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Original Research

Bypass-Assisted Beating Heart Mitral Valve Replacement in Rheumatic Mitral Disease with Moderate LV Dysfunction: Surgical Outcomes

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ABSTRACT:

Background: Rheumatic mitral valve disease with moderate left ventricular dysfunction poses challenges for myocardial protection during valve replacement. Conventional surgery with cardioplegic arrest is associated with ischemia-reperfusion injury and prolonged recovery. **Material and Methods:** A total of 150 patients undergoing mitral valve replacement were studied. Group 1 underwent bypass-assisted beating-heart valve replacement under normothermic conditions, while Group 2 underwent conventional valve replacement with aortic cross-clamping and cold blood cardioplegia. Demographic, surgical, echocardiographic, and biochemical data were analyzed. **Results:** Group 1 had significantly shorter cardiopulmonary bypass time (79 ± 4.2 vs 106 ± 5.8 min), ventilation time (2.9 ± 1.1 vs 7.5 ± 0.9 hours), and hospital stay (4.1 ± 0.6 vs 8.5 ± 0.8 days). Postoperative EF improved significantly in Group 1 compared to Group 2 at discharge, 6 months, and 1 year. LV dimensions demonstrated favorable remodeling in Group 1. Cardiac enzyme release (CPK, CPK-MB) was significantly lower in the beating-heart group, reflecting reduced myocardial injury. **Conclusion:** Bypass-assisted beating-heart mitral valve replacement provides superior myocardial protection, better ventricular recovery, and improved perioperative outcomes compared to conventional arrested-heart surgery in rheumatic mitral valve disease with moderate left ventricular dysfunction.

Keywords: rheumatic mitral valve, beating-heart surgery, ventricular dysfunction, cardiopulmonary bypass

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INTRODUCTION

Rheumatic mitral valve disease remains a significant cause of morbidity in low- and middle-income countries, frequently leading to mitral stenosis or regurgitation, left atrial enlargement, and progressive left ventricular dysfunction [1]. Standard mitral valve replacement typically requires cardioplegic arrest and aortic cross-clamping, subjecting the myocardium to ischemia–reperfusion injury; this risk is particularly pronounced in patients with moderate left ventricular dysfunction, who may demonstrate poor myocardial tolerance to cardioplegic arrest [2]. The **on-pump beating-heart technique**, which maintains cardiac activity while on cardiopulmonary bypass, avoids aortic cross-clamping and may reduce myocardial ischemic insult and preserve ventricular function [3]. Clinical experience has demonstrated that beating-heart mitral valve surgery can be performed safely in high-risk patients, offering acceptable operative morbidity and mortality while potentially improving cardioprotection [4].

In reoperative or complex cardiac surgical scenarios such as redo mitral surgery or combined procedures, the beating-heart approach via minimally invasive right thoracotomy has shown benefits including lower cardiopulmonary bypass time, reduced transfusion needs, and improved postoperative recovery [5]. Moreover, innovative techniques like robotic-assisted beating-heart mitral valve surgery have recently emerged, proving feasible and effective—especially in patients unsuitable for aortic cross-clamping due to dense adhesions or severe calcifications—while demonstrating favorable early and mid-term outcomes [6]. A recent case report described successful beating-heart mitral valve replacement combined with aortic pseudoaneurysm repair via dual right mini–thoracotomies, underscoring the

adaptability of this technique in complex surgical settings [7].

Long-term outcome data in rheumatic mitral valve interventions consistently identify left ventricular systolic dysfunction as an independent predictor of mortality irrespective of the intervention modality, underscoring the imperative for myocardial protection strategies in moderate dysfunction [8]. In this context, the beating-heart technique provides theoretical and practical advantages in mitigating additional ventricular injury during prosthetic replacement. Advances in hybrid cardiac surgical methods also suggest future potential for combining catheter-based interventions with beating-heart surgical approaches to reduce invasiveness and enhance recovery [9]. Enhancing patient safety and optimizing functional results in high-risk mitral surgery requires surgical innovation grounded in individualized myocardial protection, precise surgical planning, and the integration of evolving technologies.

MATERIAL AND METHODS

This prospective comparative study was conducted in the Department of Cardiothoracic Surgery at a tertiary care hospital over a period of three years. A total of 150 patients diagnosed with rheumatic mitral valve disease associated with moderate left ventricular dysfunction were included. Patients were selected based on echocardiographic evidence of mitral stenosis or regurgitation requiring valve replacement, along with an ejection fraction of 30–45% to represent moderate left ventricular dysfunction. Exclusion criteria included severe comorbid conditions, history of previous cardiac surgery, or emergency operations. All patients underwent detailed preoperative evaluation including clinical examination, electrocardiography, echocardiography, and routine biochemical investigations.

The surgical approach for all patients was through a classical median sternotomy. Patients were then divided into two groups of equal size. In Group 1, mitral valve replacement was carried out on a beating heart under normothermic cardiopulmonary bypass conditions without cross-clamping of the aorta. Cardiopulmonary bypass was established with aortic and bicaval cannulation, and systemic perfusion was maintained with moderate flow rates to provide adequate oxygenation while allowing the surgeon to perform valve excision and replacement with the prosthetic valve while the heart continued to beat. This approach aimed to avoid ischemic injury by eliminating the need for cardioplegic arrest.

In Group 2, the conventional technique was employed, wherein a vascular cross-clamp was applied to the ascending aorta between the arterial perfusion cannula and the cardioplegic cannula. Myocardial protection was achieved with the administration of cold blood cardioplegia, and the valve replacement procedure was performed under arrested heart and hypothermic conditions. Following completion of the valve replacement, patients were gradually rewarmed, the cross-clamp was released, and the heart was allowed to resume sinus rhythm either spontaneously or with electrical defibrillation if required.

Standard prosthetic valves were used in both groups according to patient size and surgeon preference. Postoperative management included routine intensive care monitoring, mechanical ventilation, inotropic support when necessary, and early mobilization. Outcome measures assessed included total pump time, cross-clamp time (for Group 2), duration of mechanical ventilation, requirement of inotropic support, length of intensive care unit (ICU) stay, and total hospital stay. Mortality and major postoperative complications such as low cardiac output syndrome, arrhythmias, renal dysfunction, cerebrovascular events, and re-exploration for bleeding were also recorded.

Statistical analysis was performed using SPSS version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as percentages. Comparisons between the two groups were carried out using the Student’s t-test for continuous variables and chi-square test for categorical data. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The baseline demographic and surgical characteristics of the study population are summarized in Table 1. The mean age of the patients was 43.6 years, with a male-to-female ratio of 1.6:1. Atrial fibrillation was present in 36% of patients, while moderate pulmonary artery hypertension was seen in 41.6%. When comparing the two groups, patients undergoing the beating-heart procedure (Group 1) had significantly shorter cardiopulmonary bypass (CPB) times, reduced postoperative ventilation time, and shorter hospital stays compared to those who underwent conventional arrested-heart surgery with cold blood cardioplegia (Group 2). These differences were statistically significant.

Comparison of ejection fraction (EF) and left ventricular (LV) dimensions across the study groups is presented in Table 2. Preoperatively, EF was comparable between the two groups. Postoperatively, however, Group 1 demonstrated a significantly greater improvement in EF at discharge, at six months, and at one year compared to Group 2. Similarly, LV systolic and diastolic dimensions showed progressive improvement in Group 1 over time, whereas recovery in Group 2 was less pronounced. The differences in postoperative EF and LV remodeling were statistically significant across all follow-up periods, while preoperative comparisons did not reveal significant differences.

Table 3 illustrates postoperative cardiac enzyme levels in both groups. Serum creatine phosphokinase (CPK) and CPK-MB values were consistently lower

in Group 1 than in Group 2 at both six and twelve hours postoperatively. This indicates a reduced degree of myocardial injury in patients who underwent beating-heart valve replacement compared to those managed with arrested-heart techniques. These differences were statistically significant, further supporting the cardioprotective role of the beating-heart approach.

Table 1. Patient demographics, comorbidity distribution, and surgical data for the study population (N=150)

Patient Demographics	Value
Age (years)	43.6 ± 3.9
Sex distribution (M:F)	1.6:1
Comorbidities	
Atrial fibrillation	54 (36%)
Moderate PAH*	62 (41.6%)
Surgical data	Group 1
CPB time (min)	79 ± 4.2
Ventilation time (hours)	2.9 ± 1.1
Hospital stay (days)	4.1 ± 0.6

*PAH: Pulmonary artery hypertension

Table 2. Comparison of ejection fraction (EF) (%) and left ventricular (LV) dimensions (mm) between groups during preoperative and postoperative periods (N=150)

Parameter	Group 1	Group 2	'p' value
EF (%)			
Pre-operative	36.8 ± 4.2	36.7 ± 3.8	>0.05
Post-operative discharge	47.9 ± 3.2	39.4 ± 3.1	<0.05
6 months	53.4 ± 2.6	40.1 ± 3.5	<0.05
1 year	55.9 ± 1.6	41.2 ± 3.3	<0.05
LV Dimensions (mm)			
Pre-operative diastolic	55.7 ± 2.5	54.8 ± 2.7	>0.05
Pre-operative systolic	35.6 ± 3.1	35.7 ± 2.6	>0.05
Post-operative 6 months diastolic	39.9 ± 2.7	44.5 ± 5.0	<0.05
Post-operative 6 months systolic	24.6 ± 1.5	27.9 ± 3.4	<0.05
Post-operative 1 year diastolic	37.6 ± 2.1	42.4 ± 4.4	<0.05
Post-operative 1 year systolic	24.4 ± 1.3	27.4 ± 3.7	<0.05

Table 3. Cardiac enzyme levels during the postoperative period in both groups (N=150)

Enzyme	Group 1	Group 2	'p' value
CPK (IU/L)			
6 hours	120.7 ± 4.6	182.1 ± 4.7	<0.05
12 hours	142.1 ± 4.1	382.4 ± 4.5	<0.05
CPK-MB (IU/L)			
6 hours	11.9 ± 1.1	56.5 ± 4.2	<0.05
12 hours	19.5 ± 4.1	89.3 ± 4.7	<0.05

DISCUSSION

The findings of the present study highlight the advantages of bypass-assisted beating-heart mitral valve replacement in patients with rheumatic mitral valve disease and moderate left ventricular dysfunction. Group 1 patients who underwent valve replacement on a beating heart had significantly shorter cardiopulmonary bypass and ventilation times, reduced hospital stay, and better postoperative recovery of ejection fraction compared to Group 2, where conventional cardioplegic arrest was used. These results strongly support the concept that avoiding ischemia-reperfusion injury through continuous coronary perfusion during surgery preserves myocardial function.

Similar conclusions have been reported in recent surgical literature. Singh et al. (2023) demonstrated that beating-heart mitral valve replacement reduces postoperative morbidity, particularly in patients with impaired left ventricular function, by avoiding prolonged ischemic arrest [11]. Likewise, Kumar et al. (2022) reported improved left ventricular remodeling and shorter ICU stays in patients managed with beating-heart techniques compared to conventional arrested-heart procedures [12]. The cardioprotective benefits of maintaining myocardial perfusion during surgery were further reinforced by Patel et al. (2024), who observed lower postoperative CPK-MB levels and reduced arrhythmias among beating-heart surgery recipients [13].

Furthermore, in high-risk patients with pulmonary artery hypertension and atrial fibrillation, perioperative myocardial injury significantly influences outcomes. A multicenter registry analyzed by Dey et al. (2024) highlighted that myocardial preservation strategies such as beating-heart techniques can significantly reduce perioperative complications and contribute to earlier hospital discharge [14]. More recently, Zhao et al. (2025) emphasized that beating-heart mitral valve replacement, particularly in rheumatic cases, offers superior recovery of ejection fraction at one year, confirming its value in long-term myocardial protection [15].

Taken together, the present findings are consistent with these reports and provide strong evidence that bypass-assisted beating-heart mitral valve replacement is a safe and effective alternative to traditional arrested-heart surgery in patients with rheumatic mitral valve disease complicated by moderate left ventricular dysfunction.

CONCLUSION

Bypass-assisted beating-heart mitral valve replacement in rheumatic mitral valve disease with moderate left ventricular dysfunction provides significant advantages over conventional cold cardioplegic arrest. It is associated with reduced cardiopulmonary bypass and ventilation times, shorter hospital stay, lower cardiac enzyme release, and better postoperative improvement in ejection fraction and left ventricular remodeling. These findings reinforce the role of the beating-heart technique as an effective surgical strategy in patients with compromised ventricular function and support its use in centers managing rheumatic valve disease.

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