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Beating heart mitral valve surgery via right thoracotomy in high-risk patients: A retrospective study

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Abstract

The objective of our study was to determine the safety and efficacy of mitral valves having been directly operated on the beating heart via a right thoracotomy, placement of sutures into the following patients considered at high risk. In this context, we evaluated the results of mitral valve operations performed through a right lateral chest incision in both the short and medium term. Between January 2016 and December 2022, 13 patients with high EuroSCORE values were operated with this method. The majority of the patients were men with a mean age of 73.4 years. The average EuroSCORE value, known as the patients' risk score, was 12.5. The average duration of heart-lung machine use during the operations was 139 minutes. Two patients died in hospital. The most common problems were recorded as heart arrhythmia and prolonged ventilator use. The survival rate of patients after one year was 77%. The risk of death was significantly higher in patients with cardiac contractility below 30%. In conclusion, this method seems feasible in high-risk patients with reasonable complication and mortality rates. However, appropriate and adequate selection of patients and perioperative risk management is of paramount importance if acceptable results are to be achieved.

Keywords: Mitral valve surgery, beating heart surgery, high-risk patients, cardiopulmonary bypass

Introduction

Mitral valve diseases are a serious cause of morbidity and mortality, especially in the aging population [1]. Surgical procedures such as mitral valve repair or replacement are of vital importance in the treatment of these diseases. Left untreated, this condition leads to a significant decrease in quality of life and high mortality rates [2]. In traditional mitral valve surgery, cardioplegic arrest is often used. However, this approach may predispose to complications such as myocardial ischemia and reperfusion injury [3]. New surgical techniques developed today aim to reduce such complications and increase surgical success rates [4]. Mitral valve surgery, especially with less invasive methods, both accelerates the postoperative recovery process and significantly increases patient satisfaction [5].

Mitral valve surgery performed on a beating heart promises many benefits, most importantly for those patients with a very high operative risk. This technique reduces the intra- and post-operative complications by obliterating myocardium ischemia and reperfusion injury due to cardioplegia and cardiac arrest eliminating; its also believed to hasten the recovery and enhance the quality of life among patients. The objective of this particular study was to validate the given hypothesis by examining the results in the short as well as mid period in the case of mitral valve surgery they have performed in elderly population who had risks factors. We seek to document the impact of using right lateral thoracotomy, during a beating heart surgery, so that an evidence guide can be developed for future surgical modes.

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This study's main focus was to enhance the knowledge on the results of surgical treatment of mitral valve replacement and repair in patients belonging to a population considered as being at high surgical risk. In addition, this will help identify how the effects of not using cardioplegia and beating the heart affect midterm outcomes at the rate of total complications and, postoperative recovery realms. In this view, the complications of myocardial ischemia and reperfusion injury will be absent.

The research will help to pursue the goals of identifying the benefits but also the possible shortcomings associated with the mitral valve surgery in the beating heart and annual survival outcome. The results are expected to help many surgeons to develop better strategies for the surgeries based on evidence. The aim of the study was to demonstrate the feasibility of valve replacement or repair in patients deemed inoperative for whom mitral valve surgery was not possible.

Material and Methods

Study Design and Scope

This retrospective, single-center, observational study included cases of mitral valve surgery performed between January 2016 and December 2022 in the Cardiovascular Surgery Clinic. The study was conducted to evaluate the clinical outcomes of mitral valve surgery in patients with high surgical risk. Ethics committee approval was obtained from Trabzon Medical Faculty Kanuni Training and Research Hospital Ethics Committee (No: 2024/153, Desicion date: 24.12.2024).

Patient Selection

Patients with preoperative EuroSCORE values indicating a high surgical risk were included in the study. Inclusion criteria were severe mitral regurgitation (Grade III-IV) and severe cardiac dysfunction, previous cardiac surgery and porcelain aorta. Additionally, patients with right lung adhesion and no more than first-degree aortic insufficiency underwent surgical procedure. Demographic information, clinical characteristics, preoperative laboratory findings, cardiac evaluation results and comorbidity factors were recorded in detail.

Surgical Procedure

All surgical procedures were performed under general anesthesia by the same surgical team through a right lateral thoracotomy approach. Selective cannulation of the right femoral artery and vein and superior vena cava was performed after heparinization (300 IU/kg) to provide cardiopulmonary bypass (CPB). Mild hypothermia was applied and body temperature was monitored with a nasopharyngeal temperature probe to maintain a mean target temperature of 34°C.

Technical Details

The aortic root was cannulated and the vent was inserted and both vena cava were suspended by rotation with tape. An additional vent was placed via the right superior pulmonary vein. All patients were continuously monitored with transcranial cerebral pulse oximetry in the intraoperative period and cerebral perfusion was carefully evaluated. Air leakage was prevented by aspiration with the aortic root in the reverse Trendelenburg position. Cerebrovascular Event Trans Ischemic Attack did not develop in any patient.

Left Atrial Access and CPB Management

After right atriotomy, access to the left atrium was obtained via a transseptal approach. Mean arterial pressure was maintained at 60 mmHg during CPB and appropriate manipulations were performed to maintain hemodynamic stability. Myocardial monitoring was performed with continuous ECG monitoring and signs of ischemia were carefully monitored.

Operative Data Collection

Detailed data on surgical procedures were carefully recorded. Parameters recorded included surgical time, CPB duration. In addition, the types and sizes of prosthetic valves used and the concurrent procedures performed were also recorded. The surgical team carefully evaluated all operations in order to detect any complications that may occur in the intraoperative period.

Postoperative Follow-up

During the postoperative follow-up period, the duration of intensive care unit and ward stays, intubation times and development of complications were monitored in detail. Important parameters such as bleeding requiring revision, renal dysfunction, infection and mortality were recorded. In addition, three-month and one-year survival rates were evaluated using Kaplan-Meier analyses.

Statistical Analysis

All continuous variables are reported as minimum-maximum, mean and standard deviation. Categorical data are expressed as percentages. Survival probability was measured by means of the Kaplan-Maier survival analysis. In the comparison of preoperative and postoperative echocardiography, independit sample t test was used.

Results

The mean age of the study group was 73.4 years and the age range of the individuals was between 65 and 81 years. The majority of the participants were men, and body surface area and ejection fraction values were consistent with normal ranges. High EuroSCORE values indicate that the group belongs to a population at high risk for surgery. In the distribution of comorbidities, hypertension was the most common condition, while diabetes mellitus and chronic obstructive pulmonary disease were other common conditions. Preoperative laboratory results showed that creatinine and hematocrit levels were generally within normal limits, while platelet levels showed a wide range (Table 1).

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Table 1. Demographic and preoperative data (n=13)

Variable	Mean±SD
Age (years)	73.40±5.20
Body surface area (m²)	1.82±0.17
Ejection fraction (%)	45.80±10.30
Euro SCORE	18.50±5.80
Preoperative laboratory values	
Creatinine (mg/dL), Mean±SD	1.00±0.35
Hematocrit (%), Mean±SD	36.00±2.20
Platelets (×10³/μL), Mean±SD	209±58
Gender	**n (%)**
Male	10 (76.9)
Female	3 (23.1)
Comorbidity factors	
Diabetes mellitus	4 (30.8)
Hypertension	12 (92.3)
Chronic obstructive pulmonary disease	9 (69.2)
Carotid artery disease	1 (7.7)
Peripheric vascular disease	0 (0)
Previous stroke	0 (0)
Smoking	2 (15.4)

When the operative data were analyzed, it was observed that the duration of cardiopulmonary bypass varied over a wide range, but the mean duration was consistent with similar studies in the literature. It is noteworthy that the most commonly used prosthetic valve sizes were 29 mm and 31 mm, and larger sizes were rarely preferred. Isolated mitral valve replacements were the most commonly used. In terms of intraoperative use of blood products, the mean red blood cell and fresh frozen plasma requirements of the patients were controlled. Postoperative mortality rate was a significant risk in the studied group (Table 2).

Table 2. Operative data

Variable	Mean±SD
CPB time (min)	138.60±42.30
Intraoperative blood use	
RBC units, Mean±SD	2.80±1.20
FFP units, Mean±SD	2.10±0.90
Valve type and size	
SJM mechanical MVR	**n (%)**
27 mm	2 (15.4)
29 mm	5 (38.5)
31 mm	5 (38.5)
33 mm	1 (7.7)
Concurrent procedures	
TVR	1 (7.7)
Tricuspid ring	4 (30.8)
Isolated MVR	8 (69.2)
Operation-related mortality	
Postoperative mortality	2 (15.4)

CPB: cardiopulmonary bypass, RBC: red blood cell, FFP: fresh frozen plasma, SJM: St. Jude medical, MVR: mitral valve replacement, TVR: tricuspid valve replacement

When the postoperative outcomes were evaluated, it was observed that the duration of hospitalization was at a controllable level in accordance with the literature (7.2±1.5 days). The variability observed that stay in intensive care unit (72±35.2 hours) and intubation times (68±30.5 hours). The most common complications were prolonged ventilation and pneumonia (15.4%). Other complications such as bleeding requiring revision and renal dysfunction were seen at lower rates (7.7%) (Table 3).

Table 3. Postoperative outcomes

Variable	Value
Hospital stay (days)	
Mean±SD	7.20±1.50
Min-Max	5-10
ICU stay (hours)	
Mean±SD	72.00±35.20
Min-Max	48-150
Intubation time (hours)	
Mean±SD	68.00±30.50
Min-Max	5-120
Drainage volume (mL)	
Mean±SD	450±150
Min-Max	200-800
Blood transfusion (units)	
Mean±SD	2.50±1.20
Min-Max	1-5
Postoperative complications	
Revision-required bleeding, n (%)	1 (7.70)
Postoperative stroke, n (%)	0 (0)
Hospital mortality	
Extended ventilation (>48h), n (%)	2 (15.40)
Renal dysfunction, n (%)	1 (7.70)
Pneumonia, n (%)	2 (15.40)

ICU: intensive care unit

According to the results of preoperative cardiac evaluation, most of the patients had mitral regurgitation, which was mostly advanced (Grade III-IV). The most common cause of regurgitation is ischemic etiology, although degenerative and rheumatic causes are also frequently encountered. Atrial fibrillation rhythm disturbance is present in a significant proportion of patients, while echocardiographic evaluation reveals enlarged left and right ventricular diameters and a limited capacity of the right ventricular ejection fraction. Furthermore, elevated pulmonary arterial pressure and advanced NYHA classifications suggest

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that this patient group presented with severe cardiac functional impairment. Among patients with a history of previous cardiac surgery, the proportion of patients with a history of isolated CABG, isolated valve surgery and combined CABG-valve surgery was significant (Table 4).

Table 4. Preoperative cardiac assessment

Variable	Value
Mitral valve pathology	
Mitral regurgitation, n (%)	12 (92.30)
Mitral stenosis, n (%)	1 (7.70)
Degree of mitral regurgitation	
Grade III, n (%)	5 (38.50)
Grade IV, n (%)	7 (53.80)
Etiology of mitral regurgitation	
Ischemic, n (%)	7 (53.80)
Degenerative, n (%)	3 (23.10)
Rheumatic, n (%)	2 (15.40)
Other, n (%)	1 (7.70)
Rhythm	
Atrial fibrillation, n (%)	8 (61.50)
Sinus rhythm, n (%)	4 (30.80)
Permanent pacemaker, n (%)	1 (7.70)
Echocardiographic data	
LVEDD (mm), Mean±SD	61.50±8.40
RVEDD (mm), Mean±SD	32.30±5.20
RVEF (%), Mean±SD	42.60±8.70
Pulmonary artery pressure (mmHg), Mean±SD	53.40±15.60
Degree of tricuspid regurgitation	
Grade I-II, n (%)	8 (61.50)
Grade III-IV, n (%)	5 (38.50)
NYHA class	
NYHA II, n (%)	2 (15.40)
NYHA III, n (%)	8 (61.50)
NYHA IV, n (%)	3 (23.10)
Previous cardiac surgery	
Isolated CABG, n (%)	3 (23.10)
Isolated valve surgery, n (%)	3 (23.10)
CABG + valve surgery, n (%)	2 (15.40)

LVEDD: left ventricle end diastolic diameter, RVEDD: right ventricle end diastolic diameter, RVEF: right ventricle ejection fraction, NYHA: New York Heart Association, CABG: coronary artery bypass grafting

In the evaluation of risk analysis and survival data, comprehensive statistical analyses could not be performed due to the limited sample size (n=13). Using descriptive statistics, 3-month survival rate was 84.6% (11/13 patients), 6-month survival rate was 80.0% (10/13 patients) and 1-year survival rate was 76.9% (10/13 patients). Higher mortality was observed in patients with EF<30% (n=5) (Table 5).

Table 5. Risk analysis and survival data (n=13)

Variable	Value
Risk scores	
EuroSCORE II, Mean±SD	12.50±3.50
Ontario risk score, Mean±SD	6.80±2.10
Survival rates	
30-day survival, n (%)	11/13 (84.60)
3-month survival, n (%)	11/13 (84.60)
6-month survival, n (%)	10/13 (77.00)
1-year survival, n (%)	10/13 (77.00)
Subgroup survival analysis (1 year)	
EF <30%, n (%)	3/5 (60.00)
EF >30%, n (%)	7/8 (87.50)
Concurrent procedures	
Tricuspid ring, n (%)	4/13 (30.80)
Tricuspid valve replacement, n (%)	1/13 (7.70)
Clinical outcomes	
Patients with NYHA class improvement, n (%)	8/13 (61.50)
Risk factors by patient distribution	
Age >75, n (%)	5/13 (38.50)
EF <30%, n (%)	5/13 (38.50)
Reoperation, n (%)	3/13 (23.10)

EF: ejection fraction: NYHA: New York Heart Association; Notes: Due to the limited sample size (n=13), data are presented as descriptive statistics

In the comparative evaluation of left ventricular ejection fraction in the preoperative and postoperative periods, it was observed that the mean EF value was 48.2±10.3% preoperatively and decreased to 37.8±12.4% postoperatively (p=0.023). When the survival rates of the patients during the twelve-month follow-up period were analyzed, it was observed that the survival rate, which was 100% in the first three months, decreased to 84.6% in the third month and 80.5% in the sixth month, and remained around 80% in the ninth month, and the one-year survival rate was 76.9%. Median survival time was not reached (Figures 1 and 2).

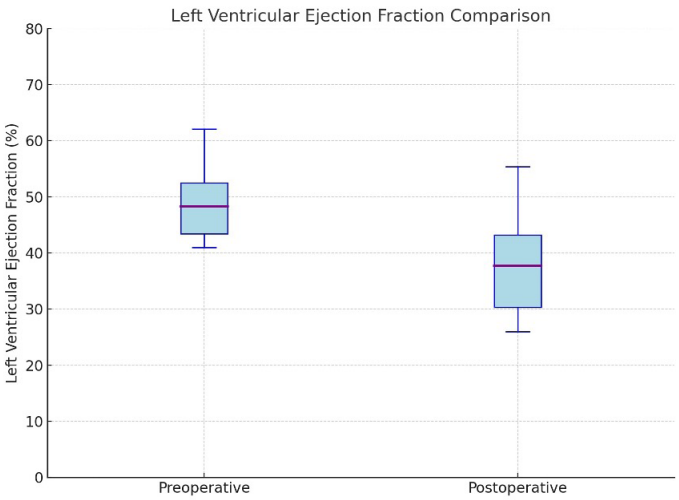

Figure 1. Comparison of left ventricular ejection fraction

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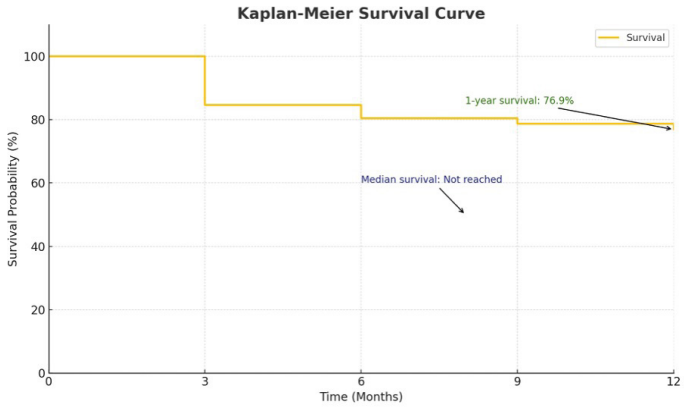

Figure 2. Kaplan-Meier survival curve

Discussion

Through our findings, our study has emphasized the superior outcomes of a beating heart approach in mitral valve disease surgery especially among high risk patients. We found that mitral valve surgery performed through right lateral thoracotomy, without cardioplegia and without cardiac arrest, resulted in shorter hospital stay and faster recovery. This rate of the one- year survival of 76.9% lead us to conclude that the use of this technique is safe also in patients at high risk. Still 15.4% in-hospital death has stressed the significance of patient selection and follow up.

Previous studies in the literature have shown that mitral valve surgery in the beating heart reduces perioperative complications and decreases 30-day mortality rates. For example, Katırcıoğlu et al. (2008) reported that this method resulted in low mortality rates and minimal complications [6]. Similarly, Pasic et al. (2017) demonstrated that this technique is an effective option, especially in heterogeneous patient groups with high surgical risk [7]. The contribution of techniques developed to optimize cardiopulmonary bypass and cross-clamp times to clinical outcomes and long-term patient satisfaction has also not been studied in detail [8]. Considering these gaps, the question of how surgical strategies can be enhanced in order to improve patient outcomes comes to the fore.

The mean duration of CPB in our study (138.6 min) was longer than other series of mitral valve surgery in the beating heart in the literature. For example, the mean CPB time was 74.35±14.8 min in the series of Ghosh et al. [9], 105±31 min in the study of Matsumoto et al. [10], 57.4±18.4 min in the series of Katircioglu et al. [6] and 103±39 min in the large series of Pasic et al. [7]. The longer duration of CPB in our series may be related to the high-risk nature of our patient group and the application of concomitant procedures. However, no patient had difficulty weaning from CPB and the operation was successfully completed in all patients. This suggests that surgery in the beating heart can be performed safely despite longer CPB periods.

In our study, the most commonly used prosthetic valve sizes were 29-31 mm, and this finding is consistent with the literature. In the literature, it is emphasized that the choice of prosthetic valve size is an important factor. Pibarot et al. emphasized the importance of effective orifice area (EOA) and patient body surface area index in the selection of the ideal prosthetic valve and reported that the risk of patient-prosthesis mismatch (PPM) increased with smaller valve sizes [11]. Stocco et al. demonstrated that biological valves have higher transvalvular gradients than mechanical valves [12]. Ghosh et al. emphasized the importance of peroperative transesophageal echocardiography in the evaluation of valve dimensions and function in mitral valve surgery in the beating heart [9]. Korteland et al. emphasized that not only valve size but also factors such as the patient's quality of life and preferences should be considered when choosing a prosthetic valve in young patients [13].

The preoperative ejection fraction (EF) of 45.8±10.3% decreased to 37.8± 12.4% postoperatively, indicating a significant decrease in cardiac function after surgery. This is consistent with the transient left ventricular dysfunction seen after surgeries using cardiopulmonary bypass, which is frequently emphasized in the literature [14]. Especially after mitral valve surgery, factors such as ventricular wall strain and volume overload have been reported to adversely affect ventricular function [15].

Although a decrease in myocardial fibrosis was observed after surgery in patients undergoing mitral valve repair, it was stated that EF values may decrease in the early postoperative period. However, it has also been reported that ventricular remodeling may improve over time and EF values may improve [16]. On the other hand, it is also reported in the literature that these decreases are more limited and the recovery process progresses faster in interventions performed with minimally invasive techniques [17].

Surgical outcomes in high surgical risk patient populations are directly related to the accuracy of the risk scores used and the effectiveness of surgical strategies. Our study showed that parameters such as EuroSCORE II and Ontario Risk Score play an important role in predicting the risk of postoperative mortality and complications. However, it is frequently emphasized in the literature that these scores systematically underestimate mortality, especially in elderly patients.

Bendiab et al. reported that EuroSCORE II and STS scores underestimate in-hospital mortality in elderly patients and that age is an independent risk factor [18]. However, the study by Carino et al. showed that EuroSCORE II overestimated mortality in low-risk patient groups. This suggests that such models may not adequately reflect actual clinical outcomes in high-volume and specialized centers [19]. Similarly, Aluru et al. pointed out the difficulties in risk assessment of increasing age and comorbidities, especially in mitral valve pathologies [20]. In the study by Dereli et al., less ischemia and better postoperative results were obtained in patients who did not use clamps after tricuspid valve surgery, similar to our results [21].

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In our study, the mortality rate (15.4%) and annual survival rate (76.9%) after mitral valve surgery were remarkable. These rates are consistent with the available literature. The study by Yang et al. shows that prolonged mechanical ventilation is an important complication in the postoperative period and increases the risk of mortality, especially in elderly patients [22]. Similarly, Genuardi et al. emphasized the negative effects of preoperative pulmonary hypertension and persistent pulmonary hypertension in the postoperative period on mortality [23]. In addition, Cetinkaya et al. reported that atrial fibrillation is one of the common complications after mitral valve surgery and may affect annual survival rates [24].

There are some limitations in our study that deserve important attention. First, because the study was single-centered and involved only a limited number of patients (n=13), the sample may not be representative of the entire patient population and hence the results obtained are difficult to be generalized. Furthermore, the retrospective nature of the design of the study restricted access to some important clinical data which made the interpretation of results somewhat difficult.

For future studies we recommend: It would be pertinent to design multi center and refective studies with larger patient cohorts. In particular, evaluating the outcomes of mitral valve surgery in beating heart in different patient groups and including quality of life scales in the evaluation will increase the knowledge in this field. Moreover, the inability to access some key clinical data as a result of the retrospective design, is yet another factor that hinders the interpretation of the findings.

Conclusion

It was concluded that mitral valve surgery performed on the beating heart via right lateral thoracotomy is a safe and feasible procedure in high-risk patients with reasonable complication rates. The one-year survival rate of 76.9% and in-hospital mortality rate of 15.4% were consistent with similar patient groups in the literature. The results emphasise the necessity of preoperative patient selection and risk assessment as the perioperative mortality risk is considerably high in patients particularly in those with an ejection fraction of less than 30%. Considering the most common complications, prolonged ventilation and pneumonia (15.4%), it is clear that postoperative care strategies should be individualized and optimized.

Conflict of Interests

The authors declare that there is no conflict of interest in the study.

Financial Disclosure

The authors declare that they have received no financial support for the study.

Ethical Approval

Ethics committee approval was obtained from Trabzon Medical Faculty Kanuni Training and Research Hospital Ethics Committee (No: 2024/153, Desicion date: 24.12.2024).

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