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Role of Dobutamine Stress Echocardiography in Prediction of Reversibility of Moderate Ischemic Mitral Regurgitation In Patients Undergoing CABG

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Abstract

Background: Ischemic mitral regurgitation (IMR) is a frequent consequence of ischemic heart disease (IHD) and commonly occurs in patients undergoing coronary artery bypass grafting (CABG). The best approach for managing moderate IMR remains debated, especially concerning the necessity of mitral valve surgery (MVS) alongside CABG. This study evaluates the role of dobutamine stress echocardiography (DSE) in predicting the reversibility of moderate IMR and its effect on surgical outcomes.

Methods: This cross-sectional study included 60 patients with moderate IMR undergoing CABG, with or without MVS, based on DSE findings. Patients were divided into two equal groups: Group A (CABG alone) and Group B (CABG with MVS). Clinical, echocardiographic, and postoperative data were collected, and patients were followed for six months.

Results: No significant difference in short-term survival was observed between the groups. However, the CABG+MVS group showed greater improvement in IMR severity, with 96.6% achieving none-to-mild IMR at follow-up compared to 80% in the CABG-only group ($p = 0.04$). Additionally, the effective regurgitant orifice area (EROA) was significantly smaller in the CABG+MVS group (5.90 ± 3.63 mm² vs. 20.03 ± 8.41 mm², $p < 0.001$). Despite these benefits, the incidence of low cardiac output syndrome (LCOS) was higher in the CABG+MVS group (60% vs. 33.3%, $p = 0.03$).

Conclusion: Combined CABG and MVS significantly improves IMR severity and clinical outcomes in patients with moderate IMR but increase the risk of LCOS. Preoperative DSE is a valuable tool in selecting appropriate candidates for MVS.

KEYWORDS
Ischemic Mitral Regurgitation; Coronary Artery Bypass Grafting; Mitral Valve; Dobutamine Stress

Introduction

Ischemic heart disease (IHD) and myocardial ischemia can lead to mitral regurgitation (MR) through various mechanisms, including dysfunction or disruption of the papillary muscle apparatus, displacement of the mitral chordae and leaflets, or dilation of the mitral annulus. When the mitral valve apparatus remains structurally intact despite MR, the condition is classified as functional MR [1].

Ischemic mitral regurgitation (IMR) is present in up to 40% of patients with coronary artery

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disease (CAD) and those undergoing coronary artery bypass grafting (CABG), with a reported five-year mortality rate of 62%. In chronic IMR, the mitral leaflets and subvalvular structures remain anatomically intact but are affected by left ventricular (LV) remodeling. This remodeling alters LV size and shape, leading to papillary muscle displacement, mitral leaflet tethering, and annular deformation [2]. While moderate IMR often resolves following CABG due to LV size reduction, persistent IMR post-CABG is linked to worse clinical outcomes. Additionally, variations in IMR definitions create challenges in comparing study results [3].

The Carpentier surgical classification of ischemic mitral valve (MV) pathology categorizes dysfunction based on leaflet motion and the underlying mechanism of IMR. It is classified into three types: Type I (Normal Leaflet Motion, Annular Dilation), Type II (Excessive Leaflet Motion, Prolapse), Type IIIa (Diastolic Restriction), and Type IIIb (Systolic Restriction) [1]. Restriction of MV leaflet mobility during systole and mitral annulus dilatation, without detectable primary lesion to the integrity of MV leaflets and subvalvular apparatus, are the common functional alterations found in IMR, therefore categorized as type IIIb and type I.

Stress echocardiography is a diagnostic imaging technique that assesses cardiac structure and function under dynamic conditions induced by either physical exercise or pharmacologic stress. This procedure increases heart rate, cardiac output, and myocardial oxygen demand. While exercise stress echocardiography provides physiological insights, pharmacologic stress echocardiography minimizes motion artifacts related to chest wall movement and respiratory effort, thereby enhancing imaging quality. This technique is widely used to evaluate myocardial ischemia, myocardial viability, and valvular dysfunction [4].

Compared to radionuclide imaging, pharmacologic stress echocardiography offers advantages such as the absence of radiation exposure, no need for specialized radiopharmaceuticals, and the ability to capture real-time images from rest to peak stress. Dobutamine stress echocardiography (DSE) has demonstrated high sensitivity and specificity in diagnosing cardiovascular diseases, making it a valuable tool in clinical practice [5].

For patients with moderate MR undergoing CABG, the decision to perform mitral valve repair (MVR) remains controversial. Some studies suggest that revascularization alone can lead to MR improvement, whereas others report no significant change. The findings of recent meta-analysis suggest that combined MVR and CABG does not improve the clinical outcomes of patients with moderate IMR compared to CABG alone [6, 7]. Persistent MR following CABG is associated with adverse outcomes, yet MVR carries additional surgical risks. Predicting MR improvement before surgery could help in avoiding unnecessary mitral valve interventions [8].

Table 1: Demographic characteristics of studied patients. Categorical data are expressed as number (%) and continuous data are expressed as mean ±standard deviation, n: Number

Variables	Total (n=60)	Groups		P-value
		CABG-MVS (n=30)	CABG+MVS (n=30)	
Age (years)	55.43±6.09	55.57±5.84	55.3±6.43	0.86
Gender:				
Male	44(73.3%)	21(70%)	23(76.7%)	0.55
Female	16(26.7%)	9(30%)	7(23.3%)	
BMI (kg/m^2)	27.58±3.60	27.90±3.83	27.27±3.39	0.50

CABG: Coronary artery bypass grafting, MVS: Mitral valve surgery, BMI: Body mass index

*Table 2: Comprehensive preoperative data of study groups. data are expressed as mean ± standard deviation for continuous variables and number (percentage) for categorical variables, *: P < 0.05 indicates statistical significance*

Variables	Total (n=60)	CABG-MVS (n=30)	CABG+MVS (n=30)	P-value
NYHA Class of Dyspnea				
I	2 (3.3%)	2 (6.7%)	0 (0%)	0.15
II	31 (51.7%)	17 (56.7%)	14 (46.7%)	0.43
III	25 (41.7%)	10 (33.3%)	15 (50%)	0.19
IV	2 (3.3%)	1 (3.3%)	1 (3.3%)	1
CCS Grade of Angina				
I	1 (1.7%)	0 (0%)	1 (3.3%)	0.31
II	29 (48.3%)	17 (56.7%)	12 (40%)	0.19
III	28 (46.7%)	12 (40%)	16 (53.3%)	0.30
IV	2 (3.3%)	1 (3.3%)	1 (3.3%)	1
Preoperative Morbid Conditions				
Smoking	36 (60%)	17 (56.7%)	19 (63.3%)	0.59
Diabetes Mellitus	27 (45%)	8 (26.7%)	19 (63.3%)	0.004*
Hypertension	28 (46.7%)	10 (33.3%)	18 (60%)	0.03*
Hypercholesterolemia	17 (28.3%)	6 (20%)	11 (36.7%)	0.15
Chronic Renal Failure	1 (1.7%)	1 (3.3%)	0 (0%)	0.31
Chronic Respiratory Disea	1 (1.7%)	0 (0%)	1 (3.3%)	0.31
Congestive Heart Failure	2 (3.3%)	0 (0%)	2 (6.7%)	0.15
Myocardial Infarction	5 (8.3%)	2 (6.7%)	3 (10%)	0.64
Previous PCI	6 (10%)	1 (3.3%)	5 (16.7%)	0.08
Angiographic Extent of CAD				
1-vessel disease	3 (5%)	1 (3.3%)	2 (6.7%)	0.55
2-vessel disease	9 (15%)	6 (20%)	3 (10%)	0.27
3-vessel disease	48 (80%)	23 (76.7%)	25 (83.3%)	0.51
LMS Disease	2 (3.3%)	1 (3.3%)	1 (3.3%)	1
Transthoracic Echocardiographic Data				
LVEF (%)	54.02 ± 7.67	54.33 ± 6.31	53.7 ± 8.92	0.75
LVEDD (cm)	4.83 ± 0.51	4.85 ± 0.52	4.82 ± 0.52	0.82
LVESD (cm)	3.24 ± 0.42	3.25 ± 0.40	3.24 ± 0.45	0.88
LA Diameter (cm)	4.45 ± 0.33	4.50 ± 0.32	4.40 ± 0.34	0.26
EROA (mm^2)	25.73 ± 9.08	23.70 ± 6.28	27.77 ± 10.94	0.08
Dobutamine Stress Echocardiographic Data				
LVEF (%)	57.17 ± 5.13	56.63 ± 4.56	57.70 ± 5.67	0.42
EROA (mm^2)	15.25 ± 7.95	8.73 ± 0.86	21.77 ± 6.33	<0.001*
WMSI	1.69 ± 0.39	1.67 ± 0.41	1.71 ± 0.37	0.67

CABG: Coronary artery bypass grafting, MVS: Mitral valve surgery, NYHA: New York Heart Association, CCS: Canadian Cardiovascular Society, LMS: Left main stem disease, LVEF: Left ventricular ejection fraction, LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, LA: Left atrium, EROA: Effective regurgitant orifice area, WMSI: Wall motion score index

*: P < 0.05 indicates statistical significance

A clear understanding of MR mechanisms is essential to determine whether MVR or replacement is required. Therefore, this study aims to investigate the effectiveness of low-dose DSE in identifying patients undergoing CABG who may benefit from MVR versus those whose MR is likely to improve with CABG alone.

Patients and Methods

Design and population

This prospective multi-center study enrolled 60 patients with moderate IMR, who were recruited from the Cardiothoracic Surgery Departments at Banha University Hospital, Naser City Insurance Hospital, and Al-Minia University Hospital. The study methodology of this non-randomized trial likely follows a comparative approach without random allocation of participants. Patients are assigned to treatment groups based on clinical decision-making rather than randomization. The patients were followed for six months. The study was conducted after obtaining approval from the Institutional Review Board (IRB), and written informed consent was obtained from all participants.

Eligibility criteria

Adult patients of both genders diagnosed with chronic stable coronary artery disease (CAD) and scheduled for isolated, elective, on-pump coronary artery bypass grafting (CABG) with moderate ischemic mitral regurge were included in the study.

Exclusion criteria comprised patients with structural causes of mitral regurgitation (MR), such as ruptured chordae or papillary muscles, abnormal leaflet thickening, annular calcification, other valvular or congenital heart diseases, or ventricular aneurysms. Additional exclusions included those with severe ischemic MR, concomitant valve replacement, prior cardiac surgery, redo-CABG, emergency CABG, or recent myocardial infarction (MI) or acute coronary syndrome (ACS).

Dobutamine stress echocardiography (DSE) was performed preoperatively on all patients. Based on the results, they were categorized into two equal groups: Group A: positive DSE results cases who underwent CABG alone without mitral valve surgery (MVS). Group B: negative DSE results cases who underwent combined CABG and MVS. Cases with positive DSE are those cases who had shown improvement in mitral regurge in DSE and so they will go CABG alone, and vice versa in negative DES cases.

Both groups were monitored using transthoracic echocardiography (TTE) six months postoperatively.

DSE Protocol

The standard dobutamine dosing protocol involves starting dose of 5mcg/kg/min, followed by incremental increases every 3 minutes to a maximum dose of 40 mcg/kg/min. If needed: Atropine (0.25–1 mg) may be administered if the target heart rate is not achieved. During the procedure, continuous ECG monitoring and BP measurement are essential. The test is stopped upon achieving a target heart rate (~85% of age-predicted maximum HR), ischemic symptoms, significant arrhythmias, or hypotension. Low-dose dobutamine (5–10 mcg/kg/min) is used instead of both endpoints (low dose and high dose) to detect contractile reserve in dysfunctional myocardium. Viable myocardium shows improvement in contractility at low doses, suggesting preserved myocardial function despite resting dysfunction. High-dose stages may not add useful information for viability studies and may introduce ischemic confounders.

A positive Dobutamine Stress Echocardiography (DSE) refers to the presence of ischemic or non-viable myocardium as indicated by certain findings during the test. It is typically characterized by: New or worsening regional wall motion abnormalities (RWMA) or failure to improve or worsening contractile function.

Surgical Technique

Coronary artery bypass grafting (CABG) combined with mitral valve surgery involved two primary techniques: mitral valve repair with an undersized ring and mitral valve replacement. Mitral valve repair is often preferred when feasible, as it preserves the native valve and avoids the risks associated with prosthetic valve replacement. Mitral valve replacement is considered when valve repair is not feasible due to extensive damage or degenerative changes in the valve apparatus. The choice between repair and replacement typically depends on the underlying etiology of the mitral valve disease, the degree of valve damage, and the patient's overall health status. In general, mitral valve repair with an

undersized ring is preferred due to its better long-term outcomes, including reduced risk of thromboembolic events and valve degeneration compared to replacement. However, replacement is necessary if repair is not possible.

Data collection

Preoperative Data: Collected parameters included demographic details, clinical characteristics such as New York Heart Association (NYHA) class, obesity, smoking status, and comorbidities (chronic obstructive pulmonary disease (COPD), hypertension, diabetes mellitus, hypercholesterolemia, systemic diseases, prior MI, and history of transient ischemic attack (TIA) or stroke). DSE parameters included ejection fraction (EF) at rest, low-dose, and peak-dose stages, wall motion score index, and myocardial viability, defined as contractility improvement in ≥4 segments.

Intraoperative Data: Recorded intraoperative details included cross-clamp time, total bypass time, blood transfusion requirements, intra-aortic balloon pump (IABP) usage, type of conduit used, and the number of distal anastomoses performed.

Postoperative Data: Postoperative outcomes included mechanical ventilation duration, lengths of intensive care unit (ICU) and hospital stays, reoperation for complications, occurrence of low cardiac output syndrome, renal impairment, respiratory complications, MI, stroke, sternal wound infection, and NYHA class. Postoperative echocardiography was used to evaluate EF, MR severity, wall motion abnormalities, and other significant findings. The primary outcome measure was degree of MR 6 months post operative.

Investigations and Procedures

Routine preoperative laboratory tests included a complete blood count (CBC), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), liver and kidney function tests, lipid profile, and coagulation parameters (prothrombin time (PT), partial thromboplastin time (PTT), and international normalized ratio (INR)). Radiological assessments included coronary angiography to evaluate multivessel disease and TTE for cardiac function assessment. DSE was conducted using incremental intravenous dobutamine infusion (5–40 µg/kg/min) to assess myocardial viability. Postoperatively, TTE was repeated at one week and six months to evaluate patient outcomes. The use of a 6-month postoperative echocardiogram as the primary follow-up monitoring tool after CABG plus MVR is often based on several clinical considerations: Early stabilization of cardiac function, consolidation of remodeling, reduced risk of early postoperative changes, evidence from clinical studies, consistency with guidelines, and predictive value of 6-month echocardiography for long-term outcomes following CABG plus MVR.

Statistical analysis

Statistical analysis was conducted using SPSS version 23 (SPSS Inc., Chicago, Illinois). Descriptive statistics are expressed as mean ± standard deviation for continuous variables and as frequencies (count and percentage) for categorical variables. To compare continuous data between groups, Student's t-test was applied, while the Chi-square test was used for categorical data. A p-value of 0.05 or less was deemed statistically significant.

Table 3: Number and site of distal coronary artery anastomosis. Categorical data are expressed as number (%) and continuous data are expressed as mean ±standard deviation.

Variables	Total (n=60)	Groups		P-value
		CABG-MVS (n=30)	CABG+MVS (n=30)	
Number of distal anastomosis	3.08±0.72	3.03±0.61	3.33±0.80	0.10
Site of distal anastomosis				
LAD	60(100%)	30(100%)	30(100%)	1
LCx	55(91.7%)	27(90%)	28(93.3%)	0.64
RCA	52(86.7%)	25(83.3%)	27(90%)	0.44

CABG: Coronary artery bypass grafting. MVS: Mitral valve surgery. LAD: Left anterior descending. LCx: Left circumflex. RCA: Right coronary artery. SD: standard deviation

Table 4: Comprehensive postoperative data of study groups. continuous data are expressed as mean ± standard deviation, categorical data are expressed as number (%)

Variables	Total (n=60)	CABG-MVS (n=30)	CABG+MVS (n=30)	P-value
Postoperative Mortality and Morbidity				
In-hospital mortality	1 (1.7%)	0 (0%)	1 (3.3%)	0.31
Low cardiac output	28 (46.7%)	10 (33.3%)	18 (60%)	0.03*
IABP	3 (5%)	1 (3.3%)	2 (6.7%)	0.55
Arrhythmia	4 (6.7%)	1 (3.3%)	3 (10%)	0.30
Reoperation	3 (5%)	1 (3.3%)	2 (6.7%)	0.55
Respiratory complications	1 (1.7%)	1 (3.3%)	0 (0%)	0.31
Neurological complications	1 (1.7%)	1 (3.3%)	0 (0%)	0.31
Postoperative Durations				
Ventilation (hours)	16.35 ± 21.96	1.20 ± 1.09	1.13 ± 0.62	0.77
ICU stays (days)	2.35 ± 1.47	2 ± 1.64	2.7 ± 1.80	0.12
Hospital stay (days)	9.10 ± 5.59	8 ± 4.82	10.2 ± 6.15	0.12
Postoperative Transthoracic Echocardiographic Data				
LVEF (%)	55.64 ± 6.18	55.60 ± 5.04	55.69 ± 7.28	0.95
LVEDD (cm)	4.58 ± 0.37	4.58 ± 0.39	4.57 ± 0.35	0.91
LVESD (cm)	3.30 ± 0.35	3.29 ± 0.37	3.30 ± 0.33	0.91
LA (cm)	4.07 ± 0.38	4.06 ± 0.40	4.09 ± 0.37	0.75
EROA (mm^2)	13.08 ± 9.62	20.03 ± 8.41	5.90 ± 3.63	<0.001*
Postoperative Changes in Severity of MR				
None/mild MR	51 (86.4%)	24 (80%)	28 (96.6%)	0.04*
Moderate/severe MR	7 (11.9%)	6 (20%)	1 (3.4%)	

CABG: Coronary artery bypass grafting, MVS: Mitral valve surgery, IABP: Intra-aortic balloon pump, LVEF: Left ventricular ejection fraction, LVEDD: Left ventricular end-diastolic diameter, LVESD: Left ventricular end-systolic diameter, LA: Left atrium, EROA: Effective regurgitant orifice area, MR: Mitral regurgitation

*: statistically significant difference ($p < 0.05$)

Results

The study included 60 patients with a mean age of 55.43 ± 6.09 years, with no significant age difference between the CABG-MVS (55.57 ± 5.84 years) and CABG+MVS (55.3 ± 6.43 years) groups ($p = 0.86$). Males made up 73.3% of the participants, with similar distributions in both groups (70% in CABG-MVS and 76.7% in CABG +MVS, $p = 0.55$). The mean BMI for the cohort was 27.58 ± 3.60 kg/m^2, with no significant difference between the groups ($p = 0.50$). Table 1

The comprehensive preoperative data showed no significant differences in NYHA class of dyspnea or Canadian Cardiovascular Society (CCS) grade of angina between the CABG-MVS and CABG+MVS groups. Most patients presented with NYHA class II dyspnea (51.7%) and CCS grade II angina (48.3%). Diabetes mellitus and hypertension were significantly more prevalent in the CABG+MVS group (63.3% vs. 26.7%, $p = 0.004$; 60% vs. 33.3%, $p = 0.03$, respectively). The extent of CAD was similar between groups, with 3-vessel disease observed in 80% of patients, and LMS disease in 3.3% of patients, distributed equally between groups. Preoperative transthoracic echocardiographic findings, including LVEF (54.02 ± 7.67%) and LV dimensions, were comparable between groups. However, DSE revealed a significantly higher EROA in the CABG+MVS group (21.77 ± 6.33 mm^2 vs. 8.73 ± 0.86 mm^2, $p < 0.001$), while LVEF and WMSI showed no differences. Table 2

Intraoperative data showed significantly longer operative times in the CABG+MVS group. The mean total bypass time was 129.8 ± 44 minutes, compared to 84.97 ± 24.64 minutes in

the CABG-MVS group ($p < 0.001$). The mean cross-clamp time was also longer in the CABG+MVS group (92.87 ± 32.83 minutes) compared to the CABG-MVS group (57.23 ± 16.26 minutes) ($p < 0.001$).

The mean number of distal anastomoses for the entire cohort was 3.08 ± 0.72, with no significant difference between the CABG-MVS (3.03 ± 0.61) and CABG+MVS (3.33 ± 0.80) groups ($p = 0.10$). All patients underwent left anterior descending artery anastomosis, with no difference between groups. Left circumflex artery anastomosis was performed in 91.7% of patients, with 90% in the CABG-MVS group and 93.3% in the CABG+MVS group ($p = 0.64$). Right coronary artery anastomosis was performed in 86.7% of patients, with 83.3% in the CABG-MVS group and 90% in the CABG+MVS group ($p = 0.44$). Table 3

Postoperative in-hospital mortality occurred in 1.7% of patients, with no deaths in the CABG-MVS group and 3.3% in the CABG+MVS group ($p = 0.31$). Low cardiac output was significantly higher in the CABG+MVS group (60%) compared to the CABG-MVS group (33.3%, $p = 0.03$). Intra-aortic balloon pump use, arrhythmia, and reoperation rates were low and showed no significant differences between groups ($p > 0.30$). Postoperative ventilation time (16.35 ± 21.96 hours), ICU stays (2.35 ± 1.47 days), and hospital stay (9.10 ± 5.59 days) were comparable between groups ($p > 0.05$). Echocardiographic findings showed no differences in left ventricular function or dimensions. However, the EROA was significantly lower in the CABG+MVS group (5.90 ± 3.63 mm^2) compared to the CABG-MVS group (20.03 ± 8.41 mm^2, $p < 0.001$). At follow-up, none-to-mild mitral regurgitation was more frequent in the CABG+MVS group (96.6%) compared to the CABG-MVS group (80%, $p = 0.04$), with significant reductions in mitral regurgitation observed in both groups ($p < 0.001$). Table 4

In the CABG-MVS group, none-to-mild mitral regurgitation increased from 0% preoperatively to 80% postoperatively, while moderate/severe mitral regurgitation decreased from 100% to 20% ($p < 0.001$). In the CABG+MVS group, none-to-mild mitral regurgitation increased from 0% to 96.6%, and moderate/severe mitral regurgitation decreased from 100% to 3.4% ($p < 0.001$).

For dyspnea, the CABG-MVS group showed a significant improvement, with NYHA class I increase from 6.7% preoperatively to 63.3% postoperatively, and classes III and IV decreasing from 33.3% and 3.3% to 6.7% and 0%, respectively ($p < 0.001$). In the CABG+MVS group, NYHA class I increased from 0% to 51.7%, while classes III and IV decreased from 50% and 3.3% to 0% ($p < 0.001$). Table 5

Discussion

IHD can lead to MR through mechanisms such as papillary muscle dysfunction, mitral chordae malposition, or annular dilation. IMR affects up to 40% of CAD patients and those undergoing CABG, with a 5-year mortality rate of 62% [1]. This study examines clinical and echocardiographic outcomes in 60 adults with moderate IMR undergoing CABG, with or without MVS, based on MR reversibility assessed during DSE.

This study's primary finding indicated that there was no difference in short-term survival; however, a significant improvement in MR severity was observed following the combined procedures of CABG and MVS, in contrast to CABG

The main finding of this study was no difference in short-term survival, but a significant improvement in MR severity following combined CABG and MVS compared to CABG alone. Ischemic MR, frequently seen in ischemic heart disease and myocardial infarction, can be either acute or chronic. Acute IMR is caused by papillary muscle infarction, while chronic IMR is associated with left ventricular remodeling and changes to the mitral valve. Surgical options for IMR include CABG alone, CABG with mitral valve replacement, and CABG with MVR. Although severe MR can be corrected during CABG, the best approach for moderate ischemic MR is still a topic of debate.

Proponents of a conservative approach to moderate IMR during CABG present several arguments: (1) revascularizing ischemic areas enhances regional wall motion and helps correct MR; (2) research suggests that CABG alone, even

Table 5: Pre- and postoperative severity of mitral regurgitation and dyspnea status

Group	Variables/NYHA Class	Time	P-value
CABG-MVS	None/mild MR	Preoperative: 0 (0%) Postoperative: 24 (80%)	<0.001*
CABG-MVS	Moderate/severe MR	Preoperative: 30 (100%) Postoperative: 6 (20%)	
CABG+MVS	None/mild MR	Preoperative: 0 (0%) Postoperative: 28 (96.6%)	<0.001*
CABG+MVS	Moderate/severe MR	Preoperative: 30 (100%) Postoperative: 1 (3.4%)	
CABG-MVS	NYHA Class I	Preoperative: 2 (6.7%) Postoperative: 19 (63.3%)	<0.001*
CABG-MVS	NYHA Class II	Preoperative: 17 (56.7%) Postoperative: 9 (30%)	
CABG-MVS	NYHA Class III	Preoperative: 10 (33.3%) Postoperative: 2 (6.7%)	
CABG-MVS	NYHA Class IV	Preoperative: 1 (3.3%) Postoperative: 0 (0%)	
CABG+MVS	NYHA Class I	Preoperative: 0 (0%) Postoperative: 15 (51.7%)	<0.001*
CABG+MVS	NYHA Class II	Preoperative: 14 (46.7%) Postoperative: 14 (48.3%)	
CABG+MVS	NYHA Class III	Preoperative: 15 (50%) Postoperative: 0 (0%)	
CABG+MVS	NYHA Class IV	Preoperative: 1 (3.3%) Postoperative: 0 (0%)	

CABG: Coronary artery bypass grafting, MVS: Mitral valve surgery, NYHA: New York Heart Association, MR: Mitral regurgitation, categorical data are expressed as number (%)

*Significant difference

with some remaining MR, does not influence long-term survival or functional outcomes; (3) MVS increases operative risk, with mortality rates often exceeding 10%; (4) small left atria in ischemic MR patients complicate mitral valve exposure and repair; and (5) mitral valve replacement necessitates long-term anticoagulation or reoperation risk.

While some observational studies suggest a benefit of adding MVS to CABG for moderate ischemic MVR, many report neutral findings [9, 10], and others find no benefit [11, 12].

Guidelines support MVR during CABG for moderate ischemic MR, though the evidence remains inconclusive. Meta-analyses have shown mixed results: Yin et al. [13] found improved MR grade with combined CABG and MV repair, but no benefit in mortality, MR improvement, NYHA class, or five-year survival. Kopjar et al. [14] reported no survival benefit or increased operative mortality with combined surgery, though the risk of residual MR was higher in the CABG-only group.

Sameer and colleagues [6] conducted a meta-analysis that found adding MVR to CABG does not improve clinical outcomes in moderate ischemic MR patients. The CABG+MVR group had higher early and late mortality, but lower NYHA scores compared to those undergoing CABG alone. A more recent meta-analysis by Li and colleagues [7], which included six randomized trials, also found no clinical advantage to adding MVR to CABG for moderate IMR patients.

Roshanali et al. [15] suggested CABG alone may suffice for moderate MR if MR improves during DSE, and their 2014 study involving 110 patients supported using DSE to select valve repair candidates but noted it could not predict long-term outcomes.

Kochanowski et al. [16] found transesophageal DSE useful for selecting the optimal surgical approach for significant ischemic MR and further confirmed its utility in guiding treatment decisions. Piatkowski et al. [17] emphasized preoperative TTE importance, including rest and stress echo, in identifying cases likely to experience recurrent IMR post-CABG. Factors like larger LV volumes, lower LVEF, and higher tethering areas on TTE, along with changes in mitral deformation indices during stress echo, were linked to IMR recurrence, suggesting the need for additional repairs or MVR in such cases.

Our DSE protocol focused on assessing myocardial viability and changes in IMR severity. Surgical intervention for moderate ischemic mitral regurgitation is more probable in the presence of myocardial viability and minimal comorbidities. An exercise-induced elevation in MR severity and systolic pulmonary artery pressure indicates that the combination of CABG and MV surgery may yield greater benefits [18, 19].

Preoperative DSE helps identify patients with moderate IMR who may benefit from CABG plus MV surgery. Myocardial viability and LV remodeling are key factors in surgical decision-making. Studies show that viable myocardium is linked to improved LV remodeling and MR reduction in moderate IMR patients undergoing isolated CABG [20, 21]. However, patients with chronic ischemic damage, limited viable myocardium, or no bypass targets in the posterior-inferior-lateral region may not benefit from isolated CABG.

Preoperative demographics, comorbidities, and cardiovascular risk factors were comparable between the two groups, suggesting that postoperative outcomes were more likely influenced by the surgical procedure than by patient-related factors.

Preoperative DSE revealed a significant reduction in EROA in the CABG-only group compared to the combined CABG and MVS group, which was not reflected on TTE. This suggests that MR reversibility, assessed by DSE, was a key factor in determining whether CABG alone was sufficient. In patients with moderate MR, EROA is typically between 20 and 40 mm^2 [22].

The CABG+MVS group had significantly higher total bypass time (129.8±44 vs. 84.97±24.64 minutes) and cross-clamp time (92.87±32.83 vs. 57.23±16.26 minutes) compared to the CABG-only group. These durations align with findings from other studies [23, 24], where longer pump and cross-clamp times were observed for CABG with MVS.

No significant difference was observed in early mortality between the two groups (0% in CABG-only vs. 3.3% in CABG+MVS), suggesting that both procedures offer similar survival benefits. Early mortality, defined as death within 30 days or during hospitalization, was comparable across both groups, which is consistent with other studies [25, 26]. Furthermore, while adding mitral valve surgery to CABG did not reduce long-term mortality. Fattouch et al. [27] found no significant difference in in-hospital mortality between the CABG group (1.8%) and the CABG with mitral valve restrictive annuloplasty group (4.1%) in patients with moderate IMR.

In contrast, Kim et al. (2018) observed a significantly higher early mortality rate in the CABG+MVS group (11.2% vs. 3.7%). An observational analysis by Sameer et al. [6] also showed higher short-term mortality with combined MV repair.

The postoperative complications exhibited a generally comparable profile; however, there was a notably higher incidence of LCOS in the CABG+MVS group, recorded at 60% in contrast to 33.3%. In this study, LCOS is characterized as the requirement for IABP or extended inotropic support, a condition frequently observed following cardiac surgery. Kim et al. [28] additionally documented heightened risks of LCOS and surgical bleeding within the CABG+MVS

cohort. In contrast, Sa et al. [29] reported reduced rates of LCOS (6.3% compared to 42.3%) and atrial fibrillation (6.3% compared to 38.5%) within the combined procedure group. Additional research has indicated an elevated incidence of supraventricular arrhythmias in the CABG+MVS cohort in comparison to those undergoing CABG solely [18, 30].

In our study, the duration of postoperative ICU stays (2±1.64 vs. 2.7±1.80 days) and length of hospital stay (8±4.82 vs. 10.2±6.15 days) were not significantly different between the CABG alone and CABG+MVS groups. Similarly, El-Hag-Aly et al. [24] found no significant difference in ICU stays (43.1±7.6 vs. 44.3±7.8 hours) or hospital stay (7.7±1.6 vs. 8.3±1.8 days) between the two groups. Goland et al. [31] also reported no significant difference in hospital stay (11.5±13 vs. 11±8.1 days).

Contrastingly, Piatkowski et al. [17] found significantly longer hospital stays in the combined procedure group (29.9 vs. 20.5 days), and Smith et al. (2014) reported longer ICU (4.8±6.1 vs. 4.0±5.7 days) and hospital stays (11.3±8.2 vs. 9.4±5.9 days) in the CABG+MVS group.

Postoperative echocardiography showed a significant decrease in EROA in the CABG+MVS group, along with a lower recurrence rate of MR (3.4% vs. 20%) compared to the CABG-only group, reflecting significant MR improvement after combined surgery. Similar results were reported by Goland and collaborators [31]. El-Hag-Aly and collaborators [24] found lower recurrence of MR in the combined group (2.5% vs. 12.5%) at follow-up.

A meta-analysis by Zhang et al. [25] confirmed that CABG+MVS resulted in lower residual MR and better outcomes compared to CABG alone. However, Hung et al. [32] reported up to 30% recurrence of moderate or progression to severe MR in the combined cohort.

Both groups showed MR improvement, with a more notable reduction in the cohort undergoing the combined procedure. CABG procedure alone also showed significant improvement in MR among patients with viable myocardium, as assessed by DSE, suggesting that the enhancement is due to reduced ischemia [15].

Recent meta-analysis studies continue to show differing perspectives on this issue. Nappi et al. [33] found that subvalvular papillary muscle repair combined with restrictive mitral annuloplasty alongside CABG may help reduce the risks of early mortality, reoperation, and re-hospitalization due to heart failure. On the other hand, a meta-analysis by Alsuayr et al. [34] indicated no significant difference between patients undergoing CABG alone and those undergoing CABG plus MVR. Nevertheless, this comparison highlights the importance of personalized treatment plans tailored to the unique characteristics of each patient.

Limitations

Our study has several limitations, including a small sample size, the absence of randomization, and the lack of long-term follow-up. It is advisable to conduct future large-scale studies with long-term evaluations that compare MVR to replacement, as well as to identify predictors of unfavorable outcomes following combined MVS and CABG for moderate IMR.

Conclusion

Our findings confirmed the short-term efficacy and safety of mitral valve surgery combined with CABG in patients with moderate IMR in terms of clinical and echocardiographic outcome.

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