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ORIGINAL STUDY

Repair versus replacement for ischemic mitral regurgitation in patients who underwent coronary artery bypass grafting plus mitral valve surgery

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Abstract

Background: **Ischemic mitral regurgitation (IMR) is a serious consequence of coronary artery disease. The optimal management of IMR is controversial. Although practice guidelines advise surgical intervention for patients presenting with a severe form of this condition, they also recognize the limited evidence supporting repair or replacement.**

Aim: **To analyze and compare the early outcomes of mitral valve repair (MVr) versus mitral valve replacement (MVR) with concomitant coronary artery bypass grafting (CABG) in patients with IMR.**

Methods: **A retrospective comparative study on 100 patients who underwent concomitant CABG for their coronary artery disease (CAD) and a mitral valve surgery for IMR, either MVr or MVR, between August 2021 and August 2023, at the National Heart Institute. The patients were divided into four groups: group I (No = 50) who underwent MVr and group II (N = 50) who underwent MVR.**

Results: **In group Ia, the mean age was 54.25 ± 10.04 years. Among the study group, 75% were males, 70% were diabetic and 60% were hypertensive, the mean pre-operative ejection fraction (EF) was 50.65 ± 7.66%. The mean bypass time was 120.50 ± 31.86 min and the mean cross-clamp time was 94.50 ± 29.28 min. The mortality rate was 5%. In group IIa, the mean age was 53.55 ± 8.88 years. Among the study group 65% were males, 65% were diabetic and 85% were hypertensive. The mean pre-operative EF was 55.75 ± 10.49%. The mean bypass time was 133.44 ± 25.08 min and the mean cross-clamp time was 107.22 ± 28.84 min. The mortality rate was 10% in group Ib, the mean age was 60.65 ± 7.37 years. Among the study group 66.6% were males, 76.6% were diabetic and 76.6% were hypertensive, the mean pre-operative EF was 46.95 ± 10.26%. The mean bypass time was 130.00 ± 40.06 min and the mean cross-clamp time was 97.50 ± 31.22 min. The mortality rate was 10% in group IIb, the mean age was 54.44 ± 10.18 years. Among the study group 63.3% were males, 56.6% were diabetic and 63.3% were hypertensive, the mean pre-operative EF was 48.55 ± 11.08%. The mean bypass time was 127.77 ± 29.90 min and the mean cross-clamp time was 98.88 ± 25.71 min. The intra-aortic balloon pump was used in 11.7%. The mortality rate was 3.3%. There were significant differences between groups regarding the post-operative degrees of severity of MR ($P < 0.001$).**

Conclusion: **Our preliminary findings showed that there was no significant difference in the surgical outcome of MVR and MVr in terms of early mortality and morbidities. However, mitral valve repair was linked to an increased incidence of residual or recurrent mitral regurgitation. Recent researches suggest the role of MVR can justifiably be indicated for severe IMR. As for moderate IMR, CABG alone without mitral valve intervention may provide similar clinical outcomes.**

Keywords: Coronary artery bypass grafting (CABG), Ischaemic mitral regurgitation (IMR), Mitral valve repair, Mitral valve replacement (MVR), Mortality

1. Introduction

Ischemic mitral regurgitation (IMR) is a common complication of chronic coronary artery disease-related left ventricular (LV) global or regional pathological remodeling. IMR is defined as mitral regurgitation (MR) resulting from ischemic heart disease-induced chronic alterations in the structure

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and function of the left ventricle (LV). It is the valvular consequence of increased tethering forces and decreased closure forces; it is not a valve disease [1]. It is documented in about 50% of patients who have experienced congestive cardiac failure and in 20% of those who have suffered an acute myocardial infarction (MI) [2]. IMR is a prevalent complication that impairs the prognosis of coronary artery disease [3,4].

It is crucial to differentiate primary MR caused by organic factors from secondary MR, which does not indicate valve disease but rather represents LV disease. Secondary MR is functional MR caused by coronary artery disease or cardiomyopathy remodeling of the LV; in this context, secondary functional MR is referred to as IMR [2]. Remodeling of the segmental/global left ventricle, which induces papillary muscle displacement and leaflet tethering, is accounted for by its pathophysiologic mechanisms [1]. These mechanisms result in leaflet malcoaptation and MR of varying degrees. The leaflets themselves are normal, and the disease occurs in the myocardium rather than in the valve itself [5].

The presence of IMR is independently associated with mortality and morbidity after myocardial infarction [6]. It is a dynamic condition with severity depending on loading conditions, heart rhythm, and residual ischemia [4]. IMR is more common after myocardial infarction especially inferior wall MI [3,7] and is related to a higher incidence of acute pulmonary edema in patients with left ventricular systolic dysfunction [8].

Surgical management of IMR has primarily comprised revascularization with or without mitral valve surgery with various techniques including annuloplasty, or mitral valve replacement [9,10]. In patients with grade I-II MR, surgical revascularization alone with CABG is sufficient. Revascularization may cause reverse remodeling of the LV which can reduce regurgitation; however, the success of isolated revascularization depends on the myocardium viability [11].

The majority of patients with higher than grade II MR undergo surgical revascularization along with mitral valve surgery. The best surgical technique for IMR management is still being debated. Those in support of mitral valve repair (MVr) believe that it improves survival, preserves ventricular function, and avoids long-term anticoagulation, whilst those in favor of mitral valve replacement (MVR) argue that it provides long-term independence from recurring mitral insufficiency. In addition, proponents of MVR argue that improved surgical techniques to preserve the subvalvular apparatus reduce the previously observed survival benefits of MVr, and that the use of tissue valves avoids the use of long-term anticoagulation [12].

The aim of this study was to analyses and compare the early outcomes of MVr versus MVR with concomitant coronary artery bypass grafting (CABG) in patients with IMR.

2. Patients and methods

This is a retrospective comparative study analyzing the collected data of 100 patients who underwent concomitant CABG for their coronary artery disease (CAD), and a mitral valve procedure, either MVr, or MVR in IMR patients at National Heart Institute between August 2021 and August 2023. This study included 100 patients divided into two groups, group I (repair group) and group II (replacement group). Each is subdivided in two subgroups (a and b) according to the severity of MR (moderate or severe MR, respectively). Group Ia and group IIa included 20 patients for each while group Ib and group IIb included 30 patients for each.

2.1. Inclusion criteria

(1) IMR patients with more than grade II MR.
(2) Patients with chronic IMR.
(3) Patients undergoing elective concomitant CABG and mitral valve surgery.

2.2. Exclusion criteria

(1) Patients with acute IMR.
(2) Patients who need emergency intervention.
(3) Patients with associated left ventricular aneurysm or ischaemic ventricular septal defect.
(4) Patients with valvular heart disease other than IMR requiring surgical intervention at the time of operation.
(5) Redo CABG or mitral valve surgery.

All Patients were subjected to the following:

(1) Investigations:
   (a) Laboratory investigations: routine preoperative laboratory investigations (Complete blood count, Liver function tests, Kidney function tests (serum urea and creatinine), and HBA1c.
   (b) Radiological investigations: plain posteroanterior chest radiography.
   (c) ECG: 12 leads ECG was done for all patients.

(d) Echocardiography: A complete echocardiography was done for all patients with the following parameters measured: Left ventricular end diastole (LVEDD), Left ventricular end systole (LVESD), Ejection fraction (EF%), Resting segmental wall motion abnormalities (RWMA), MR; grade and pathology.
(e) Cardiac catheterization: Coronary artery disease was defined as a narrowing of the diameter of a coronary artery by 50% or more.
(f) Carotid duplex: was done in patients above 50 years whether male or female.

(2) Intraoperative procedure:

(a) Operative procedure: CABG with mitral valve repair or replacement
(b) Ischemic time and total bypass time.
(c) Type of cardioplegia.
(d) No. and types of grafts.
(e) Use of inotropic support to be weaned from bypass.
(f) Use of intra-aortic balloon pump (IABP).
(3) Postoperative ICU evaluation:

(a) Hemodynamics of the patient.
(b) Blood loss.
(c) Ventilation time.
(d) Re-operation for bleeding.
(e) Use of inotropes or IABP.
(f) Low cardiac output syndrome.
(g) Total ICU stays.
(4) In-hospital stays evaluation:

(a) Postoperative evaluation, clinically and by echo assessment.
(b) Total hospital stays.

2.3. Ethical considerations

(1) Consent from the National Heart Institute to get information and use it in this study.
(2) Refer the citations to their original authors and avoid plagiarism.

2.4. Statistics

Data were thoroughly handled via Statistical Package for Social Science (IBM SPSS) version 20. Description of the qualitative data is in the form of numbers and percentages while description of normally distributed quantitative data is in the form of mean and SD. The comparison between two groups with qualitative data were done by using χ^2 test and Comparison between two independent groups regarding quantitative data with parametric distribution were done by using Independent *t*-test.

The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the *P* value was considered significant as the following:

P greater than 0.05: Nonsignificant, *P* less than 0.05: Significant, *P* less than 0.01: highly significant.

3. Results

Regarding the demographic data, the mean age of group Ia was 54.25 ± 10.04 years. There were 15 (75%) male patients. The clinical presentations were chest pain in 12 (60%) patients and dyspnea in eight (40%) patients. There were 14 (70%) diabetic patients, 13 (65%) hypertensive patients and 13 (65%) smokers. The mean height was 172.85 ± 6.82 cm, mean weight was 86.05 ± 8.64 Kg and mean BMI was 28.85 ± 2.97 Kg/M^2. According to CCS grades, one (5%) patients were grade I, 11 (55%) patients were grade II and eight (40%) patients were grade III. According to NYHA classes, six (30%) patients were class I, 13 (65%) patients were class II and one (5%) patient was class III. There were three (15%) patients with previous MI and five (25%) patients with previous PCI (as shown in Table 1).

The mean age of group IIa was 53.55 ± 8.88 years. There were 13 (65%) male patients. The clinical presentations were chest pain in 11 (55%) patients and dyspnea in 9 (45%) patients. There were 13 (65%) diabetic patients, 17 (85%) hypertensive

Table 1. Shows comparison regarding the demographic data between group Ia and group IIa.

	Group Ia (*N* = 20)	Group IIa (*N* = 20)	*P* value
Male sex	15 (75.0%)	13 (65.0%)	0.490
Age (y)	54.25 ± 10.04	53.55 ± 8.88	0.858
Presentation			
Chest pain	12 (60.0%)	11 (55.0%)	0.749
Dyspnea	8 (40.0%)	9 (45.0%)	
Diabetes mellitus (%)	14 (70.0%)	13 (65.0%)	0.735
Hypertension (%)	13 (65.0%)	17 (85.0%)	0.144
Smoking (%)	13 (65.0%)	15 (75.0%)	0.490
Height (cm)	172.85 ± 6.82	170.33 ± 4.00	0.314
Weight (kg)	86.05 ± 8.64	82.77 ± 6.66	0.322
BMI (Kg/M^2)	28.85 ± 2.97	28.49 ± 1.39	0.733
CCS			
I	1 (5.0%)	2 (10.0%)	
II	11 (55.0%)	9 (45.0%)	0.743
III	8 (40.0%)	9 (45.0%)	
NYHA			
I	6 (30.0%)	7 (35.0%)	
II	13 (65.0%)	11 (55.0%)	0.749
III	1 (5.0%)	2 (10.0%)	
Previous MI	3 (15.0%)	2 (10.0%)	0.632
Previous PCI	5 (25.0%)	7 (35.0%)	0.490

patients and 15 (75%) smokers. The mean height was 170.33 ± 4.00 cm, mean weight was 82.77 ± 6.66 Kg and mean BMI was 28.49 ± 1.39 Kg/M^2. According to CCS grades, two (10%) patients were grade I, nine (45%) patients were grade II and nine (45%) patients were grade III. According to NYHA classes, seven (35%) patients were class I, 11 (55%) patients were class II and two (10%) patients were class III. There were two (10%) patients with previous MI and seven (35%) patients with previous PCI. There were no any statistically significant difference in these data between both groups (as shown in Table 1).

The mean age of group Ib was 60.65 ± 7.37 years. There were 20 (66.6%) male patients. The clinical presentations were chest pain in nine (30%) patients and dyspnea in 21 (70%) patients. There were 23 (76.6%) diabetic patients, 23 (76.6%) hypertensive patients and 15 (50%) smokers. The mean height was 170.40 ± 6.11 cm, mean weight was 79.35 ± 8.49 Kg and mean BMI was 27.38 ± 3.23 Kg/M^2. According to CCS grades, four (13.3%) patients were grade I, 13 (43.3%) patients were grade II and 13 (43.3%) patients were grade III. According to NYHA classes, 11 (36.6%) patients were class I, 11 (36.6%) patients were class II and eight (26.6%) patients was class III. There were five (16.6%) patients with previous MI and six (20%) patients with previous PCI (as shown in Table 2).

The mean age of group IIb was 54.44 ± 10.18 years. There were 19 (63.3%) male patients. The clinical presentations were chest pain in 12 (40%) patients and dyspnea in 18 (60%) patients. There were 17 (56.6%) diabetic patients, 19 (63.3%) hypertensive patients and 14 (46.7%) smokers. The mean height was 172.55 ± 4.61 cm, mean weight was 77.77 ± 7.12 Kg and mean BMI was 26.12 ± 2.22 Kg/M^2. According to CCS grades, four (13.3%) patients were grade I, 11 (36.7%) patients were grade II, 14 patients (46.7%) were grade III and one (3.3%) patient was grade IV. According to NYHA classes, 10 (33.3%) patients were class I, 11 (36.7%) patients were class II and nine (30%) patients were class III. There were five (16.6%) patients with previous MI and seven (23.3%) patients with previous PCI. There was statistically significant difference regarding mean age between both groups ($P = 0.005$) (as shown in Table 2).

Regarding the pre-operative data: In group Ia, the mean hemoglobin concentration was 14.39 ± 1.17 mg/dl and the mean creatinine serum level was 0.91 ± 0.26 mg/dl. There were one (5%) HCV patients. The pre-operative echo data as the following: the mean LVEDD was 5.75 ± 0.40 cm, the mean LVESD was 4.04 ± 0.78 cm and the mean EF was 50.65 ± 7.66%. Dobutamine stress echocardiography revealed improvement of the EF from 39.66 ± 4.77% to 54.66 ± 7.50%. The coronary angiography revealed significant lesions in LAD in 100%

Table 2. Shows comparison regarding the demographic data between group Ib and group IIb.

	Group Ib ($N = 30$)	Group IIb ($N = 30$)	P value
Male sex	20 (66.6%)	19 (63.3%)	0.787
Age (y)	60.65 ± 7.37	54.44 ± 10.18	0.005*
Presentation			
Chest pain	9 (30.0%)	12 (40.0%)	0.416
Dyspnea	21 (70.0%)	18 (60.0%)	
Diabetes mellitus (%)	23 (76.6%)	17 (56.6%)	0.100
Hypertension (%)	23 (76.6%)	19 (63.3%)	0.259
Smoking (%)	15 (50.0%)	14 (46.7%)	0.795
Height (cm)	170.40 ± 6.11	172.55 ± 4.61	0.095
Weight (kg)	79.35 ± 8.49	77.77 ± 7.12	0.397
BMI (Kg/M^2)	27.38 ± 3.23	26.12 ± 2.22	0.055
CCS			
I	4 (13.3%)	4 (13.3%)	
II	13 (43.3%)	11 (36.7%)	0.752
III	13 (43.3%)	14 (46.7%)	
IV	0	1 (3.3%)	
NYHA			
I	11 (36.6%)	10 (33.3%)	
II	11 (36.6%)	11 (36.6%)	0.948
III	8 (26.6%)	9 (30.0%)	
Previous MI	5 (16.6%)	6 ((20.0%)	0.723
Previous PCI	5 (16.6%)	7 (23.3%)	0.490

BMI, body mass index; CCS, Canadian cardiovascular society; MI, myocardial infarction; NYHA, New York heart association; PCI, percutaneous cardiac intervention.
* Indicates statistically significant difference.

Table 3. Shows comparison regarding pre-operative labs, echocardiography, dobutamine stress echocardiography and coronary angiography between group Ia & group IIa.

	Group Ia ($N = 20$)	Group IIa ($N = 20$)	P value
Hb concentration (mg/dl)	14.39 ± 1.17	13.41 ± 1.63	0.076
Creatinine (mg/dl)	0.91 ± 0.26	0.87 ± 0.19	0.683
Virology			
Negative	19 (95.0%)	18 (95.0%)	0.548
HCV	1 (5.0%)	2 (10.0%)	
Pre-operative echo			
LVEDD (cm)	5.75 ± 0.40	5.72 ± 0.80	0.892
LVESD (cm)	4.04 ± 0.78	3.92 ± 1.06	0.734
EF (%)	50.65 ± 7.66	55.75 ± 10.49	0.151
DSE			
Pre- EF (%)	39.66 ± 4.77	43.00 ± 2.64	0.060
Post- EF (%)	54.66 ± 7.50	58.00 ± 5.29	0.239
CA			
LM	0 (0.0%)	1 (5.0%)	
LAD	20 (100.0%)	20 (100.0%)	
LCX	17 (85.0%)	15 (75.0%)	0.660
RCA	13 (65.0%)	9 (45.0%)	

of the patients, LCX in 85% of the patients and RCA in 65% of the patients (as shown in Table 3).

In group IIa, the mean hemoglobin concentration was 13.41 ± 1.63 mg/dl and the mean creatinine serum level was 0.87 ± 0.19 mg/dl. There were two (10%) HCV patients. The pre-operative echo data as the following: the mean LVEDD was 5.72 ± 0.80 cm, the mean LVESD was 3.92 ± 1.06 cm and the mean EF was 55.75 ± 10.49%. Dobutamine stress echocardiography revealed improvement of the EF from 43.00 ± 2.64% to 58.00 ± 5.29%. The coronary angiography revealed significant lesions in LM in 5% of the patients, LAD in 100% of the patients, LCX in 75% of the patients and RCA in 45% of the patients. There was no any statistically significant difference between both groups (as shown in Table 3).

In group Ib, the mean hemoglobin concentration was 13.60 ± 0.95 mg/dl and the mean creatinine serum level was 0.79 ± 0.21 mg/dl. There were three (10%) HCV patients. The pre-operative echo data as the following: the mean LVEDD was 6.05 ± 0.57 cm, the mean LVESD was 4.50 ± 0.88 cm and the mean EF was 46.95 ± 10.26%. Dobutamine stress echocardiography revealed improvement of the EF from 38.84 ± 4.07% to 54.61 ± 5.88%.The coronary angiography revealed significant lesions in LAD in 100% of the patients, LCX in 80% of the patients and RCA in 66.6% of the patients (as shown in Table 4).

Table 4. Shows comparison regarding pre-operative labs, echocardiography, dobutamine stress echocardiography and coronary angiography between group Ib and group IIb.

	Group Ib ($N = 30$)	Group IIb ($N = 30$)	*P* value
Hb concentration (mg/dl)	13.60 ± 0.95	14.04 ± 1.31	0.122
Creatinine (mg/dl)	0.79 ± 0.21	0.84 ± 0.10	0.186
Virology			
Negative	27 (90.0%)	26 (86.7%)	0.687
HCV	3 (10.0%)	4 (13.3%)	
Pre-operative echo			
LVEDD (cm)	6.05 ± 0.57	5.90 ± 0.49	0.238
LVESD (cm)	4.50 ± 0.88	4.28 ± 0.62	0.220
EF (%)	46.95 ± 10.26	48.55 ± 11.08	0.537
DSE			
Pre- EF (%)	38.84 ± 4.07	39.25 ± 2.98	0.625
Post- EF (%)	54.61 ± 5.88	55.00 ± 2.44	0.703
CA			
LAD	30 (100.0%)	30 (100.0%)	
LCX	24 (80.0%)	22 (73.3%)	0.948
RCA	20 (66.6%)	21 (70.0%)	

CA, coronary angiography; DSE, dobutamine stress echocardiography; EF, ejection fraction; Hb, hemoglobin; HCV, hepatitis C virus; LAD, left anterior descending; LCX, left circumflex artery; LM, left main; LVEDD, left ventricular end diastolic diameter; LVESD, left ventricular end systole diameter; MR, mitral regurge; OM, obtuse marginal artery; PDA, posterior descending artery; PL, posterolateral artery; RCA, right coronary artery.
*Indicates statistically significant difference.

In group IIb, the mean hemoglobin concentration was 14.04 ± 1.31 mg/dl and the mean creatinine serum level was 0.84 ± 0.10 mg/dl. There were 4 HCV patients (13.3%). The pre-operative echo data as the following: the mean LVEDD was 5.90 ± 0.49 cm, the mean LVESD was 4.28 ± 0.62 cm and the mean EF was 48.55 ± 11.08%. Dobutamine stress echocardiography revealed improvement of the EF from 39.25 ± 2.98% to 55.00 ± 2.44%. The coronary angiography revealed significant lesions in LAD in 100% of the patients, LCX in 73.3% of the patients and RCA in 70% of the patients. There was no any statistically significant difference between both groups (as shown in Table 4).

Regarding the Intraoperative data: In group Ia, the mean bypass time was 120.50 ± 31.86 min and the mean cross-clamp time was 94.50 ± 29.28 min. The used cardioplegia was warm cardioplegia in 1 patient (5%) and Custodial in 19 patients (95%). IABP was inserted in 1 patient (5%). The number of grafts were single graft in 3 patients (5%), 2 grafts in 8 patients (40%), 3 grafts in 4 patients (20%) and 4 grafts in 5 patients (25%). The grafted coronaries were LAD in 100% of the patients, diagonal in 20% of the patients, OM in 75% of the patients, ramus in 15% of the patients, distal RCA in 20% of the

Table 5. Shows comparison regarding intraoperative data between group Ia and group IIa.

	Group Ia ($N = 20$)	Group IIa ($N = 20$)	*P* value
Bypass time (min)	120.50 ± 31.86	133.44 ± 25.08	0.292
Cross clamp time (min)	94.50 ± 29.28	107.22 ± 28.84	0.286
Cardioplegia			
Warm	1 (5.0%)	0	0.311
Custodial	19 (95.0%)	20 (100.0%)	
Number of grafts			
1 graft	3 (15.0%)	2 (10.0%)	
2 grafts	8 (40.0%)	11 (55.0%)	
3 grafts	4 (20.0%)	7 (35.0%)	0.089
4 grafts	5 (25.0%)	0	
Intra-aortic balloon pump	1 (5.0%)	0	0.311
Grafted coronaries			
LAD	20 (100.0%)	20 (100.0%)	
Diagonal	4 (20.0%)	9 (45.0%)	
OM	15 (75.0%)	13 (65.0%)	
Ramus	3 (15.0%)	0	0.167
RCA	4 (20.0%)	1 (5.0%)	
PDA	5 (25.0%)	2 (10.0%)	
Mitral repair			
Ring	16 (80.0%)	–	–
Dacron patch	4 (20.0%)	–	–
Mitral replacement			
STJ 27	–	9 (45.0%)	–
STJ 29	–	7 (35.0%)	–
STJ 31	–	4 (20.0%)	–
Difficult weaning	1 (5.0%)	0	0.311

patients and PDA in 25% of the patients. The mitral valves were repaired by ring in 16 patients (80%) and Dacron patch in 4 patients (20%). Difficult weaning of cardiopulmonary bypass machine occurred in one patient (5%) (as shown in Table 5).

In group IIa, the mean bypass time was 133.44 ± 25.08 min and the mean cross-clamp time was 107.22 ± 28.84 min. The used cardioplegia was Custodial in all patients (100%). The number of grafts were single graft in two (10%) patients, 2 grafts in 11 (55%) patients and 3 grafts in seven (35%) patients. The grafted coronaries were LAD in 100% of the patients, diagonal in 45% of the patients, OM in 65% of the patients, distal RCA in 5% of the patients and PDA in 10% of the patients. The mitral valves were replaced by STJ27 in nine (45%) patients, STJ29 in seven (35%) patients and STJ31 in four (20%) patients. Difficult weaning of cardiopulmonary bypass machine did not occur in any patient. There was no any statistically significant difference between both groups (as shown in Table 5).

In group Ib, the mean bypass time was 130.00 ± 40.06 min and the mean cross-clamp time was 97.50 ± 31.22 min. The used cardioplegia was warm cardioplegia in seven (23.3%) patients and Custodial in 23 (86.7%) patients. IABP were inserted in five (16.6%) patients. The number of grafts were single graft in eight (26.6%) patients, 2 grafts in eight (26.6%) patients, 3 grafts in 10 (33.3%) patients, 4 grafts in five (16.6%) patients and 5 grafts in one (3.3%) patient. The grafted coronaries were LAD in 100% of the patients, diagonal in 36.6% of the patients, OM in 60% of the patients, ramus in 10% of the patients, distal RCA in 6.7% of the patients and PDA in 36.6% of the patients. The mitral valves were repaired by ring in 26 (86.7%) patients and Dacron patch in four (13.3%) patients. Difficult weaning of cardiopulmonary bypass machine occurred in four (13.3%) patients (as shown in Table 6).

In group IIb, the mean bypass time was 127.77 ± 29.90 min and the mean cross-clamp time was 98.88 ± 25.71 min. The used cardioplegia was warm cardioplegia in three (10%) patients and Custodial in 27 (90%) patients. The number of grafts were single graft in seven (23%) patients, 2 grafts in nine (30%) patients, 3 grafts in 12 (40%) patients and 4 grafts in two (6.7%) patients. The grafted coronaries were LAD in 100% of the patients, diagonal in 30% of the patients, OM in 53.3% of the patients, distal RCA in 23.3% of the patients, PDA in 13.3% of the patients and PL in 3.3% of the patients. The mitral valves were replaced by STJ27 in 10 (33.3%) patients, STJ29 in seven (50%) patients and STJ31 in four (16.7%) patients. Difficult weaning of cardiopulmonary bypass machine occurred in one (3.3%) patient. There was no any statistically significant difference between both groups (as shown in Table 6).

Table 6. Shows comparison regarding intraoperative data between group Ib and group IIb.

	Group Ib ($N = 30$)	Group IIb ($N = 30$)	*P* value
Bypass time (min)	130.00 ± 40.06	127.77 ± 29.90	0.788
Cross clamp time (min)	97.50 ± 31.22	98.88 ± 25.71	0.839
Cardioplegia			
Warm	7 (23.3%)	3 (10.0%)	0.165
Custodial	23 (86.7%)	27 (90.0%)	
Number of grafts			
1 graft	8 (26.6%)	7 (23.3%)	
2 grafts	6 (20.0%)	9 (30.0%)	
3 grafts	10 (33.3%)	12 (40.0%)	0.535
4 grafts	5 (16.6%)	2 (6.7%)	
5 grafts	1 (3.3%)	0	
Intra-aortic balloon pump	5 (16.6%)	2 (6.7%)	0.227
Grafted coronaries			
LAD	30 (100.0%)	30 (100.0%)	
Diagonal	11 (36.6%)	9 (30.0%)	
OM	18 (60.0%)	16 (53.3%)	
Ramus	3 (10.0%)	2 (6.7%)	0.291
RCA	2 (6.7%)	7 (23.3%)	
PDA	11 (36.6%)	4 (13.3%)	
PL	0	1 (3.3%)	
Mitral repair			
Ring	26 (86.7%)	–	–
Dacron patch	4 (13.3%)	–	–
Mitral replacement			
STJ 27	–	10 (33.3%)	–
STJ 29	–	15 (50.0%)	–
STJ 31	–	5 (16.7%)	–
Difficult weaning	4 (13.3%)	1 (3.3%)	0.161

LAD, left anterior descending; LCX, left circumflex artery; OM, obtuse marginal artery; PDA, posterior descending artery; PL, posterolateral artery; RCA, right coronary artery; STJ, Saint Jude medical valve.
*indicates statistically significant difference.

Regarding the post-operative data: In group Ia, the mean ventilation duration was 10.78 ± 4.45 h, the mean drainage amount was 418.42 ± 221.24 ml, the mean ICU stay was 2.94 ± 0.91 days and the mean hospital stay was 10.52 ± 2.58 days. The used inotropes was adrenaline in 11 (55%) patients. Two (10%) patients was reopened due to bleeding and one (5%) patient had chest infection. The early mortality occurred in one (5%) patient. After exclusion the mortality, the post-operative echo data as following: the mean LVEDD was 5.67 ± 0.55 cm, the mean LVESD was 4.03 ± 0.84 cm and the mean EF was 45.31 ± 5.74%. Assessment of the mitral valve regurge revealed mild regurge in all patients (100%). Postoperative NYHA class was class I in all patients (100%). Superficial wound infection occurred in three (15.8%) patients (as shown in Table 7).

Table 7. Shows comparison regarding post-operative data between group Ia and group IIa.

	Group Ia ($N = 20$)	Group IIa ($N = 20$)	P value
Ventilation duration (hours)	10.78 ± 4.45	11.75 ± 2.71	0.552
Drainage amount (ml)	418.42 ± 221.24	494.44 ± 203.78	0.388
Inotropes			
Adrenaline	11 (55.0%)	15 (75.0%)	0.184
IABP inserted in ICU	1 (5.0%)	0	0.311
Bleeding	2 (10.0%)	2 (10.0%)	1.000
Reopening	2 (10.0%)	1 (5.0%)	0.548
Chest infection	1 (5.0%)	0	0.311
ICU stay (days)	2.94 ± 0.91	4.66 ± 3.93	0.070
Mortality	1 (5.0%)	2 (10.0%)	0.548
	Group Ia ($N = 19$)	Group IIa ($N = 18$)	
Postoperative echo			
LVEDD (cm)	5.67 ± 0.55	5.67 ± 0.42	1.000
LVESD (cm)	4.03 ± 0.84	4.55 ± 0.66	0.132
EF (%)	45.31 ± 5.74	40.42 ± 10.62	0.131
MR			
No	0	8 (100.0%)	<0.001*
Mild	19 (100.0%)	0	
Mean MV PG (mmHg)	–	5.00 ± 1.30	–
Postoperative NYHA			
I	19 (100.0%)	16 (88.9%)	0.135
II	0 (0.0%)	2 (11.1%)	
Wound infection			
No	16 (84.2%)	14 (77.8%)	
SWI	3 (15.8%)	2 (11.1%)	0.315
DWI	0	2 (11.1%)	
Total hospital stay (days)	10.52 ± 2.58	11.37 ± 4.50	0.538

In group IIa, the mean ventilation duration was 11.75 ± 2.71 h, the mean drainage amount was 494.44 ± 203.78 ml, the mean ICU stay was 4.66 ± 3.93 days and the mean hospital stay was 11.37 ± 4.50 days. The used inotropes was adrenaline in 15 (75%) patients. One (5%) patient was reopened due to bleeding. The early mortality occurred in two (10%) patients. After exclusion the mortality, the post-operative echo data as following: the mean LVEDD was 5.67 ± 0.42 cm, the mean LVESD was 4.55 ± 0.66 cm and the mean EF was 40.42 ± 10.62%. Assessment of the mitral valve regurge revealed no regurge in all patients (100%) with mean pressure gradient 5.00 ± 1.30 mm Hg. Postoperative NYHA classes were class I in 16 (88.9%) patients and class II in two (11.1%) patients. Superficial wound infection occurred in two (11.1%) patients and deep wound infection in two (11.1%) patients. There was statistically difference regarding post-operative MR ($P < 0.001$) (as shown in Table 7).

In group Ib, the mean ventilation duration was 11.89 ± 4.62 h, the mean drainage amount was 447.50 ± 184.58 ml, the mean ICU stay was 3.05 ± 1.39 days and the mean hospital stay was 9.73 ± 2.78 days. The used inotropes were adrenaline in 25 (86.6%) patients and dobutamine in two (6.6%) patients. One (3.3%) patient was reopened due to bleeding. The early mortality occurred in three (10%) patients. After exclusion the mortality, the post-operative echo data as following: the mean LVEDD was 5.75 ± 0.68 cm, the mean LVESD was 4.25 ± 0.77 cm and the mean EF was 43.22 ± 9.27%.

Table 8. Shows comparison regarding post-operative data between group Ib and group IIb.

	Group Ib ($N = 30$)	Group IIb ($N = 30$)	P value
Ventilation duration (hours)	11.89 ± 4.62	11.77 ± 3.34	0.899
Drainage amount (ml)	447.50 ± 184.58	511.11 ± 143.12	0.106
Inotropes			
Adrenaline	26 (86.6%)	20 (66.6%)	0.152
Dobutamine	2 (6.6%)	3 (10.0%)	
IABP inserted in ICU	1 (3.3%)	0	0.313
Bleeding	1 (3.3%)	3 (10.0%)	0.300
Reopening	1 (3.3%)	2 (6.7%)	0.553
Stroke	1 (3.3%)	2 (6.7%)	0.553
Chest infection	1 (3.3%)	2 (6.7%)	0.553
ICU stay (days)	3.05 ± 1.39	3.55 ± 0.72	0.043[a]
Mortality	3 (10.0%)	1 (3.3%)	0.300
	Group Ib ($N = 27$)	Group IIb ($N = 29$)	
Postoperative echo			
LVEDD (cm)	5.75 ± 0.68	5.74 ± 0.45	0.942
LVESD (cm)	4.25 ± 0.77	4.44 ± 0.54	0.239
EF (%)	43.22 ± 9.27	38.66 ± 8.70	0.044[a]
MR			
No	6 (22.2%)	29 (100.0%)	
Trivial	2 (7.4%)	0	<0.001[a]
Mild	17 (62.9%)	0	
Moderate	2 (7.4%)	0	
Mean MV PG (mmHg)	–	6.22 ± 0.83	–
Postoperative NYHA			
I	16 (59.3%)	20 (68.9%)	0.574
II	11 (40.7%)	9 (31.1%)	
Wound infection			
No	27 (100.0%)	25 (86.2%)	0.134
SWI	0	2 (6.9%)	
DWI	0	2 (6.9%)	
Total hospital stay (days)	9.73 ± 2.78	12.44 ± 1.66	0.001[a]

DWI, deep wound infection; EF, ejection fraction; IABP, intra-aortic balloon pump; ICU, intensive care unit; left ventricular end diastolic diameter; LVEDD; LVESD, left ventricular end systole diameter; MR: mitral regurge; MV: mechanical valve; NYHA: New York heart association; PG: pressure gradient; SWI: superficial wound infection.

[a] Indicates statistically significant difference.

Assessment of the mitral valve regurge revealed no regurge in six (22.2%) patients, trivial regurge in two (7.4%) patients, mild regurge in 17 (62.9%) patients and moderate regurge in two (7.4%) patients. Post-operative NYHA class was class I in 16 (59.3%) patients and class II in 11 (40.7%) patients (as shown in Table 8).

In group IIb, the mean ventilation duration was 11.77 ± 3.34 h, the mean drainage amount was 511.11 ± 143.12 ml, the mean ICU stay was 3.55 ± 0.72 days and the mean hospital stay was 12.44 ± 1.66 days. The used inotropes were adrenaline in 20 (66.6%) patients and dobutamine in three (10%) patients. Two (6.7%) patients were reopened due to bleeding and two (6.7%) patient had chest infection. The early mortality occurred in one (3.3%) patients. After exclusion the mortality, the post-operative echo data as following: the mean LVEDD was 5.74 ± 0.45 cm, the mean LVESD was 4.44 ± 0.54 cm and the mean EF was 38.66 ± 8.70%. Assessment of the mitral valve regurge revealed no regurge in all patients (100%) with mean pressure gradient 6.22 ± 0.83 mm Hg. Postoperative NYHA class was class I in 20 (68.9%) patients and class II in nine (31.1%) patients. Superficial wound infection occurred in two (6.9%) patients and deep wound infection in two (6.9%) patients. There were statistically difference between groups regarding ICU stay ($P = 0.043$), total hospital stay ($P = 0.001$), post-operative EF ($P = 0.044$) and post-operative MR ($P < 0.001$) (as shown in Table 8).

4. Discussion

The most effective surgical method for treating severe IMR is still controversial. In the past few years, the use of MVr has greatly exceeded the use of replacement [13]. However, no randomized trials have proven that repair is superior across a spectrum of patients with severe IMR.

For severe IMR, the general consensus is that surgical treatment is indicated [14]. However, recommendations for mitral valve repair or replacement are less clear. Acker *et al*. conducted a recent randomized controlled trial (RCT) in patients with severe IMR to compare mitral valve repair with chordal-sparing MVR. At one year, there was no significant difference in left ventricular reverse remodeling or survival, but replacement produced a more lasting repair of MR [5].

Virk *et al*. conducted a meta-analysis that included twenty-two observational retrospective studies and one RCT. The mitral valve repair group had greater long-term survival in the retrospective studies. We discovered that the majority of the trials were followed for more than three years. As a result, it is possible that the influence on survival will take a longer follow-up period to become apparent [15].

In contrast, for patients with moderate IMR, whether mitral valve surgery is required in addition to CABG remains debatable. Proponents of combining CABG with mitral valve repair believe that 40% of patients continue to have moderate or severe MR following standalone CABG, and that this regurgitation may lead to poorer outcomes [16]. Some studies have suggested that concomitant mitral valve surgery has a functional benefit, whereas others have found no clinical or survival benefits from the combination of mitral valve surgery and coronary artery bypass surgery.

Smith *et al*. carried out the largest RCT on the subject [17]. Their research found that combining mitral valve surgery with CABG was related with a lower prevalence of moderate or severe MR but an increased number of adverse events. Although there was no significant difference in mortality or severe adverse cardiac or cerebrovascular event rates between the two groups, the neurologic event rate and supraventricular arrhythmia rate were greater in the mitral valve repair group. This disparity was thought to be due to the lengthier CPB duration required and the mandatory atriotomy incision required for mitral valve replacement.

Proponents of isolated CABG contend that by treating the underlying cause, the LV undergoes reverse remodeling, resulting in a reduction of MR. The presence of viable myocardium is critical to the effectiveness of such a strategy. According to Penicka and colleagues improvement in regurgitation after isolated CABG in patients with moderate IMR was confined to those who had viable myocardium and no papillary muscle dy-synchrony [18].

The presence of viable myocardium is critical to the success of surgical revascularization. In patients with IMR, successful revascularization is associated with decreased left ventricular size, higher mitral valve closing force, improved papillary synchronization, and enhanced myocardial contractility [19].

Castleberry *et al*. [20] contributed to this idea by presenting the largest real-world dataset to date. It was a one-center retrospective study. Over a 10-year period, they assessed 4989 patients with moderate or severe IMR. In this study, patients were treated with medication, percutaneous coronary intervention, CABG, or both CABG and mitral valve surgery. At 10 years, isolated CABG had the highest adjusted survival rate among these therapies. A meta-analysis by Kopjar *et al*. [16], which included 5 observational studies and 4 RCTs, likewise indicated that, for moderate IMR, concurrent CABG and mitral

valve surgery had no enhanced operational mortality or survival benefit over CABG alone.

Although the evidence from the preceding studies suggests that isolated CABG can provide comparable clinical outcomes and survival, it is also clear that CABG combined with mitral valve repair can be performed safely, and that the combined procedure may be advantageous in a certain subset of patients due to the theoretical benefit of eliminating MR and its associated adverse impact on left ventricular remodelling. As a result, future research should focus on determining which individuals may benefit the most from concurrent mitral valve repair for moderate IMR during coronary bypass surgery.

To summarize the preceding discussion, the degree of MR may be a crucial clinical factor in determining which surgical modality to use for IMR patients. Based on the findings of two major RCTs [5,17], we recommend that severe IMR patients undergo MVR. The underlying probable reason for this advice is that MVR delivers more permanent correction than mitral valve replacement while maintaining comparable clinical survival. On the other hand, we recommend that patients with moderate IMR have isolated CABG as long as there is viable myocardium fed by the target vessels to be revascularized. As a result, the myocardial viability test may be another essential clinical component for decision making in patients with moderate IMR. The possibility for solitary CABG rather than CABG + mitral valve repair is that the addition of mitral valve repair brings increased risks of neurological problems and supraventricular arrhythmias while providing no survival advantages over CABG alone.

We believe that if noviable myocardium is supplied by the target vessels to be revascularized, an intentional mitral valve repair may be required. Validation of the aforementioned mechanisms is required. We expect that by validating these mechanisms, the outcome of surgical therapy for IMR patients will improve, and that the associated approaches will eventually be spread to other centers.

4.1. Conclusion

Our preliminary findings showed that there was no significant difference in the surgical outcomes of MVR and MVr in terms of early mortality and morbidities. However, mitral valve repair was related to a higher incidence of residual or recurrent MR. According to the most recent literature, the role of MVR in severe IMR can be justified. In the case of moderate IMR, CABG without mitral valve surgery may yield comparable clinical outcomes in the presence of viable myocardium. In non-viable myocardium CABG with mitral valve repair is mandatory.

4.2. Limitations

Themain limitations of this study are its retrospective nature and the small sample size. Because of the lack of intraoperative transesophageal echocardiography at our institution, surgeons in many cases did not choose valve repair. The decision to conduct simultaneous MVR was based on surgical factors and preferences. It is also critical to evaluate the short- and long-term consequences of these operations.

Authorship

First and second authors are responsible for data collection and writing the manuscript.

Conflicts of interest

Please consider checking the following:

All authors have participated in (a) conceptualization and designing, or analyzing and drawing conclusions of the data; (b) modification and revision of the article for necessary intellectual content; and (c) approving on the final version.

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