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Implications of a Novel Modified Strategy for Combined Coronary Artery Bypass Grafting and Mitral Valve Replacement for Ischaemic Heart Disease Patients

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ABSTRACT

Background: Conventional coronary artery bypass grafting (CABG) and mitral valve replacement (MVR) is the best definitive treatment for patients with ischemic heart disease (IHD) complicated with severe ischemic mitral regurgitation (IMR). Yet the procedure itself entails high intraoperative and early postoperative risks added to the higher preoperative risk profile of its candidates. The higher risk values are largely attributed to the longer duration taken for the combined procedures with mandatory prolonged aortic cross clamping time with the risk of longer cardiac arrest state and prolonged cardiopulmonary bypass (CPB) time. **Objective:** This study primarily aimed at tracing the impact of a modified strategy adopting CABG on beating on-pumped non-aortic cross clamped heart conserving cardiac ischemia only for the MVR step of the surgery. **Patients and Methods:** This retrospective observational non-randomized study included 56 patients presented with IHD complicated with severe IMR. They had been operated upon by CABG and MVR. They had anginal pain grade III according to Canadian Cardiovascular Society (CCS) grading of angina pectoris. Intraoperative aortic cross clamping time, CPB time and mortality, postoperative mortality, morbidity outcomes, overall hospital complications rate, left ventricular ejection fraction per cent (LVEF%), CCS grading and overall one-year survival rate were evaluated. **Results:** No intraoperative mortality happened. The in-hospital mortality was 5.35%. Multivariable analysis showed that old age (OR: 1.15 (95% CI: 1.090-1.210); p= 0.001), females (OR: 3.25 (95% CI: 1.030-10.801); p= 0.041) and critical preoperative condition (OR: 3.78 (95% CI: 1.179-12.798); p= 0.027) were the foreshows of operative mortality and showed that old age (OR: 1.16 (95% CI: 1.100-1.122); p= 0.001) and critical preoperative condition (OR: 4.68 (95% CI: 1.378-15.395); p= 0.008) were those of in-hospital morbidity. The overall hospital complication rate was 23.21%. The overall one-year survival rate was 94.64% with statistically significant improvement of LVEF% with a mean 51.53±3.41 (p<0.001) and CCS grade whereas 92.45% were in CCS grade I and 7.54% in CCS grade II (p<0.001). **Conclusion:** The adopted stepwise approach showed markedly better operative and postoperative outcomes than reported with statistically significant improvement in both functional clinical statuses, LVEF% and survival at one-year follow-up.

Keywords: Combined CABG and MVR, Severe IMR, Complicated IHD.

INTRODUCTION

IHD is a common serious cardiac problem. The gold standard procedure done to alleviate it is CABG surgery [(1)]. Due to the occurrence of myocardial infarction (MI), IMR results representing a seriously highly impacting complication. It's attributed to left ventricular (LV) remodeling eventually leading to mitral leaflet tethering with resultant variable degrees of mitral regurgitation [(2)]. It represents 20-50% of the overall complications of IHD [(3)].

According to the recent recommendations, severe IMR must be corrected surgically, yet no definite procedure strategy for the combined operation was settled upon [(4)]. However, Mitral valve replacement (MVR) represents a more favorable and durable option than mitral valve repair in terms of long-term survival and prolonged postoperative outcomes [(5)].

Conventional combined CABG and MVR operation had been always accused of higher rates of postoperative morbid adverse events besides immediate, early and late mortality. These results exceed those resulting from each procedure done alone [(6)]. Based on the reports delivered by the Society of Thoracic Surgeons (STS), in-hospital mortality for the combined procedure is 8.6% compared to 1.8% for isolated CABG and 3.9% for isolated MVR [(7)].

The higher risk values are largely related to the longer duration taken for the combined procedures with mandatory prolonged aortic cross clamping (ischemic) time with the risk of longer cardiac arrest state and prolonged cardiopulmonary bypass (CPB) time. Consequently, higher incidence of adverse events and complications would arise. These include myocardial infarction (MI), coagulopathy, micro-embolization and cerebrovascular accidents (CVAs), pulmonary embolism, peripheral arterial/venous thromboembolism, low cardiac output syndrome, rhythmic complications, hemorrhagic complications and increased need of blood transfusions, immunosuppression, respiratory complications, acute renal failure and deep and superficial wound infections[(8)].

In a trial to decrease these higher risks ratios due to the prolonged combined procedures, we hypothesized a modified strategy adopting CABG on beating bypassed non-aortic cross clamped heart

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conserving myocardial ischemia only for the MVR step of the surgery, thus, preserving the assumed prolonged aortic cross clamping time and CPB duration. Thus, better favorable surgical outcomes would be achieved. This study primarily aimed at tracing the impact of this modified strategy on the operative, early and at one-year postoperative surgical outcomes. Secondary outcomes include estimation of mortality, major cardiac problems, functional clinical status and quality of life at one-year postoperatively.

PATIENTS AND METHODS

This retrospective observational non-randomized study included 56 patients who presented with IHD complicated with severe IMR. They had been operated upon by primary surgical myocardial revascularization (CABG) and MVR. All surgeries were carried out in the operating theatre of the Department of Cardiothoracic Surgery, Faculty of Medicine, Cairo University, in Beni-Suef University and in El Borg Hospital, Mohandiseen, Giza) using standard open-heart surgical procedures. Data of the study were collected for the operated-upon patients in the period between November 2018 and February 2023. Preoperative, intraoperative, and over a year after surgery, all the data were carefully examined.

Inclusion criteria: Adult patients scheduled for elective primary CABG surgery presented with multi-vessel coronary artery disease (CAD), left main (LM) or LM-equivalent CAD. They had been complicated with severe IMR fulfilling the following echocardiographic criteria: Effective regurgitant orifice area (EROA), 2 D proximal isovelocity surface area (PISA) >0.40 cm^2, regurgitant volume (RVol) >50 mL and regurgitant fraction (RF) >50%. They had anginal pain grade III according to Canadian Cardiovascular Society (CCS) grading of angina pectoris.

Exclusion criteria: Those with associated pathologies requiring surgical intervention such as aortic valve disease, tricuspid valve disease, ascending aortic aneurysm/dissection, left ventricular aneurysm, and ventricular septal defects. Re-do cases were not involved in the study.

Management regimen

Preoperatively

The assessed preoperative variables included age, sex, proper general and cardiological assessment, risk factors of cardiovascular disease e.g. hypertension, smoking, diabetes, dyslipidemia, post-menopause, and family history of susceptibility to IHD, previous MI and history of cardiac care unit (CCU) admission, history of percutaneous coronary intervention (PCI) and stenting, echocardiographic parameters [left ventricular ejection fraction per cent (LVEF%), EROA 2D PISA (cm^2), RVol (mL) and RF (%)], European System for Cardiac Operative Risk Evaluation (EuroSCORE) II, STS score, chronic obstructive pulmonary disease (COPD), atrial fibrillation (AF), history of chronic renal disease (preoperative chronic renal failure was defined as a creatinine clearance of less than 30 ml/min.), peripheral vascular disease (preoperative peripheral vascular disease was 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) and cardiac catheterization. Acetylsalicylic acid was stopped 5 days before surgery, whereas clexane and clopidogrel were stopped 12 hours and 5-7 days prior respectively. Sedative premedications were given to all patients (oral valium 5 mg the night before surgery and intramuscular morphia l0 mg the morning of operation).

Intraoperatively

Intraoperative mortality, aortic cross clamping time, CPB time, number of grafts performed, difficulty of weaning off CPB, inotropic support requirements, and the requirement for intra-aortic balloon pump (IABP) insertion were among the analysed operational factors.

Operative Technique

For the whole study population, the operational methodology remained same. The usual vertical median sternotomy technique was used to operate on all of the patients. With aorto-bicaval cannulation, CPB was started. The goal mean arterial pressure was set at 60 mmHg, and the pump flow was intended to be between 2.0 and 2.8 L/min/m^2. Distal anastomoses were made first. Using 7/0 monofilamentous sutures in a direct continuous method, the harvested reversed saphenous vein grafts (SVGs) were anastomosed distally to the targeted coronaries other than the left anterior descending (LAD) artery. The 7/0 monofilamentous sutures were used to anastmose the harvested left internal mammary artery (LIMA) to the LAD in a direct continuous manner, and then the sutures were clamped. Following cross-clamping of the ascending aorta and intermittent antegrade infusion of cold crystalloid cardioplegia initially for 45 minutes and then every 30 minutes for the subsequent doses, along with beginning systemic cooling process to achieve systemic core body temperature of 28-30°C and application of topical cooling, proper myocardial protection was achieved. Typically for all patients, left atriotomy approach was done through the Waterston’s (Sondergaard’s) groove and left atrial (LA) retractor was applied. All the patients were submitted for MVR using metallic bileaflet prostheses St. Jude sized 27-29 mm with preservation of the posterior mitral leaflet (PML) using 2/0 pledgeted ethibond sutures. After completion of the procedure and closure of the left atriotomy with 4/0 poly-propylene suture and insertion of LA vent, LIMA was unclamped. After unclamping the ascending aorta and recovering myocardial activity with partial aortic side occlusion clamping using 6/0 monofilamentous sutures in a direct continuous method, the proximal anastomoses were performed on a beating heart.

Postoperatively

The assessed postoperative variables included the intensive care unit (ICU) parameters (duration of mechanical ventilation, duration of inotropic support, total blood loss, total duration of ICU stay), operative mortality (defined as death during the postoperative 30 days), various adverse complications during hospital stay including perioperative MI (defined as 5 or more times raised creatinine kinase-MB the upper limit of normal and any new Q wave within 48 hours postoperatively or disappeared R wave on the postoperative ECG), coagulopathy, micro-embolization and CVAs (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 as the need for the use of two catecholamines above 10 microgram/kg/min dose or the use of an IABP), rhythmic complications (supraventricular or ventricular rhythm disorder), hemorrhagic complications (re-exploration to control bleeding or relieve cardiac tamponade) and blood transfusion requirements, respiratory complications (pneumonia, pulmonary collapse and respiratory failure: prolonged ventilation >48 hours postoperatively, re-intubation or tracheostomy), acute renal failure (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 operation), deep (sternal and lower limbs infections occurring within 30 days postoperatively extending beyond the deep tissue plane with positive bacterial cultures and purulent discharge) and superficial wound infections (The overall hospital complication rate was calculated on the basis of the number of patients with at least one hospital complication), total hospital stay and one-year follow-up for (LVEF%, mortality, major cardiac problems, cerebrovascular adverse events, functional clinical status and quality of life).

Ethical approval:

The study was conducted in the cardiothoracic surgery operating theaters of Cairo University, Beni-Suef University and El Borg Hospital. It was approved by the Research Ethical Committee (REC) with approval number of FMBSUREC/09042023/ Elbatanony. To participate in the study, each patient signed a written informed permission form. The Helsinki Declaration, the World Medical Association's code of ethics for human studies, directed the conduct of this investigation.

Statistical analysis

SPSS V. 21.0 was used to organise, tabulate, and statistically analyse the obtained data. Frequency and percent distributions for qualitative data were computed using the relevant Chi-square test or Fischer's exact test. The t-student test was used to compare mean, standard deviation, minimum and maximum values for quantitative data. The Spearman's rank correlation coefficient was used to determine the correlation between the parameters. Analysis of predictors of in-hospital morbidity and operative mortality were performed by multivariable logistic regression analysis. P values were deemed significant in all tests when $p \leq 0.05$, highly significant when $p \leq 0.01$ and extremely significant when $p \leq 0.001$.

RESULTS

Preoperative Data:

The cohort involved 56 patients. Their ages ranged from 47 to 69 years with a mean age of 54.36 ± 2.21 years. They were 34 (60.71%) men and 22 (39.29%) women. All patients were in CCS grade III. No patient needed preoperative IABP insertion. Characteristics of the cohort's preoperative profile are demonstrated in table (1).

Table (1): Preoperative characteristics

Hypertensives	39(69.64%)
Smokers	25(44.64%)
Diabetics	43(76.79%)
Mean FBG level	168.41±33.56 mg/dl
Dyslipidemia	41(73.21%)
Family history of susceptibility to IHD	15(26.78%)
COPD	5(8.93%)
AF	9(16.07%)
Chronic renal disease	5(8.93%)
Mean creatinine level	1.09±0.18 mg/dl
Peripheral vascular disease	3(5.35%)
LM or LM-equivalent CAD	11(19.64%)
Three or more CAD	44(78.57%)
Less than three CAD	12(21.43%)
Previous MI	43(76.78%)
Previous CCU admission	40(71.43%)
Previous PCI and stenting	33(58.93%)
Mean LVEF%	42.22±2.63
Mean EuroSCORE II	7.60±7.70%
Mean STS score	8.10±5.80%
Mean BSA	1.7±0.37 m^2

FBG: fasting blood glucose; IHD: ischemic heart disease; COPD: chronic obstructive pulmonary disease; AF: atrial fibrillation; LM: left main; CAD: coronary artery disease; MI: myocardial infarction; CCU: cardiac care unit; PCI: percutaneous coronary intervention; LVEF%: left ventricular ejection fraction per cent; EuroSCORE II: European System for Cardiac Operative Risk Evaluation; STS: Society of Thoracic Surgeons; BSA: body surface area.

Operative Data:

No intraoperative deaths occurred, and no IABP insertion was required to help with hemodynamics.

To achieve weaning, electrical cardioversion was required in 11 cases (19.64%). Before transferring the patients to the intensive care unit, metabolic acidosis was successfully treated in 23 (41.07%) cases and no one experienced intractable acidosis. For the first 24 hours postoperatively, all patients were given an epinephrine infusion of 5 micrograms/kg/minute as a supportive physiological dosage, and norepinephrine infusion (5 to 10 micrograms/kg/minute) was administered to 38 (67.85%) to manage diabetic vasoplegia (Table 2).

Table (2): Operative results.

Mean total operative time	185.66±27.35 min.
Mean total CPB time	117.87±15.96 min.
Mean total cross clamping time	58.11±5.69 min.
Three or more coronary artery targets	44(78.57%)
Less than three coronary artery targets	12(21.43%)
Smooth weaning off CPB	45(80.36%)

Postoperative Data

All of the patients were mechanically ventilated during their transport to the ICU, and when their hemodynamics were stabilised without inotropic support, without chest drains, with positive laboratory values and with an acceptable ECG rhythm, they were all sent to the ward. Acute renal failure, gastrointestinal haemorrhage, perioperative MI, CVAs, respiratory issues, deep wound infections, pleural or pericardial effusions, or respiratory problems were not encountered. In order to achieve satisfactory hemodynamic parameters, IABP was introduced in 4 (7.14%), and it was safely withdrawn in 1 (1.78%) after 36 hours. There were 13 complication rate total in hospitals, or 23.21% (Table 3).

Table (3): Postoperative outcomes

Mean duration of mechanical ventilation	9.54±4.85 hours
Mean duration of inotropic support	19.86±4.79 hours
Mean total blood loss	461.69±433.20 ml
Mean total duration of ICU stay	41.12±4.34 hours
Low cardiac output syndrome	4(7.14%)
Atrial fibrillation	9(16.07%)
Transient heart block	2(3.57%)
Hemorrhagic complication	1(1.78%)
Superficial wound infection	13(23.21%)
Mean total duration of hospital stay	8.32±1.98 days

Multivariable logistic regression analysis showed that old age and poor critical preoperative condition were the important foreshows embroiled in in-hospital morbidity (Table 4).

Table (4): Predictors of in-hospital morbidity by multivariable logistic regression analysis.

Predictor	OR	P Value	95% CI
Old age	1.16	0.001	1.100-1.122
Poor critical preoperative condition	4.68	0.008	1.378-15.395

OR: odds ratio; CI: confidence interval

The operative mortality was 3 (5.35%); all were in-hospital mortality due to intractable low cardiac output syndrome. Multivariable logistic regression analysis showed that old age, females and poor critical preoperative condition were the important foreshows embroiled in operative mortality (Table 5).

Table (5): Predictors of operative mortality by multivariable logistic regression analysis

Predictor	OR	P Value	95% CI
Old age	1.15	0.001	1.090-1.210
Female sex	3.25	0.041	1.030-10.801
Poor critical preoperative condition	3.78	0.027	1.179-12.798

OR: odds ratio; CI: confidence interval

On doing routine prior-to-hospital discharge echocardiography, it was confirmed that the replaced prostheses were well-seated well-functioning with a mean gradient of 3.21±1.88 mmHg and LVEF% showed statistically insignificant decline with a mean 40.78±0.12 ($p = 0.514$). Patients were followed up for a year after being released from the hospital. The average number of days to return to work was 60.52 ± 11.65. Patients were contacted on average 350.11 ± 14.63 days following the initial call. Neither mortality nor major cardiac problems (including low cardiac output syndrome) or cerebrovascular adverse events happened during the follow-up period and the overall one-year survival rate was 53 (94.64%). Marked improvement in both functional clinical status and LVEF% was observed.

On doing one-year follow-up echocardiography, LVEF% showed statistically significant improvement with a mean 51.53 ± 3.41 ($p<0.001$). 49/53 (92.45%) patients were in CCS grade I and 4/53 (7.54%) in CCS grade II at one-year follow-up ($p<0.001$). The cumulative duration of the study was 4.25 years (Table 6).

Table (6): One-year follow-up postoperative CCS grade and LVEF%

Variable	Preoperative	One-year Postoperative	p Value
CCS grade			
I	0	49/53(92.45%)	<0.001
II	0	4/53(7.54%)	<0.001
III	56(100%)	0	
LVEF (%)	42.22±2.63	51.53±3.41	<0.001

Categorical variables are expressed as numbers and percentages and continuous variables as mean and SD.

DISCUSSION

The combined CABG and MVR operation represents a challenging experience in treating victims with IHD and severe IMR [(9)]. Although it is the optimal management for this category of IHD patients, it comprises multiple hazardous risks that might eventually lead to unfavorable outcomes rather than higher rates of operative mortality (defined as death during the postoperative 30 days) [(10)]. Most of these risks are settled, however, more efforts are needed for more assessment especially with the currently faced older patients with more vigorous risk factors [(11)]. This group of patients is susceptible for combined CABG and MVR, which have higher scores of surgical risks than others with isolated pathology. They are usually older with higher incidence rates of associated comorbidities including DM, dyslipidemia and hypertension. Moreover, they have more worse preoperative profile with worse CCS grade and congestive heart failure episodes. Thus, the resultant is higher rates of intraoperative and critical postoperative complications and death [(10, 11, 12)].

This combined surgery records 8.6% intraoperative mortality compared to 7.4% for combined CABG and MV repair, 1.8% for isolated CABG and 3.9% for isolated MVR according to the STS database [(7)]. The MVR component of the surgical procedure entails more challenges and higher risk dangers added to the CABG component. However, MVR has more superior long-term durable results than MV repair for this subset group of patients suffering from severe IMR in the form of freedom of postoperative MR, congestive heart failure episodes and reoperation for repair correction [(13)]. Moreover, the presence of severe IMR due to LV remodeling and geometric changes poses more worse postoperative prognostic outcomes and consequently favors MVR rather than MV repair [(14)]. However, one study reported similar postoperative outcomes between MVR and MV repair for the severe IMR, but it confirmed that there is more durable correction of the MR in the patients who had undergone MVR [(15)].

In view of the higher levels of risks involved in the combined procedure of CABG and MVR, many attempts were made to improve its results especially after the emerged minimally invasive and percutaneous techniques [(16, 17, 18)]. All trials aimed at accomplishing total coronary revascularization and correction of the severe IMR with efforts to minimize the aortic cross clamping and CPB times targeting to lessen the surgical risks, the high operative mortality rates and the unfavorable postoperative adverse outcomes. These attempts included combined CABG (on-pump or off-pump) and percutaneous edge-to-edge repair (PEER), combined hybrid coronary revascularization (HCR) and PEER, combined percutaneous coronary intervention (PCI) and PEER, combined HCR and minimally invasive mitral valve replacement (mini-MVR) and combined PCI and MVR, PCI and mini-MVR [(19)].

The previously mentioned attempts have the disadvantages of lacking efficacy of complete multivessel coronary revascularization, some of them entailed MV repair which is not the best treatment for the severe IMR, high rate of acute renal insult if PCI and MVR or MV repair are done on the same setting and not three weeks apart, and higher rates of bleeding when PCI precedes MV surgical maneuver due to clopidogrel intake [(20, 21, 22)]. However, they have the pros of feasibility of staged procedures, limited approach maintaining sternal stability and integrity in some techniques, avoiding aortic cross clamping and CPB if off-pump CABG was adopted combined with PEER, associated HCR with lower morbidity and mortality indices, and reduced rates of morbidity associated with mini-MVR [(23)]. **George *et al.*** [(23)] reported STS risk reduction of 35%, very few adverse events, no operative or in-hospital deaths and no coronary instent thrombotic stenosis after 2 years post one-stage HCR involving PCI to coronary targets other than LAD and minimally invasive MV maneuver. **Santana *et al.*** [(24)] also reported low adverse events, shorter in-hospital stay, and 3.6% and 12% of mortality and all-cause mortality rates respectively at 4.5 years after PCI and minimally invasive MV maneuver. However, these procedures might be suitable for certain individualized subsets of high-risk candidates with severe kidney, aortic and hemorrhagic or neurological disease [(19)].

Open conventional CABG and MVR remains the gold standard option for cases of severe IMR as regards fulfilling total and complete coronary revascularization and definite correction of the severe IMR. However, high rates of operative mortality and postoperative morbidities are encountered with the classic prolonged on-pump/aortic cross clamped combined CABG and MVR [(19, 20, 21, 22)].

We adopted what is considered a stepwise approach to overcome the prolonged periods of aortic cross clamping needed for the combined procedures limiting it for the MVR component and performing CABG on beating on-pumped non-aortic cross clamped heart for more safety of the procedure and possible conversion to classic aortic cross clamped CABG if hemodynamic instability occurred. We weren't urged to convert the approach in any case of our cohort, and we didn't have any intraoperative mortality.

Our cohort composed of 56 patients with a mean age of 54.36 ± 2.21 years (range: 47-69). Females represented 39.29% while males were 60.71%. Other studies reported comparable cohorts, but they followed other approaches different from ours. **Okba *et al.*** [6] on conventional on-pump CABG and MVR on 72 cases, mean age was 56 years (range: 42-78). 53% were males and 47% were females. **Wang *et al.*** [25] on 178 patients who had undergone conventional on-pump CABG and MVR reported mean age of 66.80 ± 9.90 years and females were 38.20% and males were 61.80%. The study conducted by **Ullah *et al.*** [26], which analyzed the data from The National Inpatient Sample (NIS) database, USA reported a mean age of 69.92 ± 14.90 years, males represented 62.5% and females were 37.5%.

Rates of the other preoperative baseline characteristics and risk factors of our cohort were similar to other authors' cohorts [6, 25, 26] which included dyslipidemia (73.21%), DM (76.79%), hypertension (69.64%), previous MI (76.78%), previous PCI (58.93%), mean EuroSCORE II 7.60 ± 7.70%, mean STS score 8.10 ± 5.80%, COPD (8.93%), chronic renal disease (8.93%), peripheral vascular disease (5.35%), LM or LM-equivalent CAD (19.64%), three or more CAD (78.57%) and less than three CAD (21.43%). AF was diagnosed in 16.07% while **Wang *et al.*** [25] reported 43.8% and **Okba *et al.*** [6] reported 11%. However, different from other studies is the preoperative mean LVEF%. While, it was 42.22 ± 2.63% in our study, others reported higher values. It was reported as 59% (range: 40-62) **by Okba *et al.*** [6] and >50% in 80% of the study population of **Wang *et al.*** [25].

Our modified approach neither hindered accomplishing the needed total coronary revascularization nor smooth weaning off CPB. Three or more coronary arteries were targeted in 78.57% and less than three coronary arteries in 21.43%. Patients' severely incompetent mitral valves were replaced using metallic bileaflet prostheses St. Jude sized 27-29 mm with preservation of the PML. These sizes were suitable for our cohort and adequate for their mean preoperative BSA (1.7±0.37 m^2) based on previous studies that reported insignificant differences between both used sizes as regards pressure gradient on the prosthesis at both rest and active states of the person [27]. The mean total cross clamping time was 58.11 ± 5.69 min. and the mean total CPB time was 117.87 ± 15.96 min., which are significantly shorter periods of time than what was reported by other authors. **Okba *et al.*** [6] reported 122 min and 182 min, **Wang *et al.*** [25] reported 133 ± 41 min and 179 ± 53, **Ljubacev *et al.*** [28] reported 99 min and 152 min, and **Mantovani *et al.*** [29] reported 131 min and 173 min for the total cross clamping time and the total CPB time respectively. We had no intraoperative mortality. We had smooth weaning off CPB in 80.36% of our cohort. The STS declared 8.6% nationwide intraoperative mortality [7, 28]. **Okba *et al.*** [6] reported 1.8% intraoperative deaths due to failure to wean the patient from CPB. We didn't need to use IAPB in any case and 67.85% needed norepinephrine infusion 5-10 microgram/kg/min to be added to the epinephrine infusion 5 microgram/kg/min to maintain acceptable hemodynamics prior to transfer to the ICU.

Our study population showed shorter mean total duration of ICU stay and mean total duration of hospital stay of 41.12 ± 4.34 hours and 8.32 ± 1.98 days respectively compared to other reported records of about 51 hours (range: 48-72) and 13.0 ± 10.6 days respectively [6, 25]. Our cohort recorded overall hospital complication rate was 23.21%, which is markedly lower than other researchers' reported rates. **Wang *et al.*** [25] reported overall composite morbidity of 53.2% and reported prolonged mechanical ventilation for >24 hours to be the most common morbidity rating 39.9%. **Okba *et al.*** [6] reported overall morbidity of 50.9% and plural effusion was the commonest recording 11.1% and aspiration was the management. In our study, AF was the commonest postoperative morbidity rating 16.07%. However, the rate was the same for the preoperatively diagnosed population with AF. Again, our cohort recorded markedly better results of the postoperative adverse outcomes and operative mortality compared to other reports [6, 25, 26, 28, 29].

For combined CABG and MVR, the STS announced 8.6% and 7.8% for intraoperative and in-hospital deaths respectively. For CABG and MV repair, the STS announced 7.4% and 4.8% for intraoperative and in-hospital deaths respectively [7, 28]. **Wang *et al.*** [25] reported 11.2% operative mortality. **Okba *et al.*** [6] reported 8.3% operative mortality (1.8% intraoperative mortality and 6.5% in-hospital mortality due to cerebrovascular accident, multiorgan failure and cardiac tamponade). Randomized trials and meta-analysis studies conducted by **Feldman *et al.*** [16], **Obadia *et al.*** [17], **Stone *et al.*** [18], **Yin *et al.*** [30] and **Anantha *et al.*** [31] confirmed that conventional combined CABG and MVR only decreased the MR degree, but it didn't lower operative mortality. We had 5.35% operative mortality rate (in-hospital mortality due to postoperative intractable low cardiac output syndrome with no mortality intraoperatively). Our results were better than other authors' reports, mimicking the declared STS statement concerning the known less risky combined CABG and MV repair surgery and its statement about isolated MVR operative mortality of 3.9% [7].

Previous established studies illustrated that old age, women, critically ill patient and pulmonary hypertension resemble the most important criteria in risk stratification models [10, 11, 12, 25, 32]. Several reports have declared that emergency surgery, severe IHD, severe IMR, low LVEF%, acute MI, decompensated congestive heart failure, inability to anastomose LIMA to LAD and MVR are considered the important predictors of intraoperative mortality while decompensated congestive heart failure is the major risk factor for in-hospital mortality, while old age and the risk factors of IHD don't affect it [29]. Multivariable logistic regression analysis showed that old age, females and poor critical preoperative condition were the important foreshows embroiled in operative mortality while old age and poor critical preoperative condition were the important foreshows embroiled in early in-hospital morbidity in our cohort. In agreement with our results, **Wang *et al.*** [25] reported that old age, pulmonary hypertension, critical preoperative condition and female sex were the most important predictors of operative mortality. They attributed old age, pulmonary hypertension and critical preoperative condition to be the most important predictors of unfavorable postoperative outcomes. **Ullah *et al.*** [26] reported that old age >65 years and females are subjected to higher risks of in-hospital mortality, stroke and major hemorrhage.

Patients undergoing combined CABG and MVR were generally claimed to be at higher risks of both intraoperative complications and postoperative adverse events due to prolonged durations of aortic cross clamping and CPB needed for the complex combined procedures [33]. Conservation of the aortic cross clamping and CPB times preserving cardiac ischemia and maintaining good adequate myocardial protection strongly observed in our study population positively affected both the intraoperative and postoperative outcomes. This may explain the impact of the added MVR procedure for performing CABG. By limiting myocardial ischemia for only the MVR step of the surgery, more adequate myocardial protection with shorter periods of arrested heart than what is done with the conventional technique that was associated with multiple complications linked to the prolonged durations of aortic cross clamping and CPB [8, 34]. This led to promising better results. It showed better smooth weaning of bypass, reduced incidence of operative mortality, reduced duration of both ICU and in-hospital stay, and reduced postoperative complications.

During the follow-up one-year period, we had neither mortality nor major cardiac problems (including low cardiac output syndrome) or cerebrovascular adverse events in our study population. The overall one-year survival rate was 94.64% with statistically significant improvement in both functional clinical status and LVEF% (p<0.001). Again, our results were better than what was reported by other authors. Of whom **Wang *et al.*** [25] who reported 86%, 77% and 63% one-year, five-years and ten-years survival rates respectively and declared significant worse survival rate (p<0.001) compared to isolated MVR. We concluded that the combined complexity of the surgery with its entailed risks have effects on the early in-hospital postoperative duration and the initial thirty days postoperative period is the most affected rather than lately. In agreement with our conclusion, **O'Brien *et al.*** [9]**, Shahian *et al.*** [10] and **Wang *et al.*** [25] who illustrated that high rates of late mortality aren't associated with the combined surgery and most of the risks occurred in the early 30 days postoperatively. Also, **Feldman *et al.*** [16]**, Obadia *et al.*** [17]**, Stone *et al.*** [18]**, Yin *et al.*** [30] and **Anantha *et al.*** [31] reported improvement of the LV systolic function after the combined surgery.

CONCLUSION

Conventional CABG and MVR is the best definitive treatment for patients with IHD complicated with severe IMR. Yet the procedure itself entails high intraoperative and early postoperative risks added to the higher preoperative risk profile of its candidates. Thus, considering alternative strategies is mandatory trying to lessen the adverse effects and improve the results of the surgery. The adopted stepwise approach by performing CABG on beating on-pumped non-aortic cross clamped heart and limiting aortic cross clamping for the MVR component of the procedure to overcome the prolonged periods of myocardial ischemia showed significantly better operative and postoperative outcomes. The overall one-year survival rate was 94.64% with statistically significant improvement in both functional clinical status and LVEF%. Proper perioperative optimization of the cardiac condition especially control of the preoperative congestive heart failure stigmata is essential to get the best benefits.

STUDY LIMITATIONS

As a retrospective observational study without a reference group and a small sample size, its ability to clearly highlight all the significant factors implicated in the unfavourable outcomes may be moderately inadequate. Follow-up did not involve angiography and was solely based on clinical assessment and echocardiographic examination. Longer follow-up periods are necessary to confirm the results because the follow-up term was just one year long when the survival rate was estimated.

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