg kg^{-1}) after preoxygenation. Anesthesia was maintained with sevoflurane and a remifentanil infusion (0.05-0.25 µg kg^{-1} min^{-1}) while monitoring the bispectral index to maintain it within the range of 40-50. At the end of the surgery, all groups received 1 gram of acetaminophen and 1 mg kg^{-1} of intravenous tramadol before being transferred to the intensive care unit. It was observed that a standard anesthesia technique and postoperative care protocol were applied to all groups. Then, analgesics were administered based on pain scores reported in the intensive care unit. In all groups, if the VAS score 4 and exceeded 4, the initial treatment involved administering acetaminophen (10 mg kg^{-1}) and tramadol (1 mg kg^{-1}). Following this, either morphine (0.5 mg kg^{-1}) or fentanyl (1 µg kg^{-1}) was added as needed.

Additionally, based on the patient's consent and the anesthetist's preference, various thoracic fascial plane blocks were administered to patients using a linear ultrasound probe and a 21-G Pajunk needle, following this protocol.

The PSB procedure was performed under general anesthesia, in the supine position, following the induction of anesthesia. For the PSB, a local anesthetic solution of 10 mL of 0.25% bupivacaine (for each level) was administered into the interfascial space between the pectoralis major and intercostal muscles, approximately 2 cm lateral to the midline, at the levels of the 2nd and 4th intercostal spaces. The block was performed bilaterally with 40 mL of 0.25% bupivacaine.

The SAPB procedure was also performed under general anesthesia, in the supine position, following the induction of anesthesia. For the SAPB, a local anesthetic solution of 20 mL of 0.25% bupivacaine (for each side) was administered along the midaxillary line, at the level of the 4th or 5th rib, above the serratus anterior muscle and below the latissimus dorsi muscle. The block was performed bilaterally with 40 mL of 0.25% bupivacaine.

The ESPB procedure was performed in a seated position during the preoperative period, prior to general anesthesia. For the ESPB, a local anesthetic solution of 20 mL of 0.25% bupivacaine (for each side) was administered below the erector spinae muscle, at the level of the transverse process of thoracic 5. The block was performed bilaterally with 40 mL of 0.25% bupivacaine.

Statistical Analysis

Data analyses were performed by using SPSS for Windows, version 22.0 (SPSS Inc., Chicago, IL, United States). Whether the distribution of continuous variables was normal or not was determined by the Kolmogorov Smirnov test. Levene test was used for the evaluation of homogeneity of variances. Unless specified otherwise, continuous data were described as mean±SD for normal distributions, and median (Q_1;25. Persentile-Q_3;75. Persentile) for skewed distributions. Categorical data were described as a number of cases (%). Statistical analysis differences in normally distributed variables between the independent groups were compared by One Way Anova Test, Kruskal Wallis Test was applied for comparisons of the not normally distributed data. The Conover-Iman test was used for binary comparisons among the groups. Categorical variables were compared using Pearson's Chi-Square Test or Fisher's Exact Test. İt was evaluated degrees of relation between variables with spearman correlation analysis. It was accepted p-value <0.05 as a significant level on all statistical analysis.

RESULTS

The files of 128 patients who underwent cardiac surgery with sternotomy under elective conditions at Ankara Bilkent City Hospital in 2022-2023 and whose data were complete were included in the study. The patients are statistically similar in terms of demographic data and surgical characteristics (**Table 1**).

When the groups were compared in terms of preoperative lactate, postoperative lactate and lactate difference, they were found to be statistically similar (p>0.05). Similarly, no statistical difference was found between the groups in terms of glucose level, WBC, Neutrophil, lymphocyte and N/L (p>0.05). Finally, extubation times were found the shortest in the ESPB group and the longest in the control group, but no statistical difference was found (p>0.05) (**Table 2**).

When the groups were compared in terms of remifentanil consumption in the intraoperative period, a statistically significant difference was found. Remifentanil consumption was found to be lower in

Table 1. Demographic and surgical characteristics of the patients

	Group I (n:54)	Group II (n:21)	Group III (n:20)	Group IV (n:34)	p
Sex					0.261 $^{\Phi}$
Female	14 (25.9%)	10 (47.6%)	5 (25.0%)	12 (36.4%)	
Male	40 (74.1%)	11 (52.4%)	15 (75.0%)	21 (63.6%)	
Age (year)	59.5 (53.0-66.0)	62.0 (45.0-66.0)	56.5 (1.5-64.0)	61.0 (59.0-67.0)	0.272 $^{\beta}$
BMI kg/m²	26.74±4.77	27.84±5.38	27.84±3.87	27.04±3.70	0.700*
ASA	3.0 (2.0-3.0)	3.0 (2.0-3.0)	2.0 (2.0-3.0)	3.0 (2.0-3.0)	0.603 $^{\beta}$
Smoking	21 (38.9%)	10 (47.6%)	12 (60.0%)	12 (36.4%)	0.320 $^{\Phi}$
Surgery type					0.077 $^{\Phi}$
CABG	23 (42.6%)	4 (19.0%)	11 (55.0%)	17 (51.5%)	
Valve replacement	26 (48.1%)	16 (76.2%)	8 (40.0%)	11 (33.3%)	
CABG+ valve replacement	5 (9.3%)	1 (4.8%)	1 (5.0%)	5 (15.2%)	
Anesthesia duration (min)	320 (285-375)	320 (295-395)	315 (257.5-355)	310 (270-435)	0.826 $^{\beta}$

Continuous variables are expressed as either the mean±standard deviation (SD) or median (Q1-Q3) and categorical variables are expressed as either frequency (percentage).
One way anova Test *. Kruskal wallis Test Φ. Chi square Test β
p=Level of Significance. p<0.05. ASA: American Society of Anesthesiologists, BMI: Body Mass Index, CABG: Coronary artery bypass graft

Table 2. Comparison of groups in terms of lactate, glucose, extubation time, WBC, neutrophil, lymphocyte, N/L ratio

	Group I (n:54)	Group II (n:21)	Group III (n:20)	Group IV (n:34)	p
Lactate-pre (mmol/L)	1.16 (0.89-1.43)	1.26 (0.70-1.39)	1.16 (1.03-1.69)	1.17 (0.89-1.37)	0.827 $^{\Phi}$
Lactate-post (mmol/L)	2.56 (1.79-3.65)	2.13 (1.71-3.45)	2.57 (1.69-3.39)	2.33 (1.60-3.03)	0.353 $^{\Phi}$
Lactate (delta)	1.40 (0.80-2.48)	1.02 (0.63-2.29)	1.08 (0.47-2.12)	1.13 (0.58-1.73)	0.324 $^{\Phi}$
Glucose (mg/dL) (max)	182.2±50.3	177.7±40.5	191.4±64.3	171.4±38.5	0.518*
Extubation time (min)	480 (405-580)	450 (360-490)	427 (387-562)	390 (330-495)	0.106 $^{\Phi}$
WBC ($\times 10^9$/L)	7.53 (6.16-9.02)	7.25 (5.96-8.47)	7.65 (6.84-9.37)	6.70 (5.94-8.91)	0.793 $^{\Phi}$
Neutrophil ($\times 10^9$/L)	4.92 (3.58-6.10)	4.50 (3.48-5.53)	4.52 (3.63-6.13)	4.39 (3.34-5.70)	0.830 $^{\Phi}$
Lymphocyte ($\times 10^9$/L)	1.90 (1.40-2.30)	1.78 (1.53-2.29)	2.14 (1.67-2.81)	1.87 (1.36-2.31)	0.387 $^{\Phi}$
N/L ratio	2.74 (1.96-3.42)	2.27 (1.86-3.42)	1.99 (1.52-2.99)	2.58 (1.94-2.90)	0.379 $^{\Phi}$

Continuous variables are expressed as either the mean±standard deviation (SD) or median (Q1-Q3).
One Way Anova Test *. Kruskal Wallis Test Φ. p=Level of Significance. p<0.05
Conover-Inman Test was performed for the binary comparisons among the groups and the p value was set at 0.05. Significant differences were found between; a: Group I vs Group II, b: Group I vs Group III, c: Group I vs Group IV. N/L: Neutrophil/Lymphocyte. WBC: White blood cells

all block groups than in the control group (p<0.001). When the groups were compared in terms of BPS on the zero and first postoperative days, a statistically significant difference was found. BPS levels were found to be lower in all block groups than in the control group (p<0.001). When the groups were compared in terms of VAS scores on the zero and first postoperative days, a statistically significant difference was found. VAS scores were found to be lower in all block groups than in the control group (p<0.001). Similarly, A statistically significant difference was found when the groups were compared in terms of additional analgesia needs on the zero and first postoperative days. Additional analgesia needs were found to be lower in all block groups than in the control group (p<0.001). When the groups were compared in terms of side effects, only nausea was observed, but no statistically significant difference was found (**Table 3**).

DISCUSSION

The study results have demonstrated that in patients undergoing CABG, valve replacement, and the combined procedures, ESPB, SAPB, and PSB provided effective analgesia in the early postoperative period compared to those without thoracic fascial plane block. Although not statistically significant, the reduction in intraoperative remifentanil consumption, especially in the ESPB group, suggests that ESPB may contribute to a more stable intraoperative anesthesia management. On the other hand, the lack of a need for additional patient positioning and the ability to be applied after anesthesia induction make PSB and SAPB more advantageous, especially in this patient group highly sensitive to stress, compared to ESPB.

In addition to the stress factors arising from the compromised clinical condition present in patients undergoing cardiac surgery, the severe pain resulting from the surgical procedure itself can further complicate this stress response. Therefore, comprehensive perioperative pain management is crucial in preventing these stress factors and subsequently avoiding complications. In recent years, protocols for enhancing postoperative recovery, known as Enhanced Recovery After Surgery (ERAS), have become essential practices in various disciplines and have also gained significant importance in cardiac surgery.[12,13] The perioperative analgesic approach, a crucial parameter in ERAS protocols, not only suppresses the stress response but also facilitates conditions that accelerate postoperative recovery, such as the ability to breathe comfortably, sufficient coughing, and early mobilization. This approach is highly significant in limiting complications and ensuring early discharge by promoting a faster recovery in the postoperative period.[14,15] In our clinic, in accordance with these goals, consenting patients receive regional analgesia treatments in addition to conventional analgesic therapies as part of multimodal analgesia. The utilization of these regional analgesic treatments has resulted in lower intraoperative remifentanil consumption compared to patients receiving conventional analgesia.

Perioperative pain management aims to achieve both more effective analgesia with the concurrent use of multiple methods, involving drugs with different mechanisms, and the reduction of side effects by using lower doses. Particularly in cardiac surgery, limiting the consumption of systemic opioids, which provide effective analgesia, becomes even more critical through multimodal analgesia. Regional analgesia applications, as a significant component of multimodal analgesia, play a crucial role in significantly limiting opioid consumption and effectively minimizing opioid-related side effects.[16,17] In thoracic surgery, thoracic fascial plane blocks have been demonstrated to be applied either individually or in combination, thereby increasing their effectiveness.[8,9,18] In our clinic, although some patients receive combined blocks in this manner, the patients included in the study underwent a single thoracic fascial plane block.

Table 3. Comparison of groups in terms of pain scores, additional analgesia needs and side effects

	Group I (n:54)	Group II (n:21)	Group III (n:20)	Group IV (n:34)	p
Remifentanil consumption (mg)	4.5 (4.0-5.0)	2.5 (2.0-3.0)	3.0 (2.0-3.25)	2.5 (2.0-3.0)	<0.001 $^{\Phi\ a.b.c}$
BPS 1	5.0 (5.0-6.0)	3.0 (3.0-4.0)	3.5 (3.0-4.5)	3.00 (3.0-3.0)	<0.001 $^{\Phi\ a.b.c}$
BPS 2	4.0 (4.0-5.0)	3.0 (3.0-3.0)	3.0 (3.0-4.0)	3.00 (3.0-3.0)	<0.001 $^{\Phi\ a.b.c}$
VAS 1	5.0 (4.0-5.0)	2.0 (2.0-3.0)	3.0 (2.0-3.5)	1.00 (1.0-2.0)	<0.001 $^{\Phi\ a.b.c}$
VAS 2	4.0 (3.0-4.0)	2.0 (2.0-2.0)	1.5 (1.0-3.0)	1.00 (1.0-2.0)	<0.001 $^{\Phi\ a.b.c}$
Additional analgesic 1	43 (79.6%)	1 (4.8%)	5 (25.0%)	-	<0.001 $^{\beta\ a.b.c}$
Additional analgesic 2	28 (51.9%)	1 (4.8%)	2 (10.0%)	-	<0.001 $^{\beta\ a.b.c}$
Nausea	15 (27.8%)	4 (19.0%)	2 (10.0%)	5 (15.2%)	0.338 $^{\beta}$

Continuous variables are expressed as either the median (Q1-Q3) and categorical variables are expressed as either frequency (percentage).
Kruskal Wallis Test Φ. Chi Square Test β p=Level of Significance. p<0.05
Conover-Inman Test was performed for the binary comparisons among the groups and the p value was set at 0.05. Significant differences were found between; a: Group I vs Group II, b: Group I vs Group III, c: Group I vs Group IV. 1: first day, 2: second day, BPS: Behavioral Pain Score, VAS: Visual Analog Scale.

For years, thoracic epidural applications, considered the gold standard, have been limited in cardiac surgery due to the potential catastrophic complication of epidural hematoma associated with intensive anticoagulant use. In recent years, the increasingly widespread use of thoracic fascial plane blocks aims to prevent these complications.[19] However, uncertainties still exist regarding their effectiveness and mechanisms. While studies have been conducted on various plane blocks in cardiac surgery, these studies often compare a control group with two different blocks.[7,13,20] In our clinic, while conventional analgesia methods are used for every patient, fascial blocks are increasingly being incorporated in addition to conventional analgesic treatments. As observed in the study results, all three plane blocks have provided a significant analgesic effect. Moreover, it is noteworthy that all three methods resulted in lower pain scores and less remifentanil consumption compared to conventional analgesia methods.

Application of thoracic fascial plane blocks before surgical incision may also limit opioid consumption during the intraoperative period.[21] As a result, it may also reduce opioid-related side effects. In this study, all blocks were performed before surgical incision. Unlike PSP and SAPB, ESPB was applied in a sitting position before anesthesia induction. Due to difficulties in positioning after anesthesia induction and at the end of surgery, ESPB was applied before anesthesia induction. Although ESPB was applied with sedo-analgesia in this patient group, the bilateral application of ESPB may not be practically feasible in clinical practice for cardiac surgery patients, where stress and its undesirable effects are quite common. In our study, intraoperative opioid consumption was found to be similar in the ESPB, PSB, and SAPB groups. Additionally, intraoperative opioid consumption in these three groups was lower compared to conventional analgesia. Despite showing similar analgesic efficacy, considering ease of application, SAPB and PSB may be more practical in clinical practice.

Complex mechanisms are involved in lactate elevation during and after cardiac surgery. The increase in lactate is generally multifactorial, and these factors may vary from patient to patient and even change over time in individual patients.[22] Among these factors, anesthesia and analgesia preferences play a role. Surgical stress response and, consequently, lactate levels can be kept at lower levels based on anesthesia preferences.[23] In our study, despite different analgesia preferences, lactate levels were found to be similar in all groups. This situation may arise due to the influence of multiple factors on lactate levels.

In recent years, inflammatory parameters have been used for various predictive purposes. A high N/L ratio in the preoperative period has been noted to be associated with high postoperative pain scores and analgesic consumption.[24-26] The preoperative Neutrophil, Lymphocyte, and N/L ratios of the patients included in our study were similar among the groups. Therefore, it can be stated that these markers did not affect the postoperative pain status as the groups were similar in terms of inflammatory parameters in the preoperative period.

Limitations

This study has certain limitations. Firstly, it is a single-center and retrospective study. Secondly, due to the retrospective analysis of data, there is no homogeneous distribution. This lack of homogeneity limits a clearer assessment of the results. Lastly, the evaluation of basic laboratory parameters may not provide conclusive results in assessing surgical stress response. Comprehensive prospective randomized studies in this regard may yield better results regarding the effectiveness of thoracic fascial plane blocks.

CONCLUSION

Thoracic fascial plane blocks, increasingly utilized in recent years, may provide more effective analgesia compared to conventional analgesic methods. Furthermore, ERAS protocols, these blocks can limit opioid requirements during the perioperative period, reducing unwanted side effects. The advantages of PSB and SAPB, such as not requiring additional patient positioning and being applied after anesthesia induction, may make them more advantageous, especially in this patient group, which is highly sensitive to stress, compared to ESPB. More comprehensive prospective studies comparing these blocks could provide explanatory results.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study protocol was approved by the Ankara Bilkent City Hospital Ethics Committee (Date: 13.12.2023, Decision No: E.Kurul-E1-23-4389).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper and that they have approved the final version.

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