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Article

# Impact of Mitral Surgery for Mitral Regurgitation on Coexisting Aortic Regurgitation

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**Background:** There is no clear finding on the course of coexisting aortic regurgitation (AR) after treatment of mitral regurgitation (MR). We investigated the effect of mitral surgery for MR on coexisting AR.

**Methods:** Between January 2008 and December 2016, 75 patients underwent mitral surgery for MR coexisting mild AR. Of these, 65 patients who were available to follow-up postoperative echocardiographic tests 1 year after surgery were included in the present study. Patients were divided into two groups according to the degree of postoperative AR. We investigated the predictive factors for continued AR and perioperative cardiac function.

**Results:** In all, 22 patients' AR improved and became less than mild and 43 patients' persisted at mild or increased. The predictive factor for continued AR was left atrial diameter >50 mm ( $P = 0.021$ , odds ratio = 4.739, 95% confidence interval: 1.259–17.846) in multivariate logistic regression analysis. No patients underwent reoperation for continued AR in both groups. However, one patient was rehospitalized for heart failure in the continued AR group.

**Conclusion:** Left atrial diameter may be an important prognostic factor for continued AR after mitral surgery for MR. MR with mild AR should be treated as soon as before the left atrium expands.

**Keywords:** mitral regurgitation, aortic regurgitation, combined valvular disease

## Introduction

In 2014 American Heart Association/American College of Cardiology (AHA/ACC) guideline, aortic valve replacement (AVR) is reasonable in patients with moderate aortic regurgitation (AR) who are undergoing

other cardiac surgery (Class IIa).<sup>1)</sup> Generally, AVR is not performed for coexisting mild AR in patients undergoing mitral surgery for mitral regurgitation (MR). Treatment of MR relieves the burden on the left ventricle by reducing volume overload,<sup>2)</sup> but the effect of the treatment of MR on coexisting AR is unclear. We evaluated the degree of AR at 1 year after surgery in patients who underwent mitral surgery for MR with mild AR. We divided them into two groups according to the degree of postoperative AR and investigated the predictors for continued AR. If we can predict the postoperative course of continued AR, it may be possible to know the risk of reoperation associated with continued AR.

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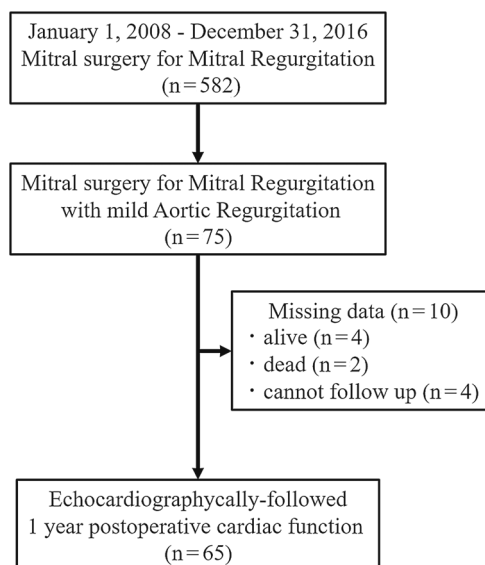


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## Materials and Methods

From January 1, 2008 to December 31, 2016, 582 patients underwent mitral valve surgery for MR at Shiga



**Fig. 1** Selection process and number of patients.

University of Medical Science. The study was approved by the institutional review board. There were 75 patients who had mild AR of them. In all, 65 patients who were available to follow-up echocardiogram 1 year after surgery were included in the present study (**Fig. 1**). Two patients died within 1 year after surgery; one died because of pneumonia and the other because of intestinal necrosis. Four patients were alive but could not be followed up by echocardiogram. We could not confirm the survival of the remaining four patients. In all, 65 patients were divided into two groups according to whether AR improved. We investigated the predictors for continued AR 1 year after operation and perioperative cardiac function.

### Surgical treatment

Our surgical procedure comprised median sternotomy with standard cardiopulmonary bypass. Myocardial protection was obtained for all patients with antegrade or retrograde infusion using cold blood cardioplegic solution. The method of mitral surgery was based on each surgeon's preference. Mitral valve repair was performed in 63 patients (96.9%). We performed annuloplasty only in 26 patients, annuloplasty and leaflet reconstruction in 29, annuloplasty with artificial chordae in 4 and annuloplasty and leaflet reconstruction with artificial chordae in 4. Eight patients had concomitant coronary artery bypass grafting and 18 had concomitant tricuspid annuloplasty.

### Echocardiographic details

Patients in our series underwent annual echocardiographic follow-up at our institution. We evaluated AR

using quantitative evaluation based on the reaching distance of the backflow jet according to Sellers' classification of aortic angiography. "Trivial" indicated that jet ended before the anterior leaflet of the mitral valve. "Mild" indicated that it ended before the papillary muscle. "Moderate" indicated that it ended before the apex, and "Severe" indicated that the AR jet reached the apex.

### Statistical analysis

The continuous variables are presented as means  $\pm$  standard deviation and categorical variables are presented as frequencies or ratios of patients. Continuous variables were compared using the t-test or Mann-Whitney U test. Categorical variables were analyzed with  $\chi^2$  or Fisher's exact test. Multivariate logistic regression analysis was used to determine independent predictors of continued AR. Predictors were entered into a univariate analysis, and any variable with a probability value of  $<0.05$  was entered into the multivariate model. Results were considered statistically significant at a probability value of  $<0.05$ . All statistical analyses were performed with the Statistical Package for Social Sciences, version 22.0 (SPSS Inc., Chicago, IL, USA).

### Results

In all, 22 patients' AR improved and became less than mild, and 43 patients' AR persisted at mild or increased. Of the 43 patients, AR remained at mild in 34 patients and AR increased at moderate in the other nine patients. Patient characteristics are listed in **Table 1**. The mean age of our study population was  $70.9 \pm 10.8$  years, with 33 men (50.8%). There were significant differences in left atrial diameter  $>50$  mm ( $P = 0.001$ ), AR jet deviation ( $P = 0.010$ ), severe MR ( $P = 0.041$ ), moderate MR ( $P = 0.041$ ), and hypertension ( $P = 0.027$ ).

Univariate logistic regression analysis revealed that left atrial diameter  $>50$  mm ( $P = 0.004$ ), AR jet deviation ( $P = 0.038$ ), severe MR ( $P = 0.043$ ), not moderate MR ( $P = 0.043$ ), and hypertension ( $P = 0.030$ ) were predictors of continued AR after mitral surgery for MR. Multivariate analysis showed that left atrial diameter  $>50$  mm was an independent predictor ( $P = 0.021$ , odds ratio = 4.739, 95% confidence interval: 1.259–17.846; **Table 2**). All patients had either moderate MR or severe MR in our study, so we entered severe MR into multivariate analysis and not moderate MR. The continued AR group had a trend of having a deviated AR jet deviation ( $P = 0.141$ ), but there was no significant difference.

**Table 1 Preoperative patient characteristics**

Aortic regurgitation 1 year after surgery	Mild ≤ (n = 43)	< Mild (n = 22)	P value
Age (year)	70.7 ± 11.7	71.2 ± 9.2	0.879
Sex (female)	22 (51.2%)	10 (45.5%)	0.669
Body surface area (kg/m <sup>2</sup> )	1.50 ± 0.18	1.50 ± 0.22	0.895
Left atrial diameter >50 mm	25 (58.1%)	4 (18.2%)	0.001
Aortic regurgitation jet deviation	15 (34.9%)	2 (9.1%)	0.010
HbA1c (%)	5.7 ± 0.6	5.5 ± 0.6	0.153
Cardio-thoracic ratio (%)	58.6 ± 8.6	56.0 ± 6.5	0.183
Ejection fraction (%)	61.3 ± 9.2	57.9 ± 16.1	0.366
Atrial fibrillation	18 (41.9%)	5 (22.7%)	0.114
Mitral regurgitation, severe	29 (67.4%)	9 (40.9%)	0.041
Mitral regurgitation, moderate	14 (32.6%)	13 (59.1%)	0.041
Mitral stenosis, moderate/severe	0 (0.0%)	0 (0.0%)	–
Tricuspid regurgitation, moderate/severe	13 (30.2%)	7 (31.8%)	0.898
Aortic stenosis, mild-severe	0 (0.0%)	0 (0.0%)	–
Bicuspid aortic valve	0 (0.0%)	0 (0.0%)	–
Left ventricular end-diastolic diameter (mm)	57.0 ± 8.0	55.1 ± 6.9	0.343
Left ventricular end-systolic diameter (mm)	37.6 ± 7.7	38.3 ± 10.1	0.765
Left ventricular end-diastolic volume (ml)	118.6 ± 57.8	98.1 ± 39.7	0.140
Left ventricular end-systolic volume (ml)	48.3 ± 35.1	44.6 ± 31.2	0.673
Ventriculo-aortic junction (mm)	21.3 ± 2.0	21.6 ± 2.7	0.637
Sinus of valsalva (mm)	31.1 ± 3.7	30.2 ± 3.2	0.325
Sinotubular junction (mm)	25.8 ± 3.5	25.6 ± 3.8	0.853
Hypertension	28 (65.1%)	8 (36.4%)	0.027
Diabetes mellitus	11 (25.6%)	4 (18.2%)	0.510

HbA1c: hemoglobin A1c

**Table 2 Univariate and multivariate analyses to determine independent predictors of continued aortic regurgitation**

	Univariate			Multivariate		
	OR	95% CI	P value	OR	95% CI	P value
Age (year)	0.996	0.949–1.046	0.877			
Sex (female)	1.257	0.449–3.523	0.663			
Body surface area (kg/m <sup>2</sup> )	1.207	0.079–18.393	0.892			
Left atrial diameter >50 mm	6.250	1.806–21.626	0.004	4.739	1.259–17.846	0.021
Aortic regurgitation jet deviation	5.357	1.100–26.089	0.038	3.692	0.648–21.031	0.141
HbA1c (%)	1.988	0.770–5.134	0.156			
Cardio-thoracic ratio (%)	1.044	0.975–1.118	0.221			
Ejection fraction (%)	1.024	0.981–1.069	0.279			
Atrial fibrillation	2.448	0.762–7.862	0.133			
Mitral regurgitation, severe	2.992	1.034–8.659	0.043	2.398	0.661–8.702	0.183
Mitral regurgitation, moderate	0.334	0.115–0.967	0.043			
Mitral stenosis, moderate/severe	–	–	–			
Tricuspid regurgitation, moderate/severe	0.929	0.307–2.813	0.896			
Aortic stenosis, mild-severe	–	–	–			
Bicuspid aortic valve	–	–	–			
Left ventricular end-diastolic diameter (mm)	1.035	0.965–1.111	0.338			
Left ventricular end-systolic diameter (mm)	0.991	0.933–1.052	0.761			
Left ventricular end-diastolic volume (ml)	1.009	0.997–1.020	0.144			
Left ventricular end-systolic volume (ml)	1.004	0.987–1.020	0.670			
Ventriculo-aortic junction (mm)	0.944	0.747–1.193	0.631			
Sinus of valsalva (mm)	1.079	0.929–1.252	0.320			
Sinotubular junction (mm)	1.014	0.877–1.174	0.850			
Hypertension	3.267	1.119–9.537	0.030	2.782	0.806–9.603	0.105
Diabetes mellitus	1.547	0.429–5.574	0.505			

CI: confidence interval; HbA1c: hemoglobin A1c; OR: odds ratio

Table 3 Cardiac function before and after mitral surgery for mitral regurgitation

Aortic regurgitation 1 year after surgery	Mild ≤ (n = 43)		< Mild (n = 22)		P value
	Before surgery	After surgery	Before surgery	After surgery	
Cardio-thoracic ratio (%)	58.6 ± 8.6	54.3 ± 7.3	56.0 ± 6.5	51.4 ± 6.6	0.022
Ejection fraction (%)	61.3 ± 9.2	58.3 ± 6.9	57.9 ± 16.1	54.7 ± 10.8	0.438
Left atrial diameter (mm)	52.6 ± 11.5	46.7 ± 11.3	45.1 ± 8.5	40.5 ± 7.0	0.061
Left ventricular end-diastolic diameter (mm)	57.0 ± 8.0	50.0 ± 6.8	55.1 ± 6.9	48.7 ± 7.0	0.004
Left ventricular end-systolic diameter (mm)	37.6 ± 7.7	34.6 ± 6.4	38.3 ± 10.1	34.7 ± 8.4	0.204
Left ventricular end-diastolic volume (ml)	118.6 ± 57.8	96.7 ± 38.9	98.1 ± 39.7	82.4 ± 35.8	0.176
Left ventricular end-systolic volume (ml)	48.3 ± 35.1	41.3 ± 23.6	44.6 ± 31.2	38.3 ± 24.8	0.464

**Table 3** shows the cardiac function before and after surgery in the two groups. Cardio-thoracic ratio ( $P = 0.014$ ), left atrial diameter ( $P = 0.018$ ), left ventricular end-diastolic diameter ( $P < 0.001$ ), and end-diastolic volume ( $P = 0.043$ ) improved in the continued AR group. Cardio-thoracic ratio ( $P = 0.022$ ) and left ventricular end-diastolic diameter ( $P = 0.004$ ) improved in the other group.

No patients underwent reoperation for continued AR in both groups. However, one patient was rehospitalized for heart failure in the continued AR group.

## Discussion

When performing mitral valve surgery for MR, it is not recommended in the guideline to perform AVR for coexisting mild AR. Several previous studies discussed the relationship between aortic stenosis and MR,<sup>3-6</sup> but few papers discussed the relationship between MR and AR. We investigated the postoperative course of continued AR after mitral surgery for MR. It may be possible to know the risk of reoperation associated with continued AR if we can determine the predictor.

Both MR and AR cause volume overload on the left ventricle.<sup>2,7</sup> Within 4–6 months after mitral surgery for MR, the left ventricular volume decreases significantly.<sup>8</sup> In the present study, more values of cardiac function improved in the continued AR groups than the other group (**Table 3**). The continued AR group had preoperative larger values of cardiac function, so the treatment of MR may have given more change to the continued AR group than the other group.

**Table 3** shows that left ventricular end-diastolic volume significantly improved in the continued AR group than the other group. In our institution, AR was evaluated using quantitative evaluation based on the reaching distance of backflow jet as previously described. The reaching distance can be evaluated relatively long with decreasing left ventricular end-diastolic volume by treating MR, even if there was no change in the amount of substantial AR.

The continued AR group had a trend of having a deviated AR jet (**Table 2**). The deviation of AR means a degenerative change of aortic valve leaflets. That is reasonable AR remains in the presence of AR jet deviation even if volume overload improves after MR treatment.

**Table 1** shows that the continued AR group had significantly larger left atrial diameter ( $P = 0.001$ ) and had a trend of larger left ventricular end-diastolic volume ( $P = 0.140$ ). The mean left atrial diameter in our entire

cohort was 50.0 mm, so we set the cutoff value to 50.0 mm. There was no difference in preoperative atrial fibrillation (**Table 1**). Matteo revealed that the more severe the MR, the larger several values including left atrial diameter and left ventricular end-diastolic volume.<sup>9)</sup> The large left atrial diameter in the AR continued group is considered to be effected MR than atrial fibrillation. Our study may suggest that sustained MR until the left atrium expanded 50 mm is associated with continued AR after mitral treatment for MR. Multivariate logistic regression analysis revealed that independent predictor for the continued AR was left atrial diameter >50 mm ( $P = 0.001$ ), so MR with coexisting mild AR should be treated as soon as before the left atrium expands.

In our follow-up 1 year after operation, one patient was rehospitalized for heart failure in the continued AR group. If we can investigate more patients using a longer follow-up, we may be able to determine the effect of continued AR on the postoperative course more accurately.

### Limitations

There are several limitations in this study. First, this is a retrospective study at a single center. Second, the relatively small number of patients might have resulted in insufficient statistical power. Finally, the follow-up period was short at 1 year after operation, so no one underwent reoperation for continued AR.

### Conclusion

The independent predictive factor for continued AR 1 year after mitral surgery for MR was left atrial diameter >50 mm. MR with mild AR should be treated as soon as before the left atrium expands.

### Disclosure Statement

The authors declared that no conflict of interest exists.

### References

- 1) Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation* 2014; **129**: 521-643.
- 2) McCutcheon K, Manga P. Left ventricular remodeling in chronic primary mitral regurgitation: implications for medical therapy. *Cardiovasc J Afr* 2018; **29**: 51-65.
- 3) Tassan-Mangina S, Metz D, Nazeyllas P, et al. Factors determining early improvement in mitral regurgitation after aortic valve replacement for aortic valve stenosis: a transthoracic and transeosophageal prospective study. *Clin Cardiol* 2003; **26**: 127-31.
- 4) Harris KM, Malenka DJ, Haney MF, et al. Improvement in mitral regurgitation after aortic valve replacement. *Am J Cardiol* 1997; **80**: 741-5.
- 5) Absil B, Dagenais F, Mathieu P, et al. Does moderate mitral regurgitation impact early or mid-term clinical outcome in patients undergoing isolated aortic valve replacement for aortic stenosis? *Eur J Cardiothorac Surg* 2003; **24**: 217-22; discussion 222.
- 6) Caballero-Borrego J, Gómez-Doblas JJ, Cabrera-Bueno F, et al. Incidence, associated factors and evolution of non-severe functional mitral regurgitation in patients with severe aortic stenosis undergoing aortic valve replacement. *Eur J Cardiothorac Surg* 2008; **34**: 62-6.
- 7) Iida N, Seo Y, Ishizu T, et al. Transmural compensation of myocardial deformation to preserve left ventricular ejection performance in chronic aortic regurgitation. *J Am Soc Echocardiogr* 2012; **25**: 620-8.
- 8) Pandis D, Grapsa J, Athanasiou T, et al. Left ventricular remodeling and mitral valve surgery: prospective study with real-time 3-dimensional echocardiography and speckle tracking. *J Thoracic Cardiovasc Surg* 2011; **142**: 641-9.
- 9) Cameli M, Mandoli GE, Nistor D, et al. Left heart longitudinal deformation analysis in mitral regurgitation. *Int J Cardiovasc Imaging* 2018; **34**: 1741-51.