Echocardiographic changes after aortic valve replacement: Does the failure rate of mitral valve change?

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Original Article

Abstract

BACKGROUND: Since some degrees of functional mitral regurgitation (MR) may be seen in patients who are candidate for undergoing isolated aortic valve replacement (AVR), determining the effectiveness of AVR surgery on MR rate improvement can be effective in designing a protocol to deal with patients with functional MR. The purpose of this study was to examine the echocardiographic changes after AVR surgery with a focus on changes in MR.

METHODS: The research was conducted as a before-after observational study on patients hospitalized in Baqiyatallah Hospital, Tehran, Iran, who were undergone AVR surgery between 2011 and 2012. After selecting the patients and obtaining informed consent to participate in the project, transthoracic echocardiographic data were collected by a specialist in Cardiology Echocardiography using ViVid 7 device before and till one week after AVR surgery. The MR rate was measured using methods; including Color Flow Doppler, PISA, Vena Cava Width and Effective Regurgitant Orifice.

RESULTS: Finally, the study was conducted on 85 patients (mean age = 56.23 ± 6.10 years, 27 women = 31.8%). Of 21 patients with preoperative MR more than mild (moderate, mild to moderate), 20 patients (95%) showed at least one degree decrease in MR. Among 64 patients who had mild MR before the surgery, 29 patients improved (45%), that this difference was statistically significant (P < 0.001).

CONCLUSION: The study results showed that in patients with preoperative MR degree higher than mild, after AVR the MR rate improved 24 times more than those who had preoperative MR degree equivalent to mild and lower. However, these changes are not affected by other echocardiographic changes and patients demographic characteristics.

Keywords: Echocardiography, Heart Valve Prosthesis Implantation, Mitral Valve Regurgitation

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Introduction

Aortic valve stenosis is one of the most common heart valve diseases that its effective and decisive treatment is valve replacement.[1] Patients requiring treatment for aortic stenosis (AS) also often have some degree of mitral regurgitation (MR).[2] In most patients, the severity of MR is in mild to moderate range, and it seems that with aortic valve gradient decrease, the severity of MR will also improve; however, with severe MR, mitral valve replacement or repair is also indicated.[3]

MR is one of the most common valvular disorders with an incidence of 7%. The main causes of MR include mitral valve prolapse, rheumatic heart disease, infective endocarditis, mitral ring calcification, cardiomyopathy, and ischemic heart disease.[1] MR can be also associated with AS and aortic regurgitation (AR). MR is associated with poor clinical outcome and can lead to atrial fibrillation, heart failure, and the need for replacement or repair of mitral valve.[2] It has been shown in several studies conducted in other countries that if the severity of functional MR rate is higher than average, mitral valve replacement or repair should be performed simultaneously with AVR; however, if the functional MR is less than moderate or lower, a conservative approach in the treatment of

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functional MR would be useful.[4] Since the simultaneous replacement of aortic and mitral valves is associated with increased mortality, especially in elderly patients, therefore, surgical treatment for functional MR should be selected in a very precise approach and in specific cases.[5]

Since some degrees of functional MR may be seen in patients who are candidate for undergoing isolated AVR, determining the effectiveness of AVR surgery on MR rate improvement can be effective in designing a protocol to deal with patients with functional MR.[6-8] Thus, for the first time in Iran, in this study, we examined the severity degree of MR before and after AVR to provide a protocol based on that on how to treat functional MR associated with aortic disease.

Materials and Methods

The research was conducted as one group before after prospective study on patients hospitalized in Baqiyatallah Hospital, Tehran, Iran, between 2011 and 2012 who was undergone AVR surgery. All patients with AS who were candidates for valve replacement were studied. The following individual candidates for valve replacement were enrolled.[1] Adults with symptomatic severe AS, asymptomatic severe AS cases, if ejection fraction (EF) < 50%, the patient candidate for coronary artery bypass graft surgery (CABG) or any other cardiac surgery or having significant MR.

Patients with the following conditions were excluded from the study:

- Patients who were candidate for transcatheter aortic valve implantation
- Any structural mitral valve diseases
- A history of infective endocarditis
- A history of CABG surgery
- Severe functional MR that has been treated by mitral valve repair (MVR)
- A history of tricuspid valve replacement or repair

Necessary comments and points about the project were given to patients, and after obtaining informed consent for participating in the project, they were included. The study imposed no cost to the patients. The study plan was approved by the Ethics and Scientific Committee of Baqiyatallah University of Medical Science.

After patient selection based on meeting the study inclusion criteria, the necessary explanations were provided for them, and transthoracic echocardiography was performed using ViVid 7 echocardiography before and one week after AVR by one specialist in Cardiology Echocardiography department. MR rate was measured using methods of Color Doppler Flow, PISA, Vena Contracta Width and Effective Regurgitant Orifice. In echocardiographic examination, the normal sizes of left atrial (LA), left ventricular end-systolic diameter (LVESD) and left ventricular end-diastolic diameter (LVEDD) were, respectively, considered as 3.8 cm, 2.4-4.2 cm, 5.4 cm and left ventricular function (LVF) ≥ 50% as well as pulmonary artery pressure (PAP) < 30 mmHg (R). MR improvement was considered as a reduction of at least one degree of the MR severity.

Echocardiographic findings associated with grading of MR severity, the left ventricular hypertrophy (LVH), and the AS were determined. LVH was diagnosed using echocardiographic findings though measuring ventricular septum thickness.

Data were entered into SPSS for Windows (version 19, SPSS Inc., Chicago, IL, USA), and the relevant tables and graphs were extracted. Descriptive statistics was expressed as percentage (%) in qualitative variables and expressed in quantitative variables by mean and standard deviation. The difference between the frequencies of the qualitative variables was measured by chi-square test and McNemar test. Comparing the quantitative variables between groups, t-test and ANOVAs were used. Paired t-test or Wilcoxon also were used for comparing the quantitative variable within group before and after the intervention. $P < 0.050$ was considered statistically significant.

Results

A total of 85 patients were enrolled in this study that 27 patients (31.8%) were female. The mean age of participants was 56 ± 6.1 years that the youngest person was 16 years old, and the oldest was 79 years old. Table 1 shows the patients characteristics in demographic and clinical data. In 61 patients (71%), mechanical aortic valves and in the remaining patients, biological valves were used. In pre-operative echocardiography, 55 patients (64.7%) had normal left ventricular ejection fraction (LVEF) regarding left ventricular systolic function; however, mild, moderate, and severe systolic dysfunction were reported in 14 patients (16.5%), 13 patients (15.3%), and 3 patients (3.5%), respectively. These values after surgery were reported, respectively, as 49 patients (57.6%) with normal LVEF, 21 patients (24.7%) with mild systolic dysfunction, 11 patients (12.9%) with moderate dysfunction and 4 patients (4.7%) with severe dysfunction that such changes were statistically significant ($P = 0.030$).

Table 1. Demographic, clinical, and para-clinical characteristics of patients

Item	Mean ± SD	n (%)
Male	-	58 (68.0)
Smoking	-	19 (16.0)
Angina	-	23 (22.0)
DOE FC I	-	1 (0.9)
DOE FC II	-	70 (68.0)
DOE FC III	-	6 (5.8)
AF	-	3 (2.6)
Syncope	-	2 (1.9)
DM	-	14 (12.0)
HTN	-	45 (39.0)
Dyslipidemia	-	20 (17.0)
Renal failure	-	2 (1.7)
Age (year)	56.0 ± 6.10	-
LVEF	47.8 ± 8.00	-
PA pressure (mmHg)	25.6 ± 11.10	-
LA size (cm)	3.9 ± 7.00	-
LV wall thickness (cm)	0.2 ± 1.24	-
LVEDD (cm)	0.7 ± 5.46	-
LVESD (cm)	0.7 ± 3.90	-

DOE FC: Dyspnoea on exertion functional class; AF: Atrial fibrillation; DM: Diabetes mellitus; HTN: Hypertension; LVEF: Left ventricular ejection fraction; PAP: Pulmonary-artery pressure; LA: Left atrial; LV: Left ventricular; LVEDD: Left ventricular end-diastolic diameter; LVESD: Left ventricular end-systolic diameter; SD: Standard deviation

Preoperative LVEF mean was as 47.8% and became as 47% after surgery. The preoperative mean LVEDD was as 5.46 ± 0.77 cm and postoperatively as 5.1 cm. This LVEDD decrease was statistically significant ($P < 0.001$). Other echocardiographic findings are given in Table 2, 3. In addition to MR degree, tricuspid regurgitation (TR) degree, aortic insufficiency (AI) severity, and AS severity were changed after AVR which these changes were statistically significant ($P < 0.001$) (Table 2). Moreover, In addition to LVEF and LVEDD, interventricular septum diameter (IVSD), aortic valve mean gradient (AVMG), and aortic valve pressure gradient (AVPG) were changed significantly ($P < 0.050$) (Table 3).

Among studied subjects, of 21 patients with preoperative MR more than mild (moderate, mild to moderate), 20 patients (95%) showed at least one degree decrease in MR. Among 64 patients who had mild MR before the surgery, the MR improved in 29 patients (45%) that these changes were statistically significant ($P < 0.001$) (Figure 1). On the other word, 33 patients (38.8%) had no MR after surgery

Table 2. Qualitative echocardiography characteristics before and after aortic valve replacement (AVR)

Item (%)	Sub-group	Before (85 cases)	After (85 cases)	P
LVEF dysfunction	No	55 (64.7)	49 (57.6)	0.109
	Mild	14 (16.5)	21 (24.7)	
	Moderate	13 (15.3)	11 (12.9)	
	Severe	3 (3.5)	4 (4.7)	
AS severity	No	23 (27.1)	79 (92.9)	< 0.001
	Mild	6 (7.1)	5 (5.9)	
	Mild to mod	2 (2.4)	1 (1.1)	
	Moderate	11 (12.9)	-	
	Mod to severe	10 (11.8)	-	
	Severe	33 (38.8)	-	
AI severity	No	3 (3.5)	62 (72.9)	< 0.001
	Mild	12 (14.1)	21 (24.7)	
	Mild to Mod	10 (11.8)	2 (2.4)	
	Moderate	15 (17.6)	-	
	Mod to severe	21 (24.7)	-	
	Severe	24 (28.2)	-	
MR severity	No	-	33 (38.8)	< 0.001
	Mild	64 (75.3)	52 (61.2)	
	Mild to Mod	20 (23.5)	-	
	Moderate	1 (1.2)	-	
LVH	No	24 (28.2)	26 (30.6)	0.096
	Mild	42 (49.4)	43 (50.6)	
	Moderate	17 (20)	14 (16.5)	
	Severe	2 (2.4)	2 (2.4)	
TR	No	10 (11.8)	16 (18.8)	< 0.001
	Mild	70 (82.4)	67 (78.8)	
	Mild to Moderate	4 (4.7)	2 (2.4)	
	Moderate	1 (1.2)	-	
PAH	No	63 (74.1)	67 (78.8)	0.052
	Mild	12 (14.1)	12 (14.1)	
	Moderate	8 (9.4)	4 (4.7)	
	Severe	2 (2.4)	2 (2.4)	

Based on McNemmar; LVEF: Left ventricular ejection fraction; AS: Aortic stenosis; AI: Aortic insufficiency; MR: Mitral regurgitation; LVH: Left ventricular hypertrophy; TR: Tricuspid regurgitation; PAH: Pulmonary arterial hypertension

Table 3. Quantitative echocardiography characteristics before and after aortic valve replacement (AVR)

Item*	Before (85 cases)	After (85 cases)	P
LVEF	47.80 ± 8.20	47.00 ± 7.83	0.038
LVEDD (cm)	5.46 ± 0.77	5.17 ± 0.63	< 0.001
LVESD (cm)	3.73 ± 0.79	3.90 ± 2.42	0.530
IVSD (cm)	1.24 ± 0.22	1.21 ± 0.20	< 0.001
AVMG (mmHg)	35.62 ± 25.98	12.25 ± 5.16	< 0.001
AVPG	55.22 ± 38.74	20.93 ± 8.75	0.009
Mean PAP (mmHg)	25.67 ± 11.17	24.89 ± 9.95	0.260
LA size (cm)	3.89 ± 0.76	3.89 ± 0.71	0.980

* All quantitative items were described as mean ± SD; SD: Standard deviation; LVEF: Left ventricular ejection fraction; LVEDD: Left ventricular end-diastolic diameter; LVESD: Left ventricular end-systolic diameter; IVSD: Inter-ventricular septum diameter; AVMG: Aortic valve mean gradient; AVPG: Aortic valve pressure gradient; PAP: Pulmonary-artery pressure; LA: Left atrial

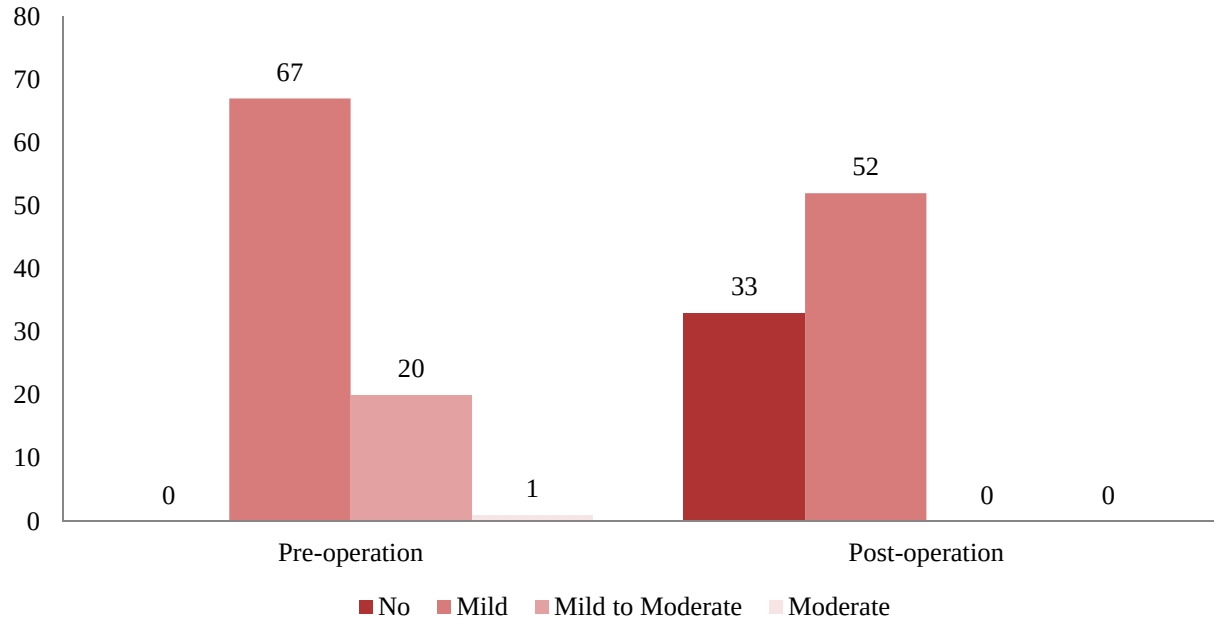

Figure 1. Mitral regurgitation frequency before and after aortic valve replacement
* Based on McNemmar test

versus all patients before surgery had degrees of MR. This means that in those with preoperative MR higher than a mild degree, the improvement in MR rate after AVR was 24 times more than those who had preoperative MR equivalent to mild and lower. Between two groups of MR improved and not improved, neither demographics variable (age, gender) and nor echocardiographic characters showed statistically significant differences (P > 0.050).

Discussion

Our study showed that MR rate has decreased in 50 patients (58%) after AVR. There are some similar studies which evaluate the impact of AVR on MR severity.

In a study in the United States by Barreiro et al. conducted in 2004 on 408 patients, the improvement rate of functional MR after AVR was reported as 81.8%.[4] In a review study by Matsumura et al. in Canada, the improvement in functional MR was observed after isolated AVR.[9] In Waisbren et al.[3] and Tunick et al.[10] studies, the improvements rates in functional MR were reported at about 66% and 64% after AVR, respectively.

In a retrospective study by Tunick et al. that had reviewed MR rates before and after AVR in echocardiographic reports of 44 patients, 60% of patients showed postoperative reduced MR and it remained unchanged in 27% and had become worse in 13%.[10] Although improvement of functional MR has been shown in these studies after isolated AVR,

however, in a study on 27 patients by Brasch et al., MR echocardiography improvement was not seen in 52% of patients.[11]

Based on the current study results, LVEF of patients shows decrease after AVR, which is statistically significant. Injection Lindeboom study conducted in The Netherlands, the patients' LVEF after CABG or AVR surgeries was improved from 46% to 55% during 3-18 days. Furthermore, end-diastolic dimensions of LA and LVEDD considerably reduced.[12]

One of the limitations of this study was the short period of post-operative evaluation. Due to the fact that in our study, echocardiography was performed during the same hospitalization period and at one week after the operation for LVEF assessment after surgery, thus, reduced LVEF at this period time might have been due to anesthetic drugs effects, cardiopulmonary pump, and during cardiac surgery and its complications. Therefore, accurate assessment of LVEF should be done periodically in order to make accurate assessments on actual LVEF of patient and AVR effect on left LVF.

In our study, the mean LV end-diastolic diameter and the mean LV end-systolic diameter decrease after AVR surgery that the change is significant only regarding LVEDD. Furthermore, the LA size remained unchanged after AVR, but the severity of TR, AR, LVH, and PAP rate showed reduction.

Comparing the variables before and after surgery, it was found that changes in LVEF, LVEDD, IVSD, AVMG, and AVPG after surgery were statistically significant, but changes in PAP, LVESD, and LA size were not significant.

As mentioned before, reduced LVEDD size after surgery was considered statistically significant that such a factor can cause a reduction in MR after operation by reducing mitral valve annulus size; however, in our study, the mitral valve size annulus was not measured in all patients before and after the surgery, which can be considered in future studies.

However, LVESD size is a more reliable index for reduction of postoperative MR, which was not significant in our study, perhaps because of the LVEF reduction in a short period after AVR. However, if we measured LVESD 3-6 months after surgery, perhaps these changes would become significant to justify MR reduction.[13]

Furthermore, postoperative reduced IVSD can cause reduced MR through reducing LV wall stress and omission of pressure and volume effects on LV and reducing LVEDP that further studies are needed to confirm these hypotheses.

The strength of our study is that any intervening factors such as CABG and repair or replacement of mitral and tricuspid valves that could have reduced the postoperative MR rate were excluded, so that patients undergoing revascularization were excluded from the study.

The study results showed no significant association between age, sex, patient's symptoms, preoperative risk factors, valve type (mechanical or biological), LVEDD size, LVESD, IVSD, LA, LVEF rate, PAP, AVMG, AVPG, and AI rate before the surgery improvement in MR, which could be due to low sample size.

However, the relationship between severity of preoperative MR and MR improvement rate after AVR was significant. The results show that in patients who are candidate for AVR, if preoperative rate of functional MR failure is at most moderate, MR rate will reduce after AVR in 58% of cases. This change especially occurs when preoperative MR is more than Mild (at maximum: moderate) so that improvement rate in these patients is approximately 24 times higher than those with mild preoperative MR.

Conclusion

Similar to previous studies, our results also showed improvement in functional MR following AVR surgery. Thus, performing surgery on aortic valve is associated with higher mortality and morbidity, especially in elderly, a conservative approach in cases with moderate functional MR that are candidate for AVR is recommended and after AVR, the patients should be evaluated for further therapeutic approach. Therefore, more coordination is needed between cardiovascular surgeons and cardiologists to determine indications for MV repair or MVR with the AVR.

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Conflict of Interests

Authors have no conflict of interests.

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