The Impact of Mitral Valve Replacement in Treating Moderate-to-Severe Ischemic Mitral Regurgitation on Preservation of the Left Ventricular Function

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ABSTRACT

Background: Moderate-to-severe ischemic mitral regurgitation (IMR) accounts for 10-20% of ischemic heart disease (IHD) cases. Although the widespread recommendations by the guidelines for dealing with it surgically, they don't clearly address mitral valve (MV) repair to be of choice over MV replacement (MVR) due to the numerous contradictory and un-conclusive results reported about both techniques.

Objective: This study aimed to evaluate the impact of MVR in treating moderate-to-severe IMR on one-year outcomes [left ventricular (LV) function, mortality, major cardiac problems, cerebrovascular adverse events, functional status, and quality of life].

Patients and methods: This retrospective study included twenty-three patients presented with IHD complicated with moderate-to-severe IMR and operated upon by coronary artery bypass grafting (CABG) and MVR. All relevant data were evaluated in the preoperative, intraoperative, and over one-year postoperative periods.

Results: The mean age was 58.22 ± 3.58 years. They were all in Canadian Cardiovascular Society (CCS) grade III. The mean preoperative left ventricular ejection fraction per cent (LVEF %) was 40.75 ± 1.35. Intraoperative mortality was nil. Early (immediate) postoperative mortality was 4.34%. Late mortality was nil. The overall hospital complications rate was 21.73%. The overall one-year survival rate was 95.65% with statistically significant improvement of LVEF% with a mean of 52.86 ± 1.59 ($p<0.001$), CCS grade and New York Heart Association (NYHA) class whereas 90.91% were in CCS grade I and NYHA class I while 9.09% in CCS grade II and NYHA class II ($p<0.001$).

Conclusion: Although conjoint MVR with CABG resembles an aggressive approach for treating moderate-to-severe IMR, its performance is safe and beneficial. Even hazardous in the early postoperative period, it showed lower rates of intraoperative, early and late mortality and morbidities particularly the newly developed postoperative atrial fibrillation (AF) and low cardiac output syndrome. At one-year follow-up period, it resulted in preserving and augmenting the LV systolic function improving significantly the impaired preoperative LVEF% and the functional clinical status of the patients.

Keywords: IHD, Moderate-to-severe IMR, CABG and MVR.

INTRODUCTION

Ischemic mitral regurgitation (IMR), which can be expressed as a regurgitation of the mitral valve (MV) following myocardial infarction (MI) due to coronary artery disease (CAD) of the circumflex or the right coronary branches resulting in significant segmental wall motion abnormalities (SWMAs). Yet, unaffected MV leaflets is the commonest complication of ischemic heart disease (IHD) accounting for 20-50% of the cases [(1)]. The grade of IMR depends on the severity of the underlying pathology that causes distortion of the LV and evident remodeling with resultant apico-lateral papillary muscle tethering and consequently MV annular disfigurement preventing proper coaptation of the MV leaflets during systole [(2)]. Even the mild grade of the disease is associated with morbid adverse complications and mortality. The moderate-to-severe IMR grade, which accounts for 10-20% of IHD cases, reports doubled-incidence of congestive heart failure and mortality [(3, 4)]. Whilst, the cut point of differentiating moderate or severe IMR is established by different diagnostic tools including echocardiography, only the quantitative parameters (amongst the others namely structural, qualitative and semiquantitative parameters) can help subclassify the moderate group and clearly outline the moderate-to-severe subgroup [(5)]. This is agreed upon according to the 2020 ACC/AHA Joint Committee and the 2021 European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) guidelines [(6, 7)].

Although the widespread recommendations by the guidelines for dealing with moderate-to-severe IMR surgically, they don't clearly address MV repair to be of choice over MV replacement (MVR) due to the numerous contradictory and un-conclusive results reported about both techniques [(8)]. Reported evidence doesn't conclude any difference in mortality, cerebrovascular adverse complications, and heart failure condition between MV repair or MVR used to treat moderate-to-severe IMR. However, MVR cases shows better preservation of the LV function and

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freedom of recurrence of mitral regurgitation (MR). This fact argues with the traditional concept adopted by many cardiac surgeons who prefer to handle MV repair over MVR [(9)], and they would consider MVR especially in the presence of dyskinesia or basal aneurysm being certain causes of MR recurrence after MV repair and also due to the existing "lack of attempting" more complex repair maneuvers of the MV subvalvular apparatus dealing exactly with the resulted pathology [(10)].

Notably, The Cardiothoracic Surgical Trials Network (CTSN) pays attention to these everlasting biases and demonstrates clearer surgical management plans with recommendations of the MVR approach over MV repair [(11)].

This study aimed to evaluate the impact of MVR in treating moderate-to-severe IMR on one-year outcomes (LV function, mortality, major cardiac problems, cerebrovascular adverse events, functional status, and quality of life).

PATIENTS AND METHODS

Study Design: This retrospective observational non-randomized study included 23 patients who presented with IHD complicated with moderate-to-severe IMR. They had been operated upon by primary surgical myocardial revascularization CABG surgery and MVR. All relevant data of the surgical procedure were studied and thoroughly evaluated in the preoperative, intraoperative, and over one-year postoperative periods.

All surgeries were carried out in Egypt (conducted in the operating theatre of the Department of Cardiothoracic Surgery, Faculty of Medicine, Cairo University) using standard open-heart on-pump surgical procedures. Data of the study was collected for the operated-upon patients in the period between August 2018 and December 2022.

Inclusion criteria: Adult patients with multi-vessel CAD, left main or left main-equivalent CAD who were scheduled for elective primary CABG surgery. They were complicated by moderate-to-severe IMR, which met the following echocardiographic criteria: 2 D effective regurgitant orifice area. The proximal isovelocity surface area (PISA) was 0.30-0.39 cm^2, the regurgitant volume (RVol) was 45-49 mL, and the regurgitant fraction (RF) was 40-49%. According to CCS categorization of angina pectoris, they reported anginal discomfort grade III.

Exclusion criteria: Conditions that necessitated surgery, such as tricuspid valve disease, ascending aortic aneurysm/dissection, left ventricular aneurysm, and ventricular septal abnormalities. The research did not include re-do situations.

Management Regimen:

The assessed preoperative variables included age, gender, risk factors of cardiovascular disease e.g. hypertension, smoking, diabetes mellitus (DM), dyslipidemia, post-menopause, and family history of susceptibility to IHD, CCS grade, New York Heart Association (NYHA) class, previous MI and history of cardiac care unit (CCU) admission, history of coronary angioplasty (percutaneous coronary intervention) (PCI) and stenting, echocardiography parameters (left ventricular ejection fraction percentage (LVEF%), EROA 2D PISA (cm^2), RVol (mL) and RF (%)), European System for Cardiac Operative Risk Evaluation (EuroSCORE) II, Society of Thoracic Surgeons (STS) score, chronic obstructive pulmonary disease (COPD) (defined by the presence of chronic cough and prolonged use of bronchodilators or corticosteroids with radiological findings including pulmonary hyperinflation, rib elevation and/or flattened diaphragm), atrial fibrillation (AF), history of chronic renal disease (defined as a creatinine clearance <30 ml/min.), peripheral vascular disease (defined as the presence of lower limb arterial disease stage I or II according to Leriche and Fontaine classification or a history of vascular surgery), body surface area (BSA)(m^2), electrocardiogram (ECG), chest X-ray (CXR) and coronary angiography. Acetylsalicylic acid was discontinued 5 days before surgery while clexane and clopidogril were discontinued 12 hours and 5–7 days respectively before it. All patients received sedative premedications (oral valium 5 mg at the night of surgery and intramuscular morphia l0 mg in the morning of surgery).

Intraoperatively: All patients had undergone intraoperative trans-esophageal echocardiography (TEE) to confirm/deny the recorded preoperative echocardiographic findings namely EROA 2D PISA (cm^2), RVol (mL), RF (%) and LVEF% prior to performing the intended procedure. Intraoperative mortality, operation duration, aortic cross clamping time, CPB time, number of grafts performed, MV prosthetic size, difficulty weaning off CPB, inotropic support medicine, and requirement for intra-aortic balloon pump (IABP) insertion were among the evaluated operative characteristics.

Conduct of anesthesia and operative technique:

Midazolam 0.03–0.05 mg/kg^{-1}, fentanyl 1-2 $micrograms/kg^{-1}$ (mcg/kg^{-1}), and propofol 1-2 mg/kg^{-1} were used to produce general anaesthesia. Atracurium 0.5 mg/kg^{-1} aided orotracheal intubation. Sevoflurane was titrated to an expired minimum alveolar concentration (MAC) of 1-1.5 in order to maintain anaesthesia, and morphine was continuously infused at a rate of 10-20 $mcg/kg^{-1}/h^{-1}$. Atracurium and fentanyl dosages were increased as necessary.

If hemodynamic instability occurred, it was treated with intravenous fluid boluses (4–8 mcg per dose), table placement, and/or norepinephrine boluses (defined as systolic blood pressure less than 90 mmHg

and/or mean arterial blood pressure less than 60 mmHg). An ECG, an arterial catheter attached to a pressure transducer, a central venous catheter placed in the internal jugular vein, a nasopharyngeal temperature probe, pulse oximetry, capnography, a urinary catheter, and frequent ABG measurements for pH, electrolytes, and glucose every 15 minutes were all used to monitor the patients. In order to maintain blood glucose levels between 110 and 150 mg/dl, diabetic patients were exposed to an intraoperative tight (strict) glycemic control routine employing a standardised intravenous insulin infusion protocol (made by combining 100 units of insulin with 50 ml 0.9% Normal Saline). In order to establish anticoagulation, an initial dosage of 300–400 IU/kg of heparin was administered to raise the active clotting time (ACT) over 400 s. Additional heparin was then administered as needed to keep the ACT above 400 s during the bypass period.

Regardless of the overall dosage of heparin, protamine chloride reversed the effects of heparin at the conclusion of CPB at a 1:1 ratio of the loading dose. Typically, an operational approach was used for every research participant. The procedure used on each patient was a typical vertical median sternotomy. Aorto-bicaval cannulation was used to start CPB, the ascending aorta was cross clamped, and warm blood intermittent antegrade method was used to provide cardioplegia every 20 minutes. The goal mean arterial pressure was established at 60 mmHg, and the pump flow was designed to be between 2.0 and 2.8 L/min/m^2. Distal anastomoses were done first. Using 7/0 monofilamentous sutures in a direct, continuous manner, the harvested reversed saphenous vein grafts (SVGs) were anastomosed distally to the targeted coronaries other than the left anterior descending (LAD). The harvested left internal thoracic artery (LITA) was clamped after being anastomosed to the LAD in a direct, continuous manner using 7/0 monofilamentous sutures.

Then, typically for all patients, left arteriotomy approach was done through the Waterston's Groove and left atrial (LA) retractor was applied. All the patients were submitted for isolated MVR using metallic bileaflet prostheses sized 27-29 mm (St. Jude) after resection of the anterior mitral leaflet and preservation of the posterior mitral leaflet using 2/0 pledgeted ethibond sutures. After completion of the procedure and closure of the left arteriotomy with 4/0 poly-propylene suture and insertion of LA vent, LITA was unclamped. After administering a hot shot dosage and unclamping the ascending aorta to restore myocardial activity, proximal anastomoses were performed on a beating heart employing partial aortic side occlusion clamping with 6/0 monofilamentous sutures in a direct, continuous manner.

Postoperatively:

The ICU parameters (length of mechanical breathing, duration of inotropic support, total blood loss, total duration of ICU stay) were among the postoperative factors evaluated, early (immediate) postoperative mortality (defined as death in the initial 30 days after surgery), adverse complications during hospital stay including perioperative MI defined as raised creatinine kinase-MB ≥ 5 times the upper limit of normal value and any new Q wave within the initial 48 hours after surgery or disappeared R wave on the postoperative ECG, coagulopathy, cerebrovascular accidents (CVAs) defined as a new stroke or a transient ischemic attack (TIA) for at least 24 hours, pulmonary embolism, peripheral arterial/venous thromboembolism, low cardiac output syndrome defined by the presence of signs of poor peripheral perfusion (cold extremities, oliguria or anuria) and/or poor central perfusion (decreased level of consciousness) and the use of two catecholamines at doses greater than 10 microgram/kg/min or an IABP to maintain systolic blood pressure above 90 mmHg, the use of inotropic support with dopamine 4 microgram/kg/min for at least 12 hours, hemorrhagic complications (re-exploration to control bleeding or relieve cardiac tamponade) and the need for blood transfusions, respiratory complications (pulmonary infection, pulmonary atelectasis, ARDS, and respiratory failure: prolonged ventilation > 48 hours postoperatively and re-intubation or tracheostomy), pleural or pericardial effusions, gastrointestinal bleeding, acute renal failure (ARF) defined as a rise in the creatinine level (absolute ≥ 0.3 mg/dl, percentage ≥ 50%) needing renal replacement therapy or dialysis excluding patients requiring dialysis before the surgery, deep sternal and lower limbs infections occurring within the initial 30 days after surgery extending beyond the deep tissue plane with positive bacterial cultures and purulent discharge, superficial wound infections (calculation of the overall hospital complications rate was based on the number of patients with at least one in-hospital complication), total hospital stay and one-year follow-up for (LVEF%, mortality, major cardiac problems, cerebrovascular adverse events, functional status and life quality).

Ethical Approval:

Approvals of the Scientific Committee of the Department of Cardiothoracic Surgery and the Scientific Committee, and the Research Ethics Committee of the Faculty of Medicine, Cairo University were all obtained (Registration number: N-163-2023 on 29-04-2023). Written informed consent was obtained from every patient. The Helsinki Declaration was followed throughout the study's conduct.

Statistical Analysis:
The collected data were arranged, tabulated, and statistically examined using SPSS version 21.0. Fischer's exact test or the appropriate Chi-square test were used to calculate the frequency and percent distributions for the qualitative data. The quantitative data's mean, standard deviation and lowest and maximum values were compared using the student-t test. The correlation between the parameters was ascertained using the Spearman's rank correlation coefficient. When the p-value was equal to or less than 0.05, it was deemed significant.

RESULTS

Preoperative Data: The study involved 23 patients. Their mean age was 58.22 ± 3.58 years (range: 48-75). They were 15 (65.21%) gentlemen and 8 (34.78%) ladies who all had history of previous MI and CCU admission, and all were in CCS grade III. None needed preoperative hemodynamic IABP support. Preoperative population's clinical characteristics were demonstrated in table (1).

Table (1): Preoperative population's clinical characteristics.

Hypertension (%)	17 (73.91)
Smoking (%)	15 (65.22)
DM (%)	18 (78.26)
Mean FBG level (mg/dl)	188.31 ± 25.11
Dyslipidemia (%)	16 (69.56)
Positive family history (%)	3 (13.04)
NYHA class II/III	5 (21.74)/18(78.26)
History of PCI and stenting (%)	13 (56.52)
Mean LVEF%	40.75 ± 1.35
Mean EROA 2D PISA (cm^2)	0.35 ± 0.03
Mean RVol (mL)	46.87 ± 1.21
Mean RF (%)	47.69 ± 0.91
Mean EuroSCORE II (%)	7.95 ± 8.35
Mean STS score (%)	9.24 ± 6.55
COPD (%)	2 (8.70)
AF	5 (21.73)
History of chronic renal disease (%)	2 (8.70)
Mean creatinine level (mg/dl)	0.90 ± 0.66
Peripheral vascular disease (%)	1 (4.35)
Mean BSA (m^2)	1.5 ± 0.68
LM or LM-equivalent CAD (%)	11 (47.83)
2 CAD (%)	4 (17.39)
≥ 3 CAD (%)	19 (82.61)

DM: diabetes mellitus; FBG: fasting blood glucose; NYHA: New York Heart Association; PCI: percutaneous coronary intervention; LVEF%: left ventricular ejection fraction per cent; EROA 2D PISA: effective regurgitant orifice area 2 D proximal isovelocity surface area; Rvol: regurgitant volume; RF: regurgitant fraction; EuroSCORE II: European System for Cardiac Operative Risk Evaluation; STS: Society of Thoracic Surgeons; COPD: chronic obstructive pulmonary disease; AF: atrial fibrillation; BSA: body surface area; LM: left main; CAD: coronary artery disease.

Operative Data:

In all patients, the preoperative echocardiographic findings were confirmed by the intraoperative TEE. Intraoperative mortality was nil. None faced persistent metabolic acidosis being efficiently corrected intraoperatively in the monitored 9 (39.13%) patients. Smooth weaning off CPB was met in 10 (43.48%). All the patients were transferred to the ICU on postoperative inotropic supports namely adrenaline and noradrenaline infusions in doses of 5-10 microgram/kg/min. Procedural characteristics are demonstrated in table (2).

Table (2): Procedural characteristics.

Mean operative time (min.)	188.57 ± 13.21
Mean aortic cross clamping time (min.)	102.23 ± 9.07
Mean CPB time (min.)	129.98 ± 11.76
2 grafts (%)	4 (17.39)
≥ 3 grafts (%)	19 (82.61)
MV prosthesis size 27 mm (%)	18 (78.26)
MV prosthesis size 29 mm (%)	5 (21.74)
Electric cardioversion (%)	13 (56.52)
IABP insertion (%)	4 (17.40)

CPB: cardiopulmonary bypass; MV: mitral valve; IABP: intra-aortic balloon pump

Postoperative Data:

No perioperative MI, CVAs, respiratory complications, deep wound infections, pleural or pericardial effusions, gastrointestinal bleeding or acute renal failure were encountered. No single one was in need for IAPB insertion. The intraoperatively inserted IABPs were successfully removed after 36 hours in 3 (13.04%) patients and 1 (4.34%) patient was unfortunately lost owing to intractable low cardiac output syndrome. Survivors were transferred to the ward when their hemodynamics were stabilized, and inotropic supports were cessated.

No more early (immediate) postoperative mortality happened during the in-hospital stay. Prior-to-hospital discharge echocardiography confirmed well-seated well-functioning replaced MV prostheses with a mean gradient of 3.10 ± 1.65 mmHg and illustrated statistically insignificant drop of the LVEF% [mean 37.11 ± 1.21 (p= 0.514)]. Postoperative outcomes were demonstrated in table (3).

Table (3): Postoperative outcomes.

Mean duration of mechanical ventilation (hours)	16.73 ± 5.49
Mean duration of inotropic support (hours)	51.14 ± 15.23
Mean total blood loss (ml)	532.55 ± 389.11
Mean total duration of ICU stay (hours)	77.34 ± 14.58
Low cardiac output syndrome (%)	1 (4.34)
Newly developed AF (%)	1 (4.34)
Ventricular arrhythmias (%)	2 (8.69)
Transient heart block (%)	2 (8.69)
Hemorrhagic complications (%)	1 (4.34)
Prolonged ventilation >48 hours (%)	3 (13.04)
Superficial wound infections (%)	4 (17.39)
The overall hospital complications rate (%)	5 (21.73)
Mean total duration of hospital stay (days)	8.51 ± 2.63

ICU: intensive care unit; AF: atrial fibrillation

The whole period of the study was 4.33 years. The mean time of returning to routine work was 65.11 ± 15.20 days. The mean time of the one-year follow-up clinical assessment and echocardiography was 361.28 ± 9.14 days. No late mortality, major cardiac problems or cerebrovascular adverse events happened during the follow-up period. There were statistically significant improvements in both clinical status and LVEF% (Table 4). The overall one-year survival rate was 22 (95.65%).

Table (4): One-year follow-up clinical status and LVEF%. Categorical variables are expressed as numbers and percentages and continuous variables as mean and SD.

Variable	Preoperative	One-year Postoperative	p Value
CCS grade			
I (%)	0	20(90.91)	<**0.001**
II (%)	0	2(9.09)	<**0.001**
III (%)	23(100)	0	<**0.001**
NYHA class			
I (%)	0	20(90.91)	<**0.001**
II (%)	5(21.74)	2(9.09)	<**0.001**
III (%)	18(78.26)	0	<**0.001**
LVEF (%)	40.75±1.35	52.86±1.59	<**0.001**

CCS: Canadian Cardiovascular Society; NYHA: New York Heart Association; LVEF: left ventricular ejection fraction per cent.

DISCUSSION

In a self-eternizing manner, chronic IMR procreates more MR. This is explained on the basis of LV papillary muscles displacement resulting from LV distortion and SWMAs following MI. This displacement from the MV annulus leads to chordae tendinae over-tension and apical MV leaflets tethering hindering effective coaptation in cardiac systole. Moreover, the post-MI LV dysfunction adds to the diminished force of leaflets closure. The closed vicious circuit starts when the MR begins leading to increased LV end-diastolic volume (LVEDV), LV mass without parallel increase in LV end-diastolic wall thickness, and LV wall stress over-tension in respect to increased preload. These pathological changes lead to further global LV myocardial function loss (progressive LV dysfunction gradually lowering the LVEF %), more papillary muscle displacement, MV leaflets tenting, and MV annular dilatation. The end result is more MR [10, 12, 13].

Although MV repair is favored by many cardiac surgeons in dealing with IMR generally. Based on several reports claiming that MV repair is better than MVR, the debate of choosing either option is still undefined and undecided clearly [14]. However, many investigators reported equivocal immediate, short-term, and long-term survival rates, which greatly depend on the clinical status of a particular patient [15, 16]. Being more reliable and reproducible than isolated CABG or conjoint MV repair, MVR remains a more suitable, sustainable, reasonable, and efficient surgical choice to interrupt the MR vicious circuit for those cases of chronic severe or moderate-to-severe IMR suffering from impaired LVEF%, marked MV leaflets tenting with complex MR jets, and associated with multiple comorbidities including hypertension, DM, and dyslipidemia [16, 17, 18].

Again, although it's claimed that MVR carries more operational hazards than MV repair, it provides longer and more durable outcomes entailing getting rid of the dangerously unfavorable recurrent MR with congestive heart failure attacks commonly reported with MV repair particularly with low LVEF% hearts, excluding the possibility of surgical re-correction of repair and establishing a definitive correction of the moderate-to-severe IMR. Also, MVR represents a more superiorly favored adopted procedure for the poorly anticipated short and long-term postoperative outcomes of the operated-upon dysfunctional LV due to the moderate-to-severe IMR [9, 19, 20].

Our study population although it was relatively small-sized sample due to meticulous selection of this subgroup of only moderate-to-severe IMR, excluding MR due to mild, moderate or severe IMR, rheumatic, myxomatous, infectious or congenital heart diseases, ballooning or scalloping of the MV leaflets, torn or elongated chordae tendinae and papillary muscle rupture, it represents a homogenous illustrative sector of those patients carrying the denominated pathology

with multiple comorbidities and comparable results to other reported cohorts. **Pompeu *et al.*** [21] reported on less sample-sized cohort (16 patients) with a higher mean age (63.4 ± 8.5 years) and comparable sex distribution (64.8/35.2%: males/females). **Ahmed *et al.*** [22] reported on more sample-sized cohort (72 patients) with a similar mean age of 56 years and 53/47% males to females. **Wang *et al.*** [23] reported on more sample-sized cohort (178 patients) with a higher mean age (66.80 ± 9.90 years) and 61.80/38.20% males to females.

Our cohort's associated comorbidities represented similarity to other authors' reports [21, 22, 23]. However, **Ahmed *et al.*** [22] reported lower AF incidence rate (11%) while **Wang *et al.*** [23] reported higher one (43.8%). Of note was the lower preoperative LVEF% and higher EuroSCORE II and STS scores of our population compared to others'. **Pompeu *et al.*** [21], **Ahmed *et al.*** [22] and **Wang *et al.*** [23] reported higher preoperative LVEF% values of 45.25 ± 4.54%, 59% and above 50% respectively. Our operative results are comparably similar to other reported ones. Luckily, we had nil intraoperative deaths as what was reported by **Pompeu *et al.*** [21] whereas **Ahmed *et al.*** [22] reported 1.8%. However, it was announced by the STS that intraoperative deaths may reach up to 8.6%, and 7.4% for conjoint MV repair national wide [24, 25]. Due to the impaired LVEF% of our population, smooth weaning off CPB was only met in 43.48%, while the rest needed electrical cardioversion to achieve safe weaning. We believe that the efficient cardioprotective measures we followed were helpful enough.

17.40% of our cohort who had severely impaired LVEF% were in need for IAPB insertion to maintain adequate hemodynamics. This point wasn't in concern of discussions reported by other authors. This may be explained by the better LVEF% of their study cohorts. Though the composite procedure entailed prolonged total operative, aortic cross clamping and CPB times, they were suitably comparable to other investigators' reports.

Similar to our results what was reported by **Pompeu *et al.*** [21] and **Ljubacev *et al.*** [25] where they reported > 90 min. and 99 min. for total aortic cross clamping time and > 120 min and 152 min for total CPB time respectively. Even longer than our results what was reported by **Ahmed *et al.*** [22], **Wang *et al.*** [23] and **Mantovani *et al.*** [26] where they reported 122 min, 133 ± 41 min and 131 min for total aortic cross clamping time and 182 min, 179 ± 53 min and 173 min for total CPB time respectively. Prior investigations showed unimportant hemodynamics and pressure gradient differences on the MV prosthesis regarding the application of either 27 mm or 29 mm St. Jude metallic bileaflet prostheses during rest and activity [27]. For our cohort, both sizes suited their calculated BSA. We applied either size according to annular adjustment. Most authors didn't stress upon this point. One author reported using bioprostheses without more details [21].

Our cohort's mean ICU course and hospital stay are similar to other authors who reported about 51 hours (range: 48-72) and 13.0 ± 10.6 days respectively [22, 23]. Surprisingly, one author reported much longer durations of 7.81 ± 5.86 days and 44.06 ± 18.61 days for ICU length and hospital stay respectively [21]. Compared to other reports [21, 22, 23, 25, 26], our study population showed even better immediate postoperative results and markedly less overall hospital complications rate. Superficial wound infection was the commonest complication and prolonged mechanical ventilation > 48 hours came second. **Ahmed *et al.*** [22] reported 50.9% overall hospital complications rate with plural effusion as the commonest complication while **Wang *et al.*** [23] reported 53.2% with prolonged mechanical ventilation > 48 hours as the commonest one. **Pompeu *et al.*** [21] reported respiratory complications and multiple blood transfusions (> 3 units of packed red blood corpuscles) as the commonest complications.

Incidence rates of both newly elapsed postoperative AF and low cardiac output syndrome were very low among our cohort and lower than other authors' reports [22, 23, 25, 26] even though the prolonged CPB time, which is a known risk factor for their development [28]. This result is in agreement with **Pompeu *et al.*** [21] who reported 6.25% and 6.30% for newly developed postoperative AF and low cardiac output syndrome respectively. The explanation is based on the fact of eliminating MR by the conjoint MVR that interrupts the cascade responsible for the development of AF. Because the attributed agents for re-entry circuits forming zones of prolonged refractory periods and emerging of AF are resultant from MR that causes LA volume overload, later-on tissue fibrosis and consequent maldistribution of diastolic depolarization potentials, refractory periods, and conduction within the atrial muscle [29]. Again, the conjoint MVR abolishes MR that is particularly greatly hazardous to hearts with impaired LVEF% and correctly directs the whole cardiac output by eliminating volume overload and the lost volume ejected towards the LA [30]. Thus, lower rate of low cardiac output syndrome can be explained. These findings add pros to the conjoint MVR for this subset group of patients.

Our study population showed better early (immediate) postoperative mortality rate compared to other reports [21, 22, 23, 25, 26, 31, 32] emulating the STS database about the conjoint MV repair (in-hospital death 4.8%) and lesser than the conjoint MVR (in-hospital death 7.8%) [24, 25]. **Pompeu *et al.*** [21] reported 6.3%, **Ahmed *et al.*** [22] reported 6.5% and **Wang *et al.*** [23] reported 11.2%. Opposing to our result what was reported by some investigators declaring that the conjoint MVR abolished the IMR but couldn't

decrease the early (immediate) postoperative mortality rate [23, 31, 32]. Some other authors reported higher incidence of perioperative mortality and thus they advised to perform less aggressive procedures, however, the subject remains controversial [14, 16].

However, we believe that our recorded low early (immediate) and late mortality and morbidity rates, despite the severity of the disease of our cohort with the multiple associated comorbidities, the impaired LVEF%, and the clearly associated direct relationship between the IMR degree with late mortality and the inverse relationship with late survival even after revascularization (1) was due to manipulating the conjoint MVR intentionally without wasting any time in an unsuccessful failed initial MV repair attempt entailing more prolonged CPB time for re-correction by valve replacement. This is in addition to the beneficial effects of the conjoint MVR in eliminating MR, preventing LV volume overload and correctly augmenting the cardiac output, which help enhance myocardial performance thus greatly improving the postoperative surgical outcomes [18].

Our cohort showed statistically insignificant drop of the LVEF% in the immediate postoperative hospital duration, but statistically significant improvement occurred at one-year follow-up. The same finding was reported by other authors [22, 23, 25, 26, 31, 32]. Surprisingly, some investigators reported statistically significant improvement of the LVEF% in the immediate postoperative period [21, 33]. Over one-year follow-up period, our cohort recorded no late mortality, no major cardiac problems including low cardiac output syndrome, no CVAs, statistically significant improvement in the functional clinical status, with overall survival rate 95.65% that is superior to the 86% reported by **Wang *et al.*** [23]. Our results illustrated that the conjoint MVR had its combined hazardous effects during the immediate (early) postoperative period rather than late. However, it has hemodynamic protective effects during both the immediate (early) postoperative period and late preserving and augmenting the LV systolic function improving significantly the impaired preoperative LVEF%. This conclusion is in agreement with other authors [22, 23, 25, 26, 31, 32, 34, 35].

STUDY LIMITATIONS

Being a retrospective observational study represents the main limitation. A relatively small sample size without a comparison group is another one. Thus, its power may be moderate lacking to clearly illustrate all the important predictors involved in the post-surgical outcomes as multivariate logistic regression analysis couldn't be performed. Third, the follow-up depended on only functional clinical examination and echocardiographic evaluation without involving coronary angiography. Fourth, because the follow-up and survival rates were only for one year, longer follow-up periods are required to establish the results.

CONCLUSION

Although conjoint MVR with CABG resembles an aggressive approach for treating moderate-to-severe IMR, its performance is safe and beneficial. Even hazardous in the early postoperative period, it showed lower rates of intraoperative, early and late mortality and morbidities particularly the newly developed postoperative AF and low cardiac output syndrome. At one-year follow-up period, it resulted in preserving and augmenting the LV systolic function improving significantly the impaired preoperative LVEF% and the functional clinical status of the patients.

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