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ORIGINAL ARTICLE

Echocardiographic variables associated with mitral regurgitation after aortic valve replacement for aortic valve stenosis

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KEYWORDS

Echocardiography;
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Abstract *Background:* Mitral regurgitation (MR) is frequently associated with aortic stenosis. Previous reports have shown that coexisting mitral insufficiency can regress after aortic valve replacement (AVR) while others recommend dealing with examination.
Aim: The study aimed to assess the severity of MR before and after aortic valve replacement for aortic stenosis and to define the determinants of its postoperative evolution.
Methods: For this purpose, 30 adult patients referred for aortic valve surgery underwent pre- and 1 month postoperative transthoracic echocardiography including 2D, MM, PW, CW and color Doppler examination.
Results: Postoperative MR improved in 68.4% of the 19 patients (63.3%) who had preoperative moderate MR ($p = 0.002$). The effect of the valve size on the postoperative MR was statistically insignificant (0.059) but was significant on regression of the mass ($p = 0.001$) and drop in mean PG ($p = 0.04$) across AV. Patients with persistent moderate MR after surgery were all in AF and had significantly larger left atrial size (45 ± 26 mm), compared to none and a smaller left atrial (37 ± 19 mm) in patients in whom MR regressed or disappeared after surgery; respectively, $p < 0.05$. The postoperative variables associated with moderate MR were peak PG across AV (29.4 ± 5.1 vs 38.0 ± 5.7 $p = 0.004$), mean PG (15.04 ± 4.4 vs 22.8 ± 5.8 $p = 0.009$) and LVMI (124.7 ± 19.3 vs 147.2 ± 31.6 $p = 0.065$).
Conclusion: Preoperative predictors of residual postoperative MR were large LA and AF while the postoperative variables were high peak and mean pressure gradient across the aortic valve and high LVMI.

1. Introduction

Mitral regurgitation (MR) frequently co-exists in patients with aortic stenosis (AS), and is often functional in origin without demonstrable structural abnormality. Initial chronic pressure overload occurring in longstanding AS produces concentric hypertrophy that increases trans-mitral pressure gradient.[1]

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This, in turn, can either worsen existing structural MR or produce MR in the absence of structural abnormality. Progression to diastolic dysfunction then produces further functional deterioration. MR of varying degrees has been reported in up to 75% of patients undergoing AVR.[2]

Co-existent mitral regurgitation may adversely influence both morbidity and mortality in patients undergoing aortic valve replacement for severe aortic stenosis. While it is accepted that concomitant mitral intervention is required in severe, symptomatic mitral regurgitation but in cases of moderate non-structural MR the surgical decision making is influenced by an expectation that there will be a reduction in MR with relief of the gradient across the aortic valve (AV).[3]

There is some evidence that regurgitation improvement may be seen following aortic valve replacement alone, avoiding the increased risk of double-valve surgery; the exact benefit of such a conservative approach is, however, yet to be adequately quantified.

1.1. Aim of the study

This study aimed to evaluate prospectively the frequency and degree of MR in patients with severe aortic stenosis and its evolution after aortic valve replacement.

2. Patients and methods

This was a prospective study which included 18 men and 12 women with a mean age of 60 ± 7 years suffering from severe Aortic stenosis. All patients were subjected to open heart surgery and had their Aortic valves replaced by mechanical prosthesis.bileaflet prosthesis (St. Jude Medical; median diameter, 22 mm; range, 19–25 mm) the selection of the size based on BSA and the diameter of the aortic root; Patients with a narrow aortic root (mostly were female) received valve size 19 or 21 mm, patients with concomitant AR, physically active or larger BSA and aortic root received valve size 23 or 25 mm.

Patients with severe aortic regurgitation, structural mitral reguge, unstable hemodynamic state, arrhythmia, and contraindication to surgery were excluded. We also excluded patients who had to undergo mitral valve or mitral annulus surgery or who needed CABG operation.

Echocardiographic study was performed using a GE Vivid 7 ultrasound apparatus twice for each patient pre and post operatively including 2D, MM, color and PW, CW Doppler for evaluation of the severity of aortic and mitral valve disease and the degree of pulmonary hypertension if present and the evaluation of the LV function, dimensions and mass.

Severity of aortic stenosis was quantified by measuring peak and mean pressure gradients across the aortic valve using continuous wave Doppler. The aortic valve area was assessed using the continuity equation.

Left ventricular end-diastolic and end-systolic dimensions, end-diastolic thickness of the interventricular septum, and posterior LV wall were assessed with M-mode parasternal echocardiography. The Penn formula was used to calculate LV mass that was indexed to the body surface area.[4]

$$\text{LV mass (Penn)} = 1.04\,([\text{LVIDD} + \text{PWTD} + \text{IVSTD}]^3 - [\text{LVIDD}]^3) - 13,6\,\text{g} \quad (4)$$

$$\text{BSA} = (W^{0.425} \times H^{0.725}) \times 0.007184$$

Presence and severity of MR were assessed using color Doppler flow imaging in apical 4 and 2 chamber views and in the parasternal long axis view. Mitral regurgitation was considered mild, moderate, or severe when the regurgitant jet area was $<4\,\text{cm}^2$, 4–8 cm^2, or $>8\,\text{cm}^2$, respectively. Left atrium dimensions were measured in the PLX and apical 4 chamber views. In case of AF average of 7–10 cycles was measured for the dimension, mean and peak PG and degree of MR.

Postoperatively, the same transthoracic parameter measurements were performed within month after aortic valve replacement using the same methods.

2.1. Statistical analysis

The collected data were analyzed using SPSS 16 software, quantitative variables were expressed as mean ± standard deviation (SD), using Wilcoxon test for comparing paired data and Mann Whitney U test for comparing independent samples. Categorical data were presented as number and percentages, using Mc Nemar test for comparing paired data and Fisher's exact test (instead of the conventional chi square because of the small cell frequency, <5) for comparing independent groups, 2 tailed P value was calculated and it was considered significant if $\leqslant 0.05$.

3. Results

Aortic stenosis was of bicuspid etiology in 2 cases and was degenerative in 28. A mild to moderate aortic regurgitation was associated in 20 patients preoperatively. The pre- and postoperative characteristics of the patients are listed in Table 1.

Postoperative MR improved in 68.4% of the 19 patients (63.3%) who had preoperative moderate MR (p 0.002).

Patients showing persistence of moderate MR after surgery were all in AF compared to none of the patients in whom moderate MR decreased or disappeared after AVR ($P < 0.05$). Their former had a significantly larger left atrial size, compared to that measured in the latter group of patients (45 ± 26 mm vs. 37 ± 19; $P < 0.05$). On the other hand, persistence of moderate MR was associated with higher peak PG over AV (28 ± 15 vs 35 ± 11 mmHg; $P > 0.05$), higher mean PG over AV (15 ± 7 mmHg vs 25 ± 5 mmHg; $P = 0.049$), higher PASP (27 ± 2 vs. 55 ± 5 mmHg; $P > 0.05$) and higher LVMI (145 ± 12 vs 170 ± 8; $P = 0.005$), compared to patients in whom MR decreased or disappeared after surgery; respectively. The systolic function was within normal in patients in both groups (60 ± 2 vs 58 ± 4); $P > 0.05$ Table 2.

The effect of the valve size on the postoperative MR was statistically insignificant (0.059) but was significant on regression of the mass ($p = 0.001$) and drop in mean PG ($p = 0.04$) across AV Table 3.

Postoperative associations of persistent MR were higher peak PG ($p = 0.004$), mean PG ($p = 0.009$) and LVMI ($p = 0.065$) Table 4.

4. Discussion

The prevalence of concomitant moderate mitral regurgitation (MR) in patients with severe aortic stenosis presenting for

Table 1 The pre- and postoperative characteristics of the patients.

Echocardiography		Preoperative ($N = 30$)		Postoperative ($N = 30$)		P Value
		Mean ± SD		Mean ± SD		
Peak PG across AV (mmHg)		82.6 ± 9.2		31.1 ± 6.2		<0.001
Mean PG across AV (mmHg)		55.3 ± 5.8		16.6 ± 5.6		<0.001
PASP (mmHg)		54.5 ± 5.7		28.3 ± 3.6		<0.001
LVIDd (mm)		52.1 ± 3.7		50.9 ± 4.8		0.198
LVIDs (mm)		32.5 ± 3.03		30.9 ± 2.24		0.043
PWTd (mm)		13.3 ± 0.86		12.4 ± 0.71		<0.001
SWTd		13.1 ± 0.94		11.8 ± 0.78		<0.001
LA size		4.42 ± 0.56		4.38 ± 0.64		0.63
LVEF%		62.9 ± 7.2		63.3 ± 7.3		0.66
LV mass (g/m2)		187.3 ± 33.6		129.2 ± 23.5		<0.001
Degree of MR		No.	%	No.	%	
	No or mild MR	11/30	36.7	24/30	80.0	0.002
	Moderate MR	19/30	63.3	6/30	20.0	
Atrial fibrillation		6/30	23.3	7/30	20.0	1.0

Table 2 Predictors of persistence of moderate MR after aortic valve replacement.

Patient criteria	Improved MR ($n = 13$)	No improvement in MR ($n = 6$)	P value
AV Peak PG	28 ± 15 mmHg	35 ± 11 mmHg	>0.05
AV Mean PG	15 ± 7 mmHg	25 ± 5 mmHg	0.049
PASP	27 ± 2 mmHg	55 ± 5 mmHg	>0.05
LA size	37 ± 19 mm	45 ± 26 mm	<0.05
AF	0	6	<0.05
LVMI	145 ± 12	170 ± 8	0.005
EF%	60 ± 2	58 ± 4	>0.05

Table 3 Relation between aortic valve size and pressure gradient, LVMI and degree of MR.

	Size 19 ($n = 12$)	Size 21 ($n = 13$)	Size 23 ($n = 4$)	Size 25 ($n = 1$)	P value
BSA (m^2)	1.64 ± 0.12	1.74 ± 0.20	1.82 ± 0.17	1.91 ± 0.17	
Postoperative mean PG	20 ± 6.8	18 ± 6.0	16 ± 5.7	12 ± 6.7	0.04
Postoperative LVMI	130 ± 17.6	124 ± 44.4	113 ± 27.1	119 ± 50.8	0.001
Postoperative MR	($n = 2$) 16%	($n = 3$)15.4%	($n = 1$)25%	0	0.059

Table 4 Postoperative variables associated with postoperative MR.

Postoperative variables	Postoperative MR		P value
	No or mild MR ($n = 24$) Mean ± SD	Moderate MR ($n = 6$) Mean ± SD	
Post Peak (mmHg)	29.4 ± 5.1	38.0 ± 5.7	0.004
Post Mean (mmHg)	15.04 ± 4.4	22.8 ± 5.8	0.009
Post mass	124.7 ± 19.3	147.2 ± 31.6	0.065

surgery is significant. It is often left uncorrected as it is thought to improve after aortic valve replacement (AVR). However, a certain subset of MR may stay the same or even worsen and may lead to poor functional outcomes.[5]

Patients with myxomatous or rheumatic mitral valves are often surgically repaired or replaced at the same setting as AVR as they are not likely to improve. While mild concomitant functional MR during AVR is left alone, severe MR is addressed during the same surgery. However, in patients with moderate MR, the management is unclear. The risk benefit ratio needs to be addressed with issues of double valve surgery mortality (unadjusted mortality is twice as high in MVR and AVR compared to AVR alone) versus the poor functional outcomes in untreated persistent MR and the potential for morbidity and mortality associated with a possible reoperation in the future.[6]

Some believe that additional MV surgery is not necessary in patients with preserved left ventricular function and without organic MV disease.[7]

Others found that despite reverse remodeling, concomitant moderate–severe mitral regurgitation adversely affects both

early and late mortality following aortic valve replacement. Concomitant mitral intervention should therefore be considered in the presence of moderate mitral regurgitation, independent of the etiology.[8]

As regard to the performed systematic literature review included 17 studies incorporating 3053 patients undergoing aortic valve replacement for aortic stenosis with co-existing mitral regurgitation, who concluded that despite reverse remodeling, concomitant moderate mitral regurgitation adversely affects both early and late mortality following aortic valve replacement.[9] It seems reasonable to look for the pre and postoperative variables associated with evolution of MR.

In the present study moderate MR improved significantly (68%) after AVR, the effect of the valve size on the postoperative MR was statistically insignificant but was significant on regression of the mass and drop in mean PG across AV. Pre LA and AF were significant predictors of postoperative residual MR and the postoperative associations of persistent MR were higher peak, mean PG and LVMI.

These results are in agreement with a study on 227 patients with stenotic AV disease without structural mitral valve disease underwent AVR, MR severity improved in 66% of patients. Predictor of lower postoperative MR was the small left atrial size ($p = 0.03$), and found that prosthetic valve type or size was not an independent predictor of postoperative MR.[10]

Also Durst et al., 2011 found that after isolated AVR a trend toward improvement in MR was observed. Left ventricular dysfunction, left atrial enlargement, and atrial fibrillation were associated with progression of MR after AVR.[11]

Emily et al., 2008 analyzed the characteristics that were independently associated with changes in MR after AVR and found that arial fibrillation is a predictor of residual MR and referred this to its relationship with left atrial size ($p = 0.02$), CHF ($p = 0.001$), and age ($p = 0.001$) and concluded that patients with atrial fibrillation are less likely to see improvement in MR. This effect is accounted by the presence of correlate variables.[12]

Considering its low grade, MR alone could not induce left atrium dilation nor increase in tricuspid regurgitation velocity that we observed. These changes could be the result of the diastolic impairment induced by LV hypertrophy.

After aortic valve replacement, LV mass and parietal thickness significantly decreased. Left ventricular remodeling results from changes in loading conditions such as reduction of pressure gradients between aorta and left ventricle, Shahab 2009 who found that patient–prosthesis mismatch (defined as the generation of a high transvalvular gradient through a normally functioning prosthetic valve) results in an increased LV work, which in turn influenced the regression of LV hypertrophy the latter is a strong independent risk factor for mortality as well as a major determinant of systolic and diastolic function and the persistence or even worsening of the degree of MR.[13]

And also Calvin et al., 2009 found that functional MR improves in approximately 75% of patients undergoing AVR for AS and the independent predictors of immediate improvement included smaller LA lesser degree of TR and lower PASP and explained that these factors reflect more physiologically substantial MR, may be less likely to improve with AVR alone.[14]

Yoshikawa et al. 2009 studied the negative effects caused by residual obstruction of the left ventricular outflow tract on 221 patients who underwent isolated aortic valve replacement with a 23-mm or smaller St. Jude Medical valve. The long-term results demonstrated that a small St. Jude Medical valve can be advantageously used in small body size, also emphasize that it is not prosthesis size per se that matters but rather the relation between body size and prosthesis size. And to keep in mind that sometimes there is a discrepancy between aortic root diameter and body surface area.[15]

4.1. Limitation

The study focused to the evolution of MR early after AVR (within 1 month) but didn't follow the effect of MR on patient survival or the need for reoperation for MR and also we have to admit that our small sample size did not allow us to evaluate the possible roles of preoperative enlarged Left atrium or AF as independent predictors for the persistence of moderate MR after AVR.

5. Conclusion

So we can conclude that patients with functional moderate MR should be subjected to careful selection of the prosthesis to avoid patient-prosthesis mismatch and to consider concomitant MV repair or replacement in case of LA dilation and AF or least obtaining these values for evaluation of the degree of MR intraoperatively in guiding the surgical management.

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