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# Comparison of pre and post operative echo changes after mitral valve replacement with cardiothoracic vascular surgery

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**Abstract**
**Background:** There is a scarcity of information on the impact of mitral valve (MV) replacement on LA size. The goal of this study was to assess changes in LA volumes after MV replacement using real-time 3-D echocardiography.
**Methods:** A total of 50 patients with severe mitral regurgitation caused by MV prolapse who were planned for early treatment were included in the study. Real-time 3-dimensional echocardiography was used to assess LA volumes prior to the surgery (maximum, before atrial active contraction [preA], and minimum). The same assessment was carried out six months and one year after the MV replacement. As a control group, twenty healthy volunteers were enlisted who were age and gender matched.
**Results:** Patients had significantly greater LA volumes before MV replacement than controls. LA volumes fell considerably six months after the operation with a further decline at one year, resulting in values similar to controls. Age (r = 0.42) and postoperative transmitral mean pressure gradient (r = 0.32) were shown to be inversely associated to the amount of LA reverse remodelling, although a positive correlation was found.
**Conclusion:** When performed early, MV replacement resulted in considerable LA reverse remodelling in patients with severe mitral regurgitation due to MV prolapse.

**Keywords:** echocardiography, mitral valve, replacement

## Introduction

Mitral valve (MV) replacement is presently the main therapeutic option for severe mitral regurgitation caused by MV prolapse or flail [1, 2]. In reality, as compared to valve replacement, this method has a higher rate of survival and allows for the preservation of both the subvalvular apparatus and the geometry and function of the left ventricle (LV) [3]. However, little is known regarding the impact of MV replacement on the size and function of the left atrium (LA), which is of major clinical importance [4-7]. Chronic mitral regurgitation is frequently linked to LA enlargement, which is a well-known predictor of unfavourable cardiovascular outcomes such stroke, atrial fibrillation, heart failure, and death [8-10]. As a result, an accurate assessment of LA size is critical, and should be based on LA volume measurement, as recommended [11], taking into mind that LA dilatation can result in considerably lopsided geometry. In a head-to-head comparison with magnetic resonance (MR) imaging, real-time 3-dimensional (3D) echocardiogram (RT3DE) was recently shown to be more accurate and reproducible than 2-dimensional (2D) echocardiography for the assessment of LA volumes [12, 13]. Furthermore, RT3DE could be a unique and accurate tool for assessing LA function by revealing phasic changes in LA volumes during the cardiac cycle [14-17].

The goal of this study was to use RT3DE to assess changes in LA size and function after MV replacement at mid- and long-term follow-up. The study focused on patients with severe degenerative mitral regurgitation who were referred for MV replacement at an early stage when there were no symptoms or major LV changes. Potential clinical and echocardiographic parameters linked to changes in LA size following the surgery were also investigated.

## Methods

The study included 50 patients who had severe mitral regurgitation caused by degenerative MV prolapse or flail and were scheduled for surgery at the cardiothoracic vascular surgery department of SMS Medical College, Jaipur. According to recent recommendations, mitral regurgitation is classified as severe when the effective regurgitant orifice area is less than 0.4 cm2 as measured by the proximal isovelocity surface area approach [18]. When no symptoms or severe LV dilation or dysfunction were present, all patients were referred to surgery at an early stage (LV ejection fraction [LVEF] N60 percent, LV end-systolic [ES] diameter b45 mm according to recent guidelines [1, 2]). To provide a full examination of LA function, patients with persistent atrial fibrillation during the preoperative period or throughout follow-up were eliminated. The existence of MV stenosis or aortic valve disease, as well as a history of endocarditis and coronary artery disease, were all additional exclusion factors (previous myocardial infarction, percutaneous revascularization, or surgical coronary revascularization).

Traditional 2D colour Doppler echocardiography was used to assess the severity of mitral regurgitation, transmitral flow pattern, and pulmonary pressures prior to the surgery. The size and function of the LV and LA were assessed using real-time 3D echocardiography. To examine changes in LV and LA size and function, the same evaluation was repeated 6 months and 1 year after MV replacement. Twenty healthy subjects (without structural heart disease or history of systemic hypertension) matched for age and gender were enrolled as a control group.

### Real-time 3D Echocardiography

A Philips iE33 system (Philips Medical Systems, Andover, MA) with an X3-1 fully sampled matrix transducer was used for transthoracic RT3DE. To acquire a bigger pyramidal volume, apical full-volume data sets were obtained by mixing 7 electrocardiogram-triggered wedge-shaped subvolumes within 1 breath-hold (frame rate: 16-37 frames per second). The 3D data set was carefully constructed to include both the LV and LA cavities. Quantitative analysis was performed offline using a semiautomated contour-tracing method (Q-Lab version 7.0; Philips Medical Systems); postprocessing of the pictures took 5 to 7 minutes. If N2 portions of the LV or LA walls could not be observed or if there were evident translation artefacts, a 3D data set was deemed unsuitable for analysis.

### Two-Dimensional Echocardiography

The severity of mitral regurgitation was determined before to the procedure using current recommendations [18]. The same method was used to assess residual regurgitation immediately after MV replacement. In addition, using continuous wave Doppler and the simplified Bernoulli equation, the postoperative mean diastolic pressure gradient across the replacemented valve was estimated from the apical 4-chamber view. Before the procedure and during follow-up, the systolic pulmonary artery pressure was calculated using the noninvasive Doppler echocardiograph method from the systolic right ventricular—right atrial gradient calculated using the modified Bernoulli equation from the peak velocity of systolic transtricuspid regurgitant flow signal, and the right atrial pressure was calculated using the inferior vena cava coefficient [19].

### Statistical Analysis

Continuous data is represented by the mean and standard deviation, whereas categorical variables are represented by absolute numbers or percentages. The Kolmogorov-Smirnov test was used to determine whether continuous variables had a normal distribution. To study changes in echocardiographic variables over time, a general linear model (GLM) for repeated measures was used. The Tukey honestly significant difference post hoc test was used to assess significant differences. Furthermore, the MV group's results were compared to controls using an unpaired Student t test with multiple comparisons correction. The Pearson correlation coefficient was used to assess the relationship between postoperative reduction in LA Vmax and clinical and echocardiographic factors. $P<0.05$ was considered significant in all tests. For statistical analysis, the statistical software programme SPSS 16.0 (SPSS Inc, Chicago, IL) was utilised.

### Results

There were no intraoperative problems in any of the 50 patients. In all patients, either immediately after the procedure or during follow-up, residual MR was minor or non-existent. At the ED and ES frames, baseline LV diameters were 59 8 mm (range 43-80 mm) and 33 7 mm (range 20-43 mm), respectively. Because of stitching flaws or inadequate characterization of the LA endocardial blood/tissue interface, five patients were removed from further investigation. This hampered the accuracy of the 3D endocardial surface reconstruction. Table I summarises the clinical features of the remaining 45 individuals.

**Table 1:** Clinical characteristics of the study population: healthy subjects (controls) in comparison with patients undergoing MV replacement

| Variables | Control | MV Replacement |
|---|---|---|
| N | 20 | 45 |
| Age (y) | 59 ± 6 | 61 ± 12 |
| BSA ($m^2$) | 1.8 ± 0.2 | 1.8 ± 0.2 |
| HR (beat/min) | 71 ± 15 | 70 ± 10 |
| Ring size (mm) | - | 30 ± 2 |

Table II compares the volumes and functions of the left ventricle at baseline and during follow-up following MV replacement to the reference values obtained in healthy patients. Before surgery, the patients had a slight LV dilatation as compared to controls, but their LVEF was normal. LV volumes significantly decreased six months after surgery compared to presurgical values, whereas LVEF showed an absolute loss of about 5%. The changes in LV volumes lasted a year following surgery, although LVEF improved significantly to pre-operation levels.

**Table 2:** Changes in LV volumes and function in mean transmitral pressure gradient and in systolic pulmonary artery pressure at baseline and during follow-up after MV replacement, in a direct comparison with the values obtained in healthy subjects (controls)

| Variables | Controls | Baseline | 6 months | 12 months |
|---|---|---|---|---|
| LV EDV/BSA (mL/$m^2$) | 54 ± 8 | 73 ± 22 | 54 ± 13 | 56 ± 13 |
| LV ESV/BSA (mL/$m^2$) | 21 ± 5 | 28 ± 10 | 24 ± 9 | 23 ± 8 |
| LVEF (%) | 62 ± 7 | 61 ± 6 | 56 ± 7 | 59 ± 8 |
| SPAP (mm Hg) | 26 ± 3 | 34 ± 4 | 25 ± 4 | 27 ± 5 |
| Mean transmitral pressure gradient (mm Hg) | 1.8 ± 0.3 | – | 4.7 ± 1.6 | 4.3 ± 1.5 |

The reduction in LA Vmax after MV replacement was linked to a number of clinical and echocardiographic factors (Table III). Because significant LA reverse remodelling occurred at 6 months but only minor improvements at 12 months, the association analysis was limited to preoperative and 6 month postoperative data. The degree of LA reverse remodelling was observed to be adversely linked with age. The magnitude of postoperative LA Vmax reduction was negatively associated to postoperative transmitral mean pressure gradient and LV ED volume reduction 6 months after MV replacement. The entity of LA reverse remodelling did not reveal any meaningful link with ring size.

**Table 3:** Correlates of LA percentage decrease in maximum volume 6 months after MV replacement (expressed as Pearson coefficient and P value)

| Variables | LA dVmax (%) | P |
|---|---|---|
| Age (y) | −0.42 | <0.001 |
| Gender | −0.03 | 0.84 |
| Ring size | 0.21 | 0.13 |
| Postoperative mean transmitral pressure gradient | −0.32 | 0.02 |
| LV EF | −0.04 | 0.81 |
| LA Vmax | 0.63 | <0.001 |
| LV dEDV (%) | 0.53 | <0.001 |

Before surgery, the global, active, and passive LA emptying fractions were considerably lower than in healthy patients (Table IV). After MV replacement, LA EF exhibited an absolute increase of about 5% from the baseline value at 6-month follow-up. At a one-year follow-up, the improvement was still present. After the surgical surgery, LA $EF_{passive}$ showed a similar trend, with no significant deviation from normal values. As a result, LA $EF_{active}$ was severely reduced at baseline and did not improve much throughout time.

**Table 4:** Left atrial total EF, $EF_{passive}$, and $EF_{active}$ obtained in healthy subjects (controls) and for patients undergoing MV replacement, at baseline, 6-month, and 12- month follow-up after surgery

| Variables | Controls | Baseline | 6 months | 12 months |
|---|---|---|---|---|
| LA EF (%) | 61 ± 6 | 47 ± 10 | 51 ± 10 | 52 ± 9 |
| LA $EF_{passive}$ (%) | 39 ± 8 | 29 ± 8 | 32 ± 12 | 34 ± 11 |
| LA $EF_{active}$ (%) | 37 ± 10 | 26 ± 9 | 27 ± 10 | 27 ± 10 |

## Discussion

The following are the key conclusions of the current research: (1) A significant LA reverse remodelling was observed both 6 months and 1 year after MV replacement, along with a significant reduction in LV volumes; (2) the extent of LA reverse remodelling was inversely correlated with age and postoperative transmitral mean pressure gradient, whereas a positive correlation was found with the reduction in LV volume after the procedure; and (3) MV replacement also resulted in a significant reduction in LV volumes.

The LA size measurement is especially significant in patients with mitral regurgitation since the condition has a direct impact on the LA, which is responsible for correcting for volume overload and preventing pulmonary congestion [20]. Furthermore, LA enlargement (defined as a Vmax of less than 40 mL/m2) was found to have significant prognostic significance, as it was a predictor of heart failure, stroke, new onset of atrial fibrillation, and cardiovascular death [8-10]. As a result, considering the potential prognostic implications, whether MV surgery results in a large reduction of LA volume is also of clinical importance.

However, nothing is known about the impact of MV surgery, particularly MV replacement, on the size of the LA [4-6]. LA volume is the primary measurement of LA size, according to the most recent recommendations for heart chamber quantification [11]. Because the form of the LA is frequently uneven, 2D measurements such as LA anteroposterior or superoinferior diameters are less trustworthy. Furthermore, due to the diverging position and orientation of image planes, LA volume evaluation by 2D echocardiography is constrained by significant geometric assumptions and low reproducibility.

The level of LA reverse remodelling was similarly connected with the value of LA volume before the operation in the current study, implying that patients with LA enlargement can still experience a normalisation of LA size when operated on at an early stage. Patients with normal or nearly normal LA dimensions may not have noticeable alterations following MV replacement.

Despite the lack of convincing evidence of predictive usefulness, clinical interest in LA function analysis is expanding. Accurate noninvasive measurements of LA function, on the other hand, are currently unavailable. RT3DE has recently been proposed as a unique technique for assessing several LA functions (global, passive, and active), allowing for automatic identification of phasic variations in LA volume throughout the cardiac cycle [14-17].

After MV replacement, considerable LA reverse remodelling was found, as well as a significant improvement in LA global emptying fraction in the current investigation (LA ejection fraction). The LA ejection fraction, in particular, was dramatically reduced before the operation when compared to healthy participants, but had already improved significantly 3 months later. This improvement was mostly due to a normalisation of the LA passive emptying fraction, which is closely related to LV function and is highly dependent on loading conditions [14].

## Conclusions

When treated early in the course of severe degenerative mitral regurgitation, MV replacement results in considerable LA reverse remodelling and improved function, as indicated by RT3DE.

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