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Evaluation of Anesthetic Management and Clinical Outcomes in Minimally Invasive Cardiac Surgery: A Retrospective Single-Center Study

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Abstract:

Objective: Minimally invasive cardiac surgery (MICS) has gained increasing popularity due to reduced surgical trauma and enhanced recovery protocols. However, data focusing on anesthetic management and postoperative clinical outcomes, particularly from Turkiye, are limited. This study aimed to retrospectively evaluate anesthetic approaches and postoperative outcomes in patients undergoing minimally invasive cardiac surgery at a single tertiary center.

Methods: This retrospective, exploratory observational study included adult patients who underwent minimally invasive cardiac surgery between January 1, 2020, and September 30, 2025 at our hospital. Demographic characteristics, perioperative anesthetic management, intraoperative variables, postoperative outcomes and complications were analyzed. Fascial plane block–based analgesia was compared with intravenous analgesia regarding extubation time, analgesic requirements, and length of hospital stay. Risk factors for postoperative complications were evaluated using univariate and multivariate logistic regression analyses.

Results: A total of 33 patients were included in the analysis, with a mean age of 56.2±11.9 years; 75.8% were male. The most common procedures were minimally invasive coronary artery bypass grafting (42.4%) and aortic valve replacement (27.3%). Fascial plane blocks were applied in 66.7% of patients and were associated with reduced need for rescue analgesia (36.4% vs. 100%, P<0.001), earlier extubation (P=0.014), and shorter hospital stay (P=0.038), although considerable inter-patient variability was observed. Postoperative complications occurred in 42.4% of patients, with delirium (18.2%) and pneumonia (12.1%) being the most frequent. Diabetes mellitus, smoking, and prolonged cardiopulmonary bypass duration were associated with increased postoperative complication risk. In multivariate analysis, smoking remained an independent predictor of postoperative complications.

Conclusion: In this exploratory single-center study, minimally invasive cardiac surgery was performed safely in appropriately selected patients. Fascial plane block–based analgesia was associated with improved postoperative recovery. These preliminary findings warrant validation in larger, prospective studies. Preoperative optimization may further enhance outcomes.

Keywords: Minimally Invasive Cardiac Surgery, Anesthetic Management, Fascial Plane Block, Enhanced Recovery After Surgery, Postoperative Outcomes

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The preference for minimally invasive surgical techniques has increased with the implementation of enhanced recovery after surgery (ERAS) protocols aimed at accelerating postoperative recovery and optimizing perioperative outcomes. In the field of cardiac surgery, recent advancements in technology and surgical techniques have led to the development and widespread adoption of alternative approaches to conventional open surgery. Minimally invasive cardiac surgery (MICS) is defined as surgical intervention on the cardiac structures without the need for full median sternotomy or through limited incisions [1, 2]. When appropriate patient selection and sufficient surgical expertise are ensured, this approach may offer several advantages, including reduced surgical trauma, decreased blood loss, accelerated postoperative recovery, improved cosmetic outcomes, shorter hospital and intensive care unit stays, reduced healthcare costs, and earlier mobilization [3, 4]. Nevertheless, the successful implementation of these techniques requires specialized equipment and considerable surgical experience.

Minimally invasive cardiac surgery encompasses a variety of approaches, including right anterior thoracotomy, left anterior mini-thoracotomy, partial sternotomy, ministernotomy, and video-assisted minimally invasive (port-access) cardiac surgery. These techniques have been successfully applied in a wide range of procedures, particularly mitral valve surgery, aortic valve replacement, atrial septal defect repair, and coronary artery bypass grafting (CABG) [5, 6].

From an anesthetic perspective, MICS presents distinct challenges compared with conventional cardiac surgery. The frequent need for one-lung ventilation, alternative patient positioning, peripheral cannulation strategies, and the increased role of transesophageal echocardiography (TEE) necessitate the development of procedure-specific anesthetic management strategies by the anesthesia team [7].

Postoperative pain management represents another critical aspect of perioperative care in MICS. Thoracotomy-based approaches may result in a different pain profile compared with median sternotomy due to irritation of the intercostal nerves. Consequently, regional anesthesia techniques, multimodal analgesia protocols, and early mobilization strategies play a pivotal role in optimizing postoperative recovery and improving patient comfort [8, 9].

Although the surgical outcomes of minimally invasive cardiac surgery have been widely reported in the literature, data focusing on anesthetic management and detailed postoperative clinical outcomes are limited. In particular, published data from Turkey are scarce, and there is a need for further studies to support the development of standardized anesthetic protocols tailored to minimally invasive cardiac procedures.

The aim of this study was to retrospectively evaluate anesthetic management strategies and postoperative clinical outcomes in patients undergoing minimally invasive cardiac surgery at our institution between January 1, 2020, and September 30, 2025. Specifically, we analyzed perioperative anesthetic approaches, complications, intensive care parameters, and in-hospital morbidity and mortality in patients undergoing MICS.

METHODS

Study Design and Patient Population

This retrospective study was conducted at the Department of Cardiovascular Surgery, Bursa Yuksek Ihtisas Training and Research Hospital. All adult patients aged between 18 and 80 years who underwent minimally invasive cardiac surgery between January 1, 2020, and September 30, 2025, were included. Given the small sample size and heterogeneous surgical procedures, this study should be considered exploratory and hypothesis-generating rather than confirmatory in nature.

Inclusion and Exclusion Criteria

Inclusion criteria were as follows:

- Age ≥18 years
- Patients who underwent minimally invasive cardiac surgery using one of the following approaches:
    - -Right or left anterior/anterolateral mini-thoracotomy
    - -Partial upper hemisternotomy (J-sternotomy)
    - -Ministernotomy
    - -Video-assisted minimally invasive (port-access) cardiac surgery

Exclusion criteria included:

•Patients younger than 18 years

•Conversion to conventional open surgery via median sternotomy

•Incomplete or insufficient medical records

Data Collection

Data were collected retrospectively from the hospital electronic medical record system, anesthesia charts, operative reports, and intensive care unit follow-up forms. A standardized data collection form was used to ensure consistency.

Preoperative Variables

The following preoperative variables were recorded: Demographic characteristics (age, sex, height, weight, body mass index)

•American Society of Anesthesiologists (ASA) physical status classification

•EuroSCORE II

•Comorbidities including: hypertension, diabetes mellitus, chronic obstructive pulmonary disease, peripheral arterial disease, chronic kidney disease and history of cerebrovascular disease

•Cardiac evaluation parameters including: Left ventricular ejection fraction (%)

Intraoperative Variables

Surgical Variables

•Type of surgical procedure:

-Isolated mitral valve surgery

-Isolated aortic valve surgery

-Combined valve procedures

-Atrial or ventricular septal defect repair

-Minimally invasive coronary artery bypass grafting (CABG)

-Cardiac tumor excision

•Use of cardiopulmonary bypass (CPB)

•Duration of CPB (minutes)

•Aortic cross-clamp time (minutes)

•Total operative time (minutes)

Anesthetic Management

Airway management strategies included single- or double-lumen endotracheal intubation and, when appropriate, the use of bronchial blockers. Hemodynamic monitoring consisted of invasive arterial blood pressure measurement in all patients. Transesophageal echocardiography (TEE) was used intraoperatively at the discretion of the anesthesia team.

The use and type of regional anesthesia techniques, as well as local anesthetic dosages when applicable, were recorded. Intraoperative analgesic management strategies were documented. Vasoactive medications administered intraoperatively included inotropes (dopamine, dobutamine, epinephrine), vasodilators (nitroglycerin, nitroprusside), and vasopressors (norepinephrine, vasopressin).

The choice between fascial plane block–based analgesia and intravenous analgesia was made at the discretion of the attending anesthesiologist based on institutional practice evolution and individual clinical judgment. No randomization was performed. Fascial plane blocks, when employed, included ultrasound-guided superficial or deep parasternal intercostal blocks, serratus anterior plane blocks, or pectoral nerve blocks, depending on the surgical approach. The local anesthetic agents used were typically 0.25% bupivacaine (20-30 mL per side). Notably, fascial plane block utilization increased over the study period, particularly after 2023, as institutional experience with these techniques grew. This temporal evolution and non-randomized allocation may introduce selection bias and temporal confounding, which should be considered when interpreting comparative outcomes. Transfusion requirements were recorded, including units of packed red blood cells, fresh frozen plasma, platelet concentrates, and cryoprecipitate.

Arterial blood gas parameters—including partial pressure of oxygen (PaO_2), partial pressure of carbon dioxide ($PaCO_2$), pH, lactate levels, and hematocrit—as well as mean arterial pressure (MAP) were measured and recorded at predefined time points: T0 (baseline, after induction), T1 (5 minutes after induction), T2 (initiation of CPB), T3 (hypothermic phase during CPB), T4 (after aortic cross-clamp removal), T5 (weaning from CPB), and T6 (after sternal or thoracic closure).

Postoperative Variables

Postoperative variables included:

•Time to extubation (minutes)

•Requirement for reintubation

•Length of intensive care unit stay (minutes)

•Pain management parameters, including opioid and non-opioid analgesic consumption and need for rescue analgesia

•Requirement and duration of vasoactive drug support

•Postoperative transfusion requirements

Postoperative Complications

Postoperative complications were categorized as follows:

Cardiac Complications:

•New-onset atrial fibrillation
•Ventricular arrhythmias
•Myocardial infarction
•Low cardiac output syndrome
•Pericardial effusion or tamponade

Pulmonary complications:

•Pneumonia
•Pneumothorax
•Prolonged air leak (>5 days)
•Pleural effusion requiring drainage
•Acute respiratory distress syndrome (ARDS)

Neurological complications:

•Stroke
•Transient ischemic attack
•Delirium
•Peripheral nerve injury

Renal complications:

•Acute kidney injury defined according to KDIGO criteria
•Requirement for renal replacement therapy
•Surgical site infection
•Mediastinitis
•Sepsis

Bleeding complications:

•Reoperation for bleeding
•Massive transfusion (>10 units of packed red blood cells)

Clinical Outcomes

Clinical outcomes included time to extubation (minutes), length of hospital stay (days), discharge status (home, rehabilitation facility, or transfer to another hospital), and in-hospital mortality.

Ethical Approval and Patient Confidentiality

The study protocol was approved by the institutional ethics committee (Approval No: 2024-TBEK 2025/09-08, date: 10.09.2025). The study was conducted in accordance with the principles of the Declaration of Helsinki. Due to the retrospective design of the study, informed consent was waived. All patient data were anonymized, and access was restricted to the research team. Data security was ensured in accordance with institutional information security protocols.

Statistical Analysis

Statistical analyses were performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA) or R software (version 4.x). Continuous variables were expressed as mean ± standard deviation or median with interquartile range, as appropriate. Categorical variables were presented as counts and percentages. Normality of data distribution was assessed using the Kolmogorov–Smirnov or Shapiro–Wilk test. Comparisons between different surgical approaches were performed using the Student’s t-test or Mann–Whitney U test for continuous variables and the chi-square test or Fisher’s exact test for categorical variables. Multiple group comparisons were conducted using analysis of variance (ANOVA) or the Kruskal–Wallis test. Risk factors for postoperative complications were evaluated using univariate logistic regression analysis followed by multivariate logistic regression analysis with stepwise backward elimination. Predictors of prolonged intensive care unit and hospital stay were analyzed using linear regression models. Given the limited sample size and number of events, multivariate models were built conservatively, and results should be interpreted with caution regarding potential overfitting. Survival analysis for 30-day mortality was performed using Kaplan–Meier survival curves, and Cox proportional hazards regression analysis was applied when appropriate. A P-value of <0.05 was considered statistically significant.

RESULTS

Between January 1, 2020, and September 30, 2025, data from 33 patients who underwent minimally invasive cardiac surgery were analyzed. The mean age of the patients was 56.18 ± 11.90 years, and the mean body mass index was 26.22±2.06 kg/m². Of the patients, 75.8% were male (n=25) and 24.2% were female (n=8), and 97% were classified as ASA physical status III. Regarding comorbidities, hypertension was present in 60.6% of patients, diabetes mellitus in 36.4%, and coronary artery disease in 66.7%. A history of smoking was observed in 48.5% of patients. The median ejection fraction was 60% (35–65), and the median EuroSCORE II was 1 (0–3) (Table 1).

When surgical procedures were evaluated, 42.4% of patients (n = 14) underwent coronary artery bypass grafting (CABG), 27.3% (n=9) aortic valve replacement (AVR), 18.2% (n=6) mitral valve replacement (MVR), 9.1% (n=3) atrial septal defect (ASD) repair, and 3.0% (n=1) atrial mass surgery (Table 2).

Changes in mean arterial pressure (MAP), PaO_2, lactate, and hematocrit values during the operative period were analyzed using the Friedman test at time points T0 (baseline), T3 (hypothermic phase), and T6 (after closure). MAP values were highest at baseline (T0) and differed significantly from other time points (P<0.001). PaO_2 values increased significantly during CPB (P<0.001). No significant change in pH was observed throughout the procedure (P=0.151), whereas lactate levels increased significantly (P<0.001) and hematocrit levels decreased significantly (P<0.001) (Table 3).

Double-lumen endobronchial tubes were used for airway management in all patients; 77.5% received a 37-Fr double-lumen tube, while 22.5% received a 35-Fr double-lumen tube.

For postoperative analgesia, 66.7% (n=22) of patients received fascial plane block–based analgesia, while 33.3% (n=11) received intravenous analgesia. The choice of analgesia method was not randomized and was based on attending anesthesiologist preference and temporal changes in institutional practice. Additional analgesic requirements were not observed in 63.6% of patients in the fascial plane block group, whereas all patients in the intravenous analgesia group required rescue analgesics (P<0.001). Furthermore, the fascial plane block group demonstrated earlier extubation (P=0.014) and shorter hospital stay (P=0.038). These differences should be interpreted with caution given the non-randomized design and potential confounding factors.

The mean duration of surgery was 313.9 ± 67.4 minutes. The median cardiopulmonary bypass (CPB) duration was 101 minutes (42–270), and the median aortic cross-clamp time was 55 minutes (0–143). The median intraoperative target temperature was 34°C (range: 30–34°C). Intraoperative dobutamine support was required in 93.9% of patients.

TABLE 1. Demographic Characteristics of Patients

Variable	Data
Age (years)	56.18±11.90
BMI (kg/m^2)	26.22±2.06
Sex (male/female)	25 (75.8)/8 (24.2)
ASA III	32 (97.0)
Hypertension	20 (60.6)
Diabetes mellitus	12 (36.4)
Coronary artery disease	22 (66.7)
Smoking	16 (48.5)
EF (%)	60 (35-65)
EuroSCORE II (%)	1 (0-3)

Data are shown as mean±standard deviation or n (%) or median (minimum-maximum) where appropriate. ASA, American Society of Anesthesiologists; BMI, body mass index; EF, ejection fraction; EuroSCORE, European System for Cardiac Operative Risk Evaluation.

TABLE 2. Distribution of Surgical Procedures

Type of surgery	n	%
CABG	14	42.4
AVR	9	27.3
MVR	6	18.2
ASD repair	3	9.1
Atrial mass surgery	1	3.0

CABG, Coronary artery bypass grafting; AVR, Aortic valve replacement; MVR, Mitral valve replacement; ASD, Atrial septal defect.

TABLE 3. Changes in Intraoperative Parameters

Time point	MAP	PaO_2	Lactate	Hematocrit	pH
T0	102	102	1.20	41	7.38
T3	70	225	1.80	26	7.35
T6	74	165	2.60	29	7.35
P-value	**<0.001***	**<0.001***	**<0.001***	**<0.001***	0.151

Data are shown as medians. T0, baseline (after induction); T3, hypothermic phase during CPB, T4, After aortic cross-clamp removal; T6, after thoracic/sternal closure; CPB, cardiopulmonary bypass; MAP, mean arterial pressure; PaO_2, partial pressure of arterial oxygen. *Friedman test is used for comparisons. Statistically significant P-values are shown in bold.

In the postoperative period, the median length of intensive care unit stay was 2 days (range 1–10), the median extubation time was 360 minutes (range 210–2880; approximately 48 hours for the longest case), and the median length of hospital stay was 4 days (range 3–70). The wide ranges reflect considerable variability and the presence of outlier cases, likely related to the heterogeneity of surgical procedures and postoperative complications. Strong positive correlations were observed between extubation time and both ICU length of stay (r=0.629, P<0.001) and hospital length of stay (r=0.685, P<0.001). No patient required reintubation (Table 4).

The presence of hypertension was associated with significantly prolonged extubation time (P=0.040). Diabetes mellitus had a significant impact on CPB duration (P=0.020), extubation time (P=0.005), and length of hospital stay (P=0.002) (Table 5).

Postoperative complications occurred in 42.4% of patients (n=14). The most frequent complications were delirium (18.2%, n=6) and pneumonia (12.1%, n=4). Patients who developed complications had significantly longer extubation times (P=0.003), ICU stays (P=0.012), and hospital stays (P<0.001) (Table 6).

In univariate logistic regression analysis, the presence of diabetes mellitus (OR=9.6, P=0.007), smoking (OR = 5.42, P=0.028), and each 1-minute increase in CPB duration (OR=1.02, P=0.036) were significantly associated with postoperative complications. In multivariate analysis, smoking was associated with increased risk of postoperative complications (OR=7.76, P=0.050). Diabetes mellitus showed borderline significance (P = 0.060). The model explained 54% of the variance (Nagelkerke R^2 = 0.54) (Table 7). However, with only 14 complication events and 3 predictors, the events-per-variable ratio (approximately 4.7:1) is below the recommended threshold of 10:1, raising concerns about model stability and potential overfitting. These results should therefore be interpreted as exploratory and hypothesis-generating.

TABLE 4. Postoperative Course Parameters

Parameter	Median	Min-Max
ICU length of stay (days)	2	1-10
Extubation time (minutes)	360	210-2880
Hospital length of stay (days)	4	3-70

Min, minimum; Max, maximum, ICU, intensive care unit.

DISCUSSION

In this exploratory retrospective study, we evaluated anesthetic management strategies and postoperative clinical outcomes in 33 patients who underwent minimally invasive cardiac surgery (MICS) at our institution between January 2020 and September 2025. This preliminary analysis indicates that MICS can be performed safely and effectively with appropriate patient selection and a multidisciplinary approach, though further validation in larger cohorts is needed.

The median extubation time in our study was 360 minutes. This finding is consistent with a retrospective study published in 2024 demonstrating significantly reduced mechanical ventilation duration in patients undergoing MICS compared with conventional median sternotomy [10]. Another study reported that operating room extubation after minimally invasive valve surgery was safe and significantly shortened intubation duration (median 480 minutes vs. 780

TABLE 5. Effects of Hypertension and Diabetes Mellitus on Postoperative Durations

Group		CPB (min)	P-value	Extubation (min)	P-value
Hypertension	No	77 (42-270)	0.136	270 (210-1080)	**0.040***
	Yes	105 (52-192)		413 (240-2880)	
Diabetes mellitus	No	88 (42-175)	**0.020***	360 (210-540)	**0.005***
	Yes	133 (67-270)		570 (240-2880)	

Data are shown as median (minimum-maximun). CPB, cardiopylmonary bypass.
*Mann-Whitney U test. Statistically significant P-values are shown in bold.

minutes, P<0.001) [11]. Similarly, a fast-track extubation protocol targeting extubation within 180 minutes was associated with a 24.7% reduction in extubation time [12]. The absence of reintubation in our study further supports the safety and reliability of the anesthetic and extubation protocols applied.

The lower requirement for additional analgesics observed in patients who received fascial plane block–based analgesia (36.4% vs. 100%, P<0.001) suggests potential effectiveness of this regional anesthesia approach, though the non-randomized design limits causal inference. The temporal evolution of our institutional practice, with increasing adoption of fascial plane blocks particularly after 2023, introduces possible temporal confounding. Yu *et al*. [13] reported that regional anesthesia techniques may be effective for postoperative pain control in cardiac surgery. Other studies have emphasized the role of fascial plane blocks—including erector spinae plane, serratus anterior plane, and pectoral nerve blocks—in facilitating the transition toward opioid-free anesthesia [14]. White *et al*. [15] demonstrated that regional anesthesia plays a critical role in postoperative pain management in MICS and that multimodal analgesia creates an opioid-sparing recovery environment. Cosarcan *et al*. [16] reported that fascial plane blocks have become an integral component of enhanced recovery protocols in coronary artery bypass surgery, achieving an operating room extubation rate of 91%. In our study, the association between fascial plane block use and shorter extubation time and hospital length of stay is consistent with these reports; however, prospective randomized studies are needed to establish causality and control for potential confounding variables.

TABLE 6. Distribution of Postoperative Complications

Complication	n	%
Delirium	6	18.2
Pneumonia	4	12.1
Bleeding	2	6.1
Pneumonia+ARDS	1	3
Atelectasis	1	3.0
Total	14	42.4

ARDS, acute respiratory distress syndrome.

The median intensive care unit stay of 2 days and median hospital length of stay of 4 days observed in our cohort are broadly consistent with previously reported data, although substantial variability was present (hospital stay range: 3–70 days). This wide range likely reflects differences in surgical complexity, patient comorbidities, and postoperative complications. Similar studies have reported typical ICU stays of 24–48 hours in patients undergoing MICS [15]. Petersen *et al*. [17] demonstrated a reduction in hospital length of stay to 6.1±2.6 days in patients undergoing MICS within an ERAS framework. In another study, the implementation of an ultra-fast-track protocol in transaxillary minimally invasive mitral valve surgery increased the rate of first-day ICU discharge [18]. Salenger *et al*. [19] reported that MICS is associated with reduced hospital length of stay and potentially lower healthcare costs. Furthermore, other studies have shown that combining ERAS protocols with MICS improves patient outcomes and shortens hospital stay [20]. Our findings support these observations in typical cases, while acknowledging that a subset of patients experienced prolonged hospitalizations due to complications.

In our study, strong positive correlations were

TABLE 7. Logistic Regression Analysis of Factors Associated with Postoperative Complications

Variable	Univariate OR (95% CI)	P-value	Multivariate OR (95% CI)	P-value
DM	9.6 (1.85-49.88)	**0.007***	7.87 (0.92–67.66)	0.060
Smoking	5.42 (1.20–24.52)	**0.028***	7.76 (1.00–59.96)	**<0.050***
CPB duration	1.02 (1.00–1.05)	**0.036***	1.02 (0.99–1.05)	0.148

CI, Confidence interval; CPB, Cardiopulmonary bypass; DM, Diabetes mellitus; OR, Odds ratio)
*P<0.05; Nagelkerke R^2=0.54. Statistically significant P-values are shown in bold.

observed between extubation time and both ICU length of stay (r=0.629, P<0.001) and hospital length of stay (r=0.685, P<0.001). These findings emphasize the clinical importance of early extubation, a key target of ERAS protocols, and its impact on overall postoperative recovery.

Evaluation of comorbidities revealed that hypertension was associated with prolonged extubation time (P=0.040), while diabetes mellitus significantly affected cardiopulmonary bypass duration (P=0.020), extubation time (P=0.005), and hospital length of stay (P=0.002). These findings underscore the importance of optimal preoperative management of comorbid conditions in patients undergoing MICS. In multivariate logistic regression analysis, smoking increased the risk of postoperative complications (OR=7.76, P=0.050), while diabetes mellitus approached but did not reach statistical significance (P=0.060). However, these findings must be interpreted cautiously given the small number of events (n=14) relative to the number of predictors, which increases the risk of model overfitting and produces unstable effect estimates with wide confidence intervals. These findings should be considered hypothesis-generating, and validation in larger cohorts is necessary before clinical application. The overall postoperative complication rate in our study was 42.4%, with delirium (18.2%) and pneumonia (12.1%) being the most common complications. Wang *et al*. [11] reported that operating room extubation after minimally invasive valve surgery did not increase the incidence of postoperative delirium. The significantly longer extubation time, ICU stay, and hospital stay observed in patients who developed complications highlight the critical role of complication prevention strategies in improving clinical outcomes.

In MICS procedures, where airway management and oxygenation are of particular importance, the use of double-lumen endotracheal tubes may be unavoidable depending on the surgical approach and procedure type. In our cohort, all patients were managed with double-lumen endotracheal tubes. Decisions regarding extubation were made by the multidisciplinary team based on surgical and hemodynamic stability and adequate respiratory capacity. Previous studies have emphasized that extubation decisions in MICS should be based on multidisciplinary assessment and adequate gas exchange criteria [21].
The frequent use of dobutamine support during the intraoperative period, particularly during separation from cardiopulmonary bypass (93.9% of patients), suggests that hemodynamic support is often required in MICS due to peripheral cannulation and cardiopulmonary bypass–related physiological changes. The significant decrease in mean arterial pressure after baseline and the significant increase in lactate levels reflect the expected metabolic effects of cardiopulmonary bypass. The absence of significant changes in pH throughout the procedure indicates effective maintenance of acid–base balance.

In recent years, a clear shift has occurred in MICS analgesia from central neuraxial techniques toward peripheral fascial plane blocks and from high-dose opioid strategies toward multimodal analgesia. Hong *et al*. [22] provided a comprehensive evaluation of parasternal intercostal, interpectoral, pectoserratus, serratus anterior, erector spinae, and retrolaminar plane blocks in cardiac surgery. Capuano *et al*. [23] categorized parasternal blocks into superficial and deep techniques and reported that superficial approaches may be safer. Sepolvere *et al*. [24] demonstrated that thoracic fascial plane blocks are integral components of ERAS protocols and that deep parasternal intercostal plane blocks reduce opioid consumption. Our findings regarding fascial plane block efficacy are consistent with the literature, and we observed an increasing preference for superficial parasternal intercostal block techniques, particularly after 2023.

Strengths and Limitations

The strengths of this study include the evaluation of various MICS procedures (CABG, AVR, MVR, ASD repair, and atrial mass excision) within a single center, comprehensive perioperative data collection, and the assessment of the effectiveness of fascial plane block–based analgesia. However, several limitations should be acknowledged, including the retrospective design, relatively small sample size (n=33), heterogeneity of the surgical and anesthesia teams, single-center experience, and the absence of long-term follow-up data. The comparison between fascial plane block and intravenous analgesia was non-randomized; analgesia selection was based on attending anesthesiologist preference and evolved temporally during the study period. This introduces potential selection bias and temporal confounding, precluding causal inferences about the superiority of either approach. These limitations underscore that our findings should be considered exploratory and hypothesis-generating, requiring validation in larger, prospective, randomized controlled trials. Despite these limitations, our study contributes valuable data as one of the few MICS series reported from Turkiye.

CONCLUSION

In this exploratory single-center study, minimally invasive cardiac surgery was performed safely with acceptable morbidity in appropriately selected patients and in the presence of an experienced multidisciplinary team. Fascial plane block–based analgesia was associated with improved postoperative pain control, reduced additional analgesic requirements, and shorter extubation and hospital discharge times. However, the non-randomized design and potential for temporal and selection bias preclude definitive conclusions regarding superiority of this analgesic approach. Diabetes mellitus and smoking were identified as potential risk factors for postoperative complications, underscoring the importance of preoperative optimization, though these associations require validation given the limited sample size and risk of model overfitting. The integration of early extubation strategies and ERAS protocols with MICS has the potential to further enhance patient outcomes. Given the exploratory nature, small sample size, and limitations of this single-center retrospective study, larger prospective multicenter studies, ideally with randomized comparisons of analgesia strategies, are needed to confirm these preliminary findings and support the development of evidence-based, standardized perioperative protocols for minimally invasive cardiac surgery.

Ethics Approval and Consent to Participate

This study was approved by the University of Health Sciences Bursa Yuksek Ihtisas Training and Research Hospital Medical Sciences Ethics Committee. (Decision No: 2024-TBEK 2025/09-08; date: 10.09.2025). All procedures were conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments. Due to the retrospective design of the study, informed consent was waived. All patient data were anonymized, and access was restricted to the research team.

Data Availability

All data generated or analyzed during this study are included in this published article. The data that support the findings of this study are available on request from the corresponding author, upon reasonable request.

Authors' Contribution

Study Conception: AO, ABT; Study Design: AO, ABT; Supervision: AO, ABT; Funding: AO, ABT; Materials: ABT; Data Collection and/or Processing: AO; Statistical Analysis and/or Data Interpretation: AO; Literature Review: AO, ABT; Manuscript Preparation: AO, ABT; and Critical Review: ABT.

Conflict of Interest

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