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When to repair ischemic mitral valve regurgitation? An algorithmic approach

F. Roshanali, A. Vedadian, S. Shoar, S. Sandoughdaran, M. Naderan, M. H. Mandegar

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Summary
Background Despite huge progress in the surgical management of ischemic mitral regurgitation, there is still controversy regarding the ideal treatment option.

Aims Our study aimed to define an algorithmic approach in order to select those patients who will benefit the most from concomitant mitral valve procedure.

Methods Patients with mitral regurgitation (MR) who met the inclusion criteria were included in our study. Patients with structural MR including ruptured chordae or papillary muscle, abnormal leaflet thickening, annular calcification, or other valvular or congenital heart diseases, ventricular aneurysms and those who were candidates for other surgical procedures were excluded. A total of 350 patients (about 12 %) were classified as having ischemic mitral regurgitation (IMR) and were enrolled in our analysis. All the patients underwent coronary artery bypass grafting and by the designed algorithmic approach were also decided to have additive procedures for their concomitant IMR.

Results Six months survival was 91.5 % among all the patients in this study. During the follow-ups 86.9 % of the patients survived . Overall mortality rate was 13.1 % (*n* = 46), of which 7.1 % (*n* = 25) occurred due to cardiac and 6 % (*n* = 21) as a result of a non-cardiac cause.

Conclusions Individualising methods to select patients suffering from IMR for concomitant mitral valve procedure and coronary artery bypass grafting (CABG) seems to serves more effectively by reducing unnecessary surgeries and at the same time not missing absolute indications for concomitant valve repairs. Our algorithm showed a promising efficacy to effectively select patients for CABG and concomitant mitral valve procedures.

Keywords: Ischemic mitral regurgitation, Coronary artery bypass grafting, Concomitant mitral valve procedures, Algorithmic approach

Introduction

Despite huge progress in the surgical management of ischemic mitral regurgitation (IMR) [1–2], there is still controversy regarding the ideal treatment. IMR continues to have a remarkable incidence roughly between 20 and 25 % increasing cardiovascular mortality rate and causing higher probability of heart failure [3–7]. Therefore, cardiac surgeons may have more concern to eliminate a distinct approach this disease.

Although most surgeons would advocate that concomitant mitral valve repair in patients with moderate to severe IMR (defined as grade 3 + or 4 + IMR) undergoing coronary artery bypass grafting (CABG) is beneficial [8–9], the surgical management of moderate IMR still remains under debate.

Some studies demonstrated that CABG alone by resolving perfusion impairment may improve regional wall motion leading to IMR reversal. Moreover, late outcomes of IMR patients who have undergone isolated CABG are acceptable [10–12]. On the other hand, some studies have showed that performing concomitant mitral

S. Shoar, MD (✉) · F. Roshanali, MD · A. Vedadian, MD
Department of Cardiology and Cardiac Surgery, Day General Hospital, No. 1434873111, Tavanir Street,
Valie Asr Avenue, Tehran, Iran
e-mail: ssht84@yahoo.com

A. Vedadian, MD · S. Shoar, MD · M. H. Mandegar, MD
Department of Cardiac Surgery, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran

S. Shoar, MD
Department of General Surgery, Shariati General Hospital, Tehran, Iran

S. Sandoughdaran, MD · M. Naderan
School of Medicine, Tehran University of Medical Sciences, Tehran, Iran

valve surgery in patients with moderate IMR undergoing CABG would not benefit these patients [13–14]. Patients survival after concomitant IMR repair is still weak regardless of the type of procedure which has been implicated [15]. However, it has been evident that survival with mitral valve replacement is significantly less than repair [16–17]; it was also reported that mortality is nearly the same after mitral valve replacement in comparison with repair [18].

With regard to the controversies in the literatures about the ideal management of each stage of moderate IMR in candidates of CBAG, we conducted the current study to define an algorithmic approach in order to select those patients who will benefit the most from concomitant mitral valve procedure.

Methods and materials

Study design

This is a prospective study in which all the patients were evaluated by transthoracic echocardiography (TTE) before the surgery. The findings were reconfirmed by provocative intraoperative trans-esophageal echocardiography (TEE). Patients then underwent CABG and if indicated, concomitant valve procedure.

Patients' selection

Between January 2007 and January 2010, 2,840 consecutive patients were referred to the Department of Cardiac Surgery in Day general Hospital for elective coronary artery bypass grafting (CABG). Pre-operative trans-thoracic echocardiography (TTE) was performed for all of the patients to determine if MR and/or any other cardiac components dysfunction exist. The findings were confirmed with pre-operative angiography and in case of any inconsistency with trans-esophageal echocardiography (TEE).

If patients with MR fulfilled the inclusion criteria (Table 1), they were considered as functional MR (also referred to as FMR or IMR) and then included in our study. Patients with structural MR including ruptured chordae or papillary muscle, abnormal leaflet thickening, annular calcification, or other valvular or congenital heart diseases, ventricular aneurysms and those who were candidates for other surgical procedures were excluded. A total of 350 patients (about 12 %) were classified as having IMR and were enrolled in analysis. Institutional Review Board of Day General Hospital approved the study protocol and patients filled an informed consent to enter the study.

Table 1. Inclusion criteria for this study

Significant symptomatic multi-vessel coronary artery disease
More than one week of myocardial infarction occurrence
No evidence of active ischemia during echocardiography
No evidence of mitral stenosis
Type I or IIIb by Carpentier classification
Annular dilatation with normal leaflet motion (type I)
Restricted systolic leaflet motion (type IIIb)
Both of above

Algorithmic approach

All the patients were evaluated by TEE using quantitative echocardiographic measurements. Grade of IMR, effective regurgitant orifice area (ERO), annulus diameter, left ventricular ejection fraction and left ventricular end systolic volume were all measured. Patients were classified based on New York Heart Association (NYHA) classification.

Figure 1 shows our algorithmic approach to surgically treatment of IMR. In case of ERO <20 ($n=94$) (Group 1), patients were considered a candidate for CABG alone while the rest of the patients ($n=256$) (Group 2) in whom ERO was measured >20 were evaluated for life expectancy and/or any severe co-morbidities. On this basis, 30 patients again (Group 2) underwent CABG alone due to presence of multiple comorbidities or calculated life expectancy <5 years. Table 2 demonstrates patients' comorbidities, survival status and mortality causes in group 2. The remaining patients ($n=226$), with life expectancy >5 years or without multiple comorbidities were then evaluated by low-dose dobutamine stress echocardiography (DSE) to determine if IMR would be reversible after CABG. IMR was considered reversible according to DSE results in 49 patients; hence, they underwent CABG alone (Group 3). On the other hand, the remaining patients ($n=177$) underwent concomitant CABG and mitral valve procedure in which the type of valve procedure was determined according to trans-esophageal echocardiography (TEE) findings and surgeon decision. In this regard, interpapillary muscle distance (PMD) and coaptation depth (CD) was measured by TEE. PMD <20 mm or CD <10 mm was considered an indication to perform annuloplasty along with CABG ($n=120$) (Group 4); on the other hand, depending on the surgeons' discretion of mitral valve function during the surgery, annuloplasty with additive procedures ($n=26$) (Group 5) or mitral valve replacement (MVR) ($n=31$) (Group 6) was performed in addition to CABG. TTE was re-performed in all the patients after the surgery and before they were discharged and then annually.

Techniques

In this study, all the echocardiography was performed by two cardiologists that were blind for the study design. Previous studies have documented that intra-operative TEE downgrades MR severity [13, 19]. Consequently, in this study intra-operative TEE was carried out by provocative testing to increase both pre-load and after-load which may in turn clarify the underlying worsening of IMR and assist with intra-operative decision making.

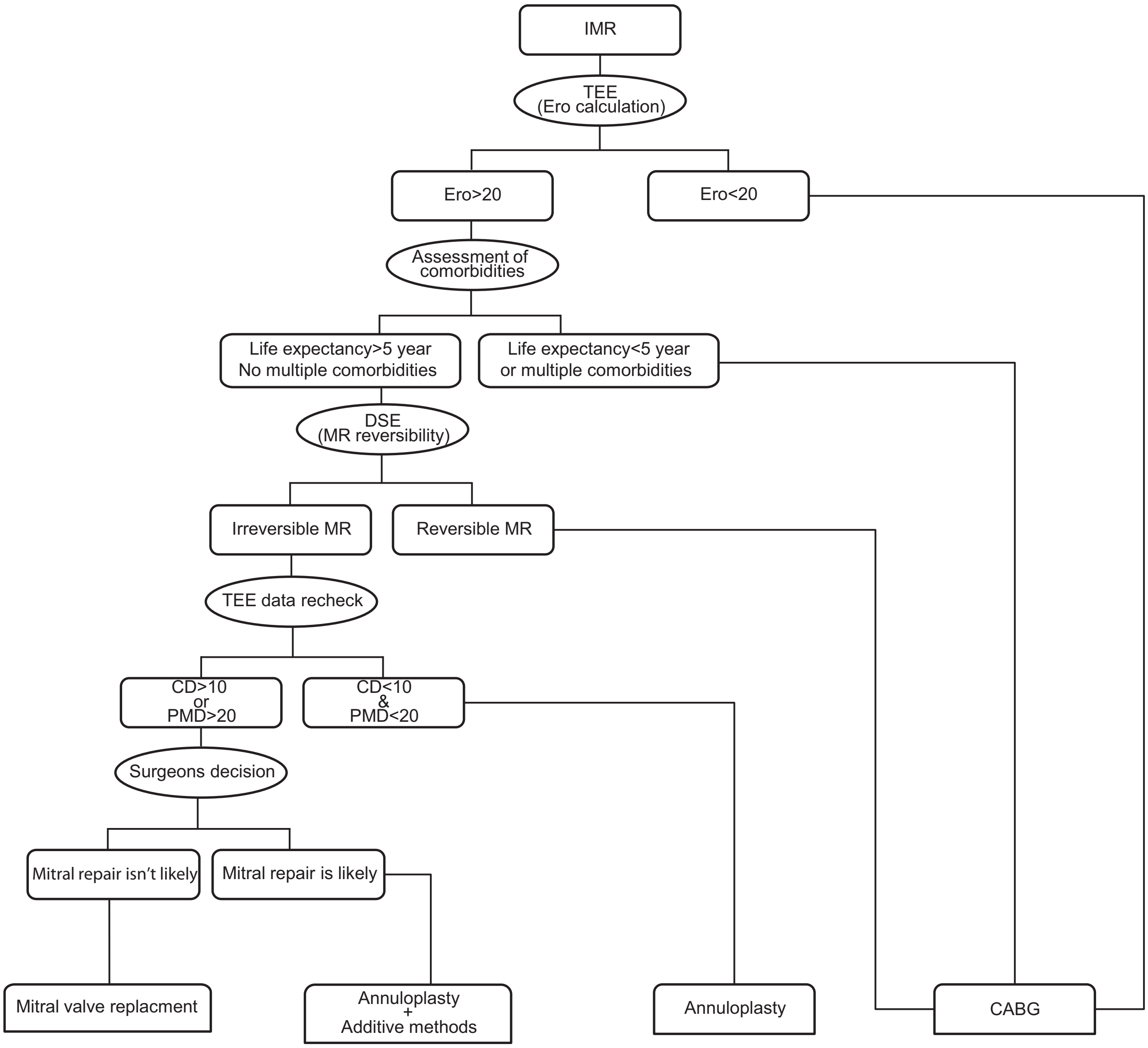

Fig. 1 The algorithmic approach for ischemic mitral regurgitation management. *IMR* ischemic mitral regurgitation, *TEE* trans-esophageal echocardiography, *Ero* effective regurgitant orifice area, *DSE* dobutamine stress echocardiography, *MR* mitral regurgitation, *CD* cooptation depth, *PMD* inter-papillary muscle distance, *CABG* coronary artery bypass grafting

Echocardiography techniques

Echocardiography was performed with a commercially available ultrasound device (GE Vivid 7, Horten, Norway). Ejection fraction (EF) was measured using the modified biplane Simpson's method. The severity of MR was determined based on quantitative PISA method and calculation ERO. Interpapillary muscle distance was measured through parasternal short axis view in TTE and transgastric view in TEE at the end of systole (on peak of T wave). CD was also measured as a distance between annulus and coaptation point. Annulus' size was measured in 4-chamber view (medial-lateral size) in TTE or TEE. Stress echocardiography for evaluation of IMR reversibility was performed as follows: after obtaining resting TTE, low-dose DSE was performed. Dobutamine infusion 2.5 µg/kg/min was started and then subsequently increased to 5, 7.5 and 10 µg/kg/min at 3-minutes stages avoiding inducing ischemia. At each stage, MR severity was assessed by real time echocardiography.

Surgical techniques

Coronary artery bypass grafting (CABG)

All the patients in this study underwent complete revascularisation procedures. CABG was performed through a median sternotomy, aortic and bicaval cannulation,

Table 2. Comorbidities, survival status and cause of death in patients of group 2

Patients	Associated disease	Survival/cause of death
1	Severe COPD	Respiratory failure
2	Colon cancer	Alive
3	Stomach cancer	Alive
4	Prostate cancer	Metastases
5	Esophagus cancer	Sudden cardiac death
6	Thyroid cancer	Metastases
7	Prostate cancer	Alive
8	Prostate cancer	Metastases
9	Pancreases cancer	Heart failure
10	Uterine cancer	Metastases
11	Breast cancer	Metastases
12	Prostate cancer	Multi organ failure
13	Breast cancer	Arrhythmia
14	Severe COPD	Alive
15	Pulmonary cancer	Respiratory failure
16	Lymphoma	Heart failure
17	Colon cancer	MI
18	Stomach cancer	Alive
19	Pulmonary cancer	Multi organ failure
20	Severe COPD	Respiratory failure
21	Severe COPD	Alive
22	Breast cancer	Sudden cardiac death
23	Severe COPD	Respiratory failure
24	Severe COPD	Heart failure
25	Multiple sclerosis	Alive
26	Old age + renal failure (very ill)	MI
27	Severe COPD	Alive
28	Severe COPD	Alive
29	Colon cancer	Alive
30	Severe COPD	Respiratory failure

Of 30 patients in group 2, 20 patients expired within the follow up (8 cardiac and 12 non-cardiac deaths)
COPD chronic obstructive pulmonary disease, *MI* myocardial infarction

moderate hypothermic cardiopulmonary bypass and cold-blood retrograde cardioplegia. Left internal thoracic arteries were used to bypass the left anterior descending artery when available and greater saphenous vein grafts were used for revascularisation of other diseased coronary arteries. Distal coronary anastomoses were carried out first and if indicated followed by other cardiac procedures in sequence.

Mitral valve procedures

Following coronary anastomosis, mitral valve got exposed through a vertical transseptal incision. The valve was inspected and the abnormality confirmed. In all the patients, despite normal feature of mitral leaflets, chordae and PMs, one or both PMs were malpositioned.

Mitral annuloplasty

The size of mitral annuloplasty ring (Carpentier Edwards Physio Ring, Edwards Lifesciences, Irving, CA) was decided by a standard measurement of the intertrigonal distance and anterior leaflet height, thereupon downsizing was done. The technique has been described in one of our previously published studies [20].

Mitral valve replacement

In all the candidates for mitral valve replacement according to surgeon's decision, the entire subvalvular apparatuses were preserved in an anatomic fashion. Either St. Jude (St. Jude Medical, St. Paul, Minnesota) or On-X (Medical Research Institute, Austin, Texas) mechanical prostheses were used in all the patients avoiding remarkable difference between the two groups. Complete chordal preservation technique of MVR was the same as described earlier [21].

Alternative repair of mitral valve

Based on described algorithm, 26 patients were considered candidate to undergo mitral valve repair plus annuloplasty instead of MVR. Decision was made by the corresponding surgeon according to the intra-operative status of mitral valve. Additive procedures including papillary muscle approximation, chordae cutting or edge to edge repair were also subject to perform.

Statistical analysis

Data were analysed using statistical package for social sciences (SPSS, version 16, Chicago, Inc). Student's *t*-test and Chi-square were applied for normal qualitative and quantitative variables while Mann–Whitney U test was employed for non-parametric continuous data. On the other hand, one-way analysis of variances (ANOVA) was used for multi-categorical variables. Values were considered significant at $p<0.05$.

Results

Of 350 patients included in the study, 79.1% were male. Mean ± SD age was 56.1 ± 10.9 years (range between 32 and 72 years). Mean ± SD follow-up time was 40.2 ± 9.3 months (ranging between 1 and 52 months) for all the patients and 41.6 ± 7.5 month (ranging between 7 and 52 months) for survivors. Table 3 summarises patients' characteristics. No statistically significant was pres-

Table 3. Patients' primary characteristics

MR Grade > +2 (%)	73.1
ERO (mean ± SD) (mm^2)	27.4 ± 10.2
PMD (mean ± SD)	18.3 ± 6.2
CD (mean ± SD)	9.7 ± 2.2
Annulus diameter (mean ± SD)	37.3 ± 4.0
LVEF (mean ± SD)	39.9 ± 6.5
LVESV (mean ± SD)	87.3 ± 21.9
NYHA (mean ± SD)	3.00 ± 0.70

MR mitral regurgitation, *ERO* effective regurgitant orifice area, *PMD* inter-papillary muscles distance, *CD* coaptation depth, *LVEF* left ventricular ejection fraction, *LVESV* left ventricular end-systolic volume, *NYHA* classification New York Heart Association

ent between the two groups in terms of demographic characteristics.

Six months survival was 91.5 % among all the patients in this study. 86.9 % of the patients survived during the follow-ups. Overall mortality rate was 13.1 % ($n=46$), of which 7.1 % ($n=25$) occurred due to cardiac and 6 % ($n=21$) as a result of a non-cardiac cause. Mortality rate was 8.5, 66.7, 8.2, 6.7, 9.7 and 11.5 % in group 1–6, respectively. Mortality rate due to cardiac causes in group 1–6 was 4.4, 26.6, 6.1, 4.2, 9.7 and 7.7 %, respectively. These findings demonstrate that there is a statistically significant difference between group 2 and the other groups in terms of mortality rate ($p<0.0001$) (Table 4).

During the follow-up, just 11 % of the survivors had IMR > 2 +, mean ± SD EF was 45.2 ± 5.5 and mean ± SD NYHA score was calculated as 1.52 ± 0.69. MR > +2 was found in 90 % of patients in group 2 revealing a statistically significant difference with other groups ($p<0.0001$) (Table 5). Mean ± SD NYHA was roughly the same in all groups except group 2 ($p<0.0001$) as shown in Table 5. EF was nearly the same in all groups after the surgery (Table 5 except group 2, mean ± SD degree of MR differed significantly prior and after the surgery in each group (Table 6). Also the difference between pre- and post-operative degree of MR did not reveal any significant difference between all the groups ($p>0.05$) except group 2 ($p<0.000$) (Table 6). Mean ± SD EF in each group significantly improved after the surgery in group 1, 4, 5, and 6 as is presented in Table 6. EF changes before and after the surgery was not significantly different between all the groups ($p>0.05$) (Table 6). Furthermore, mean ± SD NYHA score decreased post-operatively in the patients of each group (Table 6); again, except group 2 ($p<0.001$) there was no statistically significant difference between NYHAs before and after the surgery ($p>0.05$) (Table 6).

Discussion

Chronic ischemic mitral regurgitation has been reported in up to 40 % of myocardial infarction cases and assumed a major risk factor for adverse outcomes including

Table 4. Demographic and primary characteristics of patients in each group

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	*P* value
Sex (M/F)	74/20	21/9	36/13	100/20	26/5	20/6	0.513
Age (mean ± SD)	55.4 ± 10.8	55.6 ± 10.4	56.1 ± 10.6	56.2 ± 11.0	56.9 ± 12.0	57.1 ± 10.3	0.979
Follow-up time, month (mean ± SD)	39.7 ± 10.4	33.2 ± 13.9	41.0 ± 6.4	42.5 ± 6.5	39.8 ± 8.8	38.3 ± 10.1	0.000*
MR > +2 (%)	16.0	90.0	83.7	96.7	100.0	100.0	0.000**
ERO** (mean ± SD)	14.6 ± 5.9	28.3 ± 6.5	31.2 ± 6.6	33.1 ± 7.0	32.6 ± 6.4	33.3 ± 7.2	0.000***
PMD (mean ± SD)				14.7 ± 3.3	26.8 ± 3.6	24.7 ± 3.0	0.000****
CD (mean ± SD)				8.4 ± 1.2	12.1 ± 1.8	12.2 ± 1.6	0.000*****
Annulus (mean ± SD)	38.0 ± 3.4	33.7 ± 4.6	38.5 ± 2.9	37.4 ± 3.9	37.5 ± 4.3	36.2 ± 4.8	0.000******
LVEF (mean ± SD)	40.9 ± 5.6	35.5 ± 9.8	40.5 ± 6.1	40.6 ± 5.8	37.9 ± 6.2	40.0 ± 6.5	0.001^{+}
LVESV (mean ± SD)	89.3 ± 21.3	86.1 ± 17.0	85.3 ± 20.7	86.3 ± 22.4	83.3 ± 23.0	94.3 ± 26.5	0.392
NYHA (mean ± SD)	2.93 ± 0.77	3.47 ± 0.68	2.92 ± 0.64	2.97 ± 0.66	2.94 ± 0.68	3.15 ± 0.61	0.004^{++}

MR mitral regurgitation, *ERO* effective regurgitant orifice area, *PMD* inter-papillary muscles distance, *CD* coaptation depth, *LVEF* left ventricular ejection fraction, *LVESV* left ventricular end-systolic volume, *NYHA* New York Heart Association

$^{+}$Group 2 with groups 1, 3 and 4; $^{++}$Group 2 with groups1, 3, 4 and 5; *Group 2 with other groups; **Group 1 with other groups; ***Group 1 with other groups and group3 with group 4; ****Group 4 with groups 5 and 6; *****Group 4 with groups 5 and 6; ******Group 2 with groups 1, 3, 4 and 5

Table 5. Patients' post-operative characteristics

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	*P* value
MR > +2 (%)	14.0	90.0	8.5	6.9	0.0	4.3	0.000*
LVEF (Mean ± SD)	45.0 ± 5.6	41.0 ± 6.1	45.2 ± 6.0	45.9 ± 5.4	45.6 ± 4.5	44.4 ± 5.3	0.147
NYHA (Mean ± SD)	1.40 ± 0.62	2.20 ± 1.14	1.29 ± 0.46	1.73 ± 0.77	1.46 ± 0.58	1.35 ± 0.49	0.000**

MR mitral regurgitation, *LVEF* left ventricular ejection fraction, *NYHA* New York heart association

*Group 2 with other groups; **Group 2 with groups 1, 3, 5 and 6 or group 4 with groups1 and 3

Table 6. Differences between pre- and post-operative values of MR degrees, LVEF and NYHA

		Group 1		Group 2		Group 3		Group 4		Group 5		Group 6		*P* (repeated measurement)
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
MR (mean ± SD)	Pre O.	2.17	0.46	3.13	0.57	3.16	0.69	3.58	0.56	3.61	0.50	3.50	0.51	0.000*
	Post O.	1.88	0.73	3.50	0.71	1.23	1.07	1.20	0.92	0.12	0.43	1.39	0.58	
	Dif	0.30	0.92	−0.20	0.92	1.94	1.21	2.37	1.12	3.50	0.65	2.13	0.81	
P value		0.003		0.509		0.000		0.000		0.000		0.000		
LVEF (mean ± SD)	Pre O.	40.85	5.57	35.50	9.77	40.51	6.14	40.63	5.82	37.90	6.16	40.00	6.48	0.159
	Post O.	45.00	5.58	41.00	6.15	45.24	6.02	45.93	5.42	45.56	4.46	44.35	5.29	
	Dif	3.95	6.04	1.50	7.47	3.78	9.14	5.33	8.29	7.78	5.43	4.13	5.77	
P value		0.000		0.541		0.011		0.000		0.000		0.002		
NYHA (mean ± SD)	Pre O.	2.93	0.77	3.47	0.68	2.92	0.64	2.97	0.66	2.94	0.68	3.15	0.61	0.001**
	Post O.	1.40	0.62	2.20	1.14	1.29	0.46	1.73	0.77	1.46	0.58	1.35	0.49	
	Dif	1.62	0.95	1.20	1.14	1.60	0.75	1.19	0.99	1.50	0.88	1.96	0.77	
P value		0.000		0.009		0.000		0.000		0.000		0.000		

P value was calculated in each group to determine the presence of significant differences between pre- and post-operative values (MR, LVEF and NYHA). Repeated measurement test was also performed to compare between regular measurements of variables
*Group 2 with other groups; **Group 2 with other *groups*
MR mitral regurgitation, *LVEF* left ventricular ejection fraction, *NYHA* New York heart association, *Post O* post-operative, *Pre O* pre-operative, *Dif* difference

impaired left ventricular function or cardiac death [22–24]. However, despite documented evidences regarding beneficial effects of adding mitral valve repair to CABG in improving NYHA functional class and echocardiographic parameters of heart structures, its advantages on long-term outcome still remains unclear [25]. In the absence of level-one evidence to support or opposite the role of concomitant mitral valve procedure in accordance with CABG in patients suffering from ischemic events, existing studies are in favours of mitral valve repair as an effective method to approach to IMR when reperfusion surgeries are on hands [26]. However, the road is not straight-forward neither in cases of moderate IMR. Current trends seem to converge in patient selection approach to decide which cases benefits most from concomitant mitral valve repair and CABG and who will be most likely to reverse the IMR after improving has been achieved in myocardial perfusion [27]. Our study, hence, aimed to determine the efficacy of such a patient selection method through an algorithm approach. The algorithm was indeed designed according to our previous studies on the same topic [20–21, 28–29].

As first step in the algorithmic approach (Fig. 1), an accurate estimation of MR severity would be necessary and the limiting point for an ischemic MR would seem to be less than organic MR. Due to an easier measuring method and much feasible way of application, ERO can be considered as a predictor for MR severity in a way that the MR is significant if ERO is measured to be more than 20 [4].

According to the study by Borger et al. [8], patients with multiple comorbidities or a life expectancy less than 5 years should undergo CABG alone. Hence, the patients in our study did not undergo concomitant mitral valve procedure in case of significantly diminished life expectancy or multiple comorbidities (Fig. 1).

Low-dose DSE could predict reversibility of IMR following performing CABG due to the improved myocardial perfusion [29]. Those patients whose MR severity decreases by performing DSE will be more probable to resolve their IMR by CABG alone; on the other hand, IMR cases with unchanged regurgitation severity after DSE would benefit more from concomitant mitral valve procedures and CABG ad would be selected as candidates for this type of combinative procedure (Fig. 1).

The uncertainty between mitral valve repair and replacement has existed for a long time. However, recent evidences support the efficacy and lower 30 days mortality rate in patients undergoing mitral valve repair compared with techniques of valve replacement [30]. But it has been reported that as high as 30 % of the patients treated by valve repair will develop MR recurrence during the follow-up periods [20, 31–32]. Therefore, an index has been introduced by Calafiore et al. [33] referring to as mitral valve coaptation depth (CD) to predict the possibility of functional mitral regurgitation recurrence after annuloplasty; the authors showed that values of CD more than 10 mm could be a predicting determinant for MR reoccurrence [33]. According to our recent study, interpapillary muscle distance (PMD) more than 20 mm, measured by echocardigraphy prior the operation seem as a better index to predict recurrence of MR after mitral valve annuloplasty has been performed [20]. Hence, patients in the current study were candidate for ring annuloplasty if CD $<$ 10 and PMD $<$ 20 before the operation.

One of the most important causes of mitral valve repair failure is believed to be tethering phenomenon in which the leaflets are pulled towards the LV apex. In order to reduce or annihilate the tethering effect and subsequently control the regurgitation, additional surgical procedures have been proposed including papillary muscle approximation [28], cutting the secondary chordae of the anterior leaflet of the mitral valve [34], edge to edge repair method [35] and posterior papillary muscle relocation [36]. These techniques are time consuming and their long term outcomes are not clear in comparison with the cost they may impose. Hence, MVR or annuloplasty in association with papillary muscle approximation, chordae cutting or edge to edge repair was performed in our study.

We presented an algorithm for management of IMR. Following 3 years after the first admission in our centre for revascularisation and concomitant procedures, cardiac mortality was relatively acceptable (7.1 %) considering the poor prognosis of patients with ischemic mitral regurgitation. However, mortality rate was high in group 2 in our study (66.7 % total mortality and 26.7 % cardiac cause of death) which was deemed very poor prognosis. As shown in Table 2, most of the patients in this group suffer from comorbidities including malignancy, sever chronic obstructive pulmonary disease (COPD) or other concomitant disease.

Except group 2, mortality rate did not significantly differ between the other groups. Since the calculated ERO was considered as the primary determinants in our algorithmic approach as explained by other study [37], we can claim that all the patients in group 3–6 (who had worse prognosis due to the higher ERO compared with group 1), the most appropriate procedure has been performed that justify the outcome. Also comparing the reoccurrence frequency of mitral regurgitation, and improvements of ejection fraction values and NYHA functional class between all the groups, it was demonstrated that all the patients except those in group 2 have similar outcomes (Table 6).

Our findings suggest that survival and prognosis in IMR patients would be the same as the IMR patients with better prognosis in result of choosing the appropriate procedure based on individualisation. However, by selecting the patients undergoing more invasive procedures, this algorithmic approach decreases the risk of developing complications after more invasive operations such as MVR.

Our results should be interpreted in the light of their limitations which are the variety of applied procedures and the heterogeneous population which was enrolled. Hence, comparison of the outcome of the current study with other studies addressing the outcomes of IMR managements does not seem feasible. However, a remarkably lower mortality rate (13.1 %) and a MR relapsing rate of about 11 % is in the favour of the efficacy of this approach to selectively include the patients at their most proper treating spot. Again with special attention to the short term follow up of this study, further studies are needed to determine longer outcomes and survival or other determinants of prognosis in patients with IMR.

Conclusion

Individualising methods to select patients suffering from IMR for concomitant mitral valve procedure and CABG seems to serves more effectively by reducing unnecessary surgeries and at the same time not missing absolute indications for concomitant valve repairs. The proposed algorithm in this study showed a promising efficacy to effectively select patients for CABG and concomitant mitral valve procedures.

Conflict of interest
The authors declare that there is no actual or potential conflict of interest in relation to this article.

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