Restrictive mitral valve annuloplasty versus mitral valve replacement for functional ischemic mitral regurgitation: An exercise echocardiographic study

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Objective: Mitral valve annuloplasty and mitral valve replacement are common strategies for the management of functional ischemic mitral regurgitation with ischemic cardiomyopathy. However, mitral valve annuloplasty may create some degree of functional mitral stenosis. The purpose of this study was to compare the mitral valve hemodynamics in patients with functional ischemic mitral regurgitation undergoing mitral valve annuloplasty or mitral valve replacement, using exercise echocardiography.

Methods: We performed resting and exercise echocardiography in 70 patients matched for indexed effective orifice area, systolic pulmonary arterial pressure, and left ventricular ejection fraction after mitral valve annuloplasty or mitral valve replacement with coronary artery bypass grafting.

Results: There was no significant difference between the 2 groups regarding baseline demographic and clinical data. Exercise systolic pulmonary arterial pressure was higher in the mitral valve annuloplasty group compared with the mitral valve replacement group (from 36.3 ± 8.1 mm Hg to 55 ± 12 mm Hg, vs mitral valve replacement: 33 ± 6 mm Hg to 42 ± 6.2 mm Hg, $P = .0001$). Exercise-induced improvement in effective orifice area and indexed effective orifice area was better in the mitral valve replacement group (mitral valve replacement: +0.23 ± 0.04 vs mitral valve annuloplasty: −0.1 ± 0.09 cm^2, $P = .001$, for effective orifice area; mitral valve replacement: +0.14 ± 0.03 vs mitral valve annuloplasty: −0.04 ± 0.07 cm^2/m^2, $P = .03$, for indexed effective orifice area). Exercise indexed effective orifice area was correlated with exercise systolic pulmonary arterial pressure ($r = -0.45$; $P = .01$). In a multivariable analysis mitral valve annuloplasty, postoperative indexed effective orifice area and resting mitral peak gradients were independent predictors of elevated systolic pulmonary arterial pressure during exercise.

Conclusions: In patients with functional ischemic mitral regurgitation, mitral valve annuloplasty may cause functional mitral stenosis, especially during exercise. Mitral valve annuloplasty was associated with poor exercise mitral hemodynamic performance, lack of mitral valve opening reserve, and markedly elevated postoperative exercise systolic pulmonary arterial pressure compared with mitral valve replacement. (J Thorac Cardiovasc Surg 2014;148:447-53)

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Functional ischemic mitral regurgitation (FIMR) is associated with poor outcome, and its best management remains controversial.[1-3] Mitral valve annuloplasty (MVA) and mitral valve replacement (MVR) combined with coronary artery bypass grafting represent the most common surgical strategies.

The rationale of restrictive MVA is to reduce the mitral annulus by shortening the anteroposterior distance with a prosthetic ring selected 2 sizes below the measured intertrigonal length.[4] Recent studies suggest that MVA may create some degree of postoperative functional mitral

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Abbreviations and Acronyms

AUC = area under the curve
EOA = effective orifice area
FIMR = functional ischemic mitral regurgitation
IEOA = indexed effective orifice area
LV = left ventricular
LVEF = left ventricular ejection fraction
LVOT = left ventricular outflow tract
MR = mitral regurgitation
MVA = mitral valve annuloplasty
MVR = mitral valve replacement
PH = pulmonary hypertension
SD = standard deviation
SPAP = systolic pulmonary arterial pressure
SV = stroke volume

stenosis, thereby increasing systolic pulmonary arterial pressure (SPAP) and decreasing functional capacity, similarly to that observed in mitral stenosis or mitral prosthesis–patient mismatch.[5-7]

In the setting of FIMR, most studies comparing outcomes after MVA or MVR have evaluated mitral valve hemodynamics using resting Doppler echocardiography,[8,9] which often does not correlate with patient symptoms.[10] Exercise Doppler echocardiography represents a more reliable method to evaluate mitral valve hemodynamic performance.[10]

The aim of this study was to compare both resting and exercise mitral valve hemodynamic performance in patients undergoing surgical correction of FIMR. We designed this study to compare the hemodynamic performance of MVA with MVR and to identify the determinants of exercise SPAP.

MATERIALS AND METHODS

Patient Population

We retrospectively reviewed data prospectively collected on 194 consecutive patients with FIMR who underwent MVA or MVR combined with coronary artery bypass grafting, at the Cardiovascular Department, Ospedale "Papa Giovanni XXIII," Bergamo Italy, between February 2005 and August 2009. Ethical approval was given by the local hospital committee, and informed consent was obtained from all patients.

Indication for surgery was given during multidisciplinary meeting. Because there is no clear consensus on the superiority of MVA or MVR for severe FIMR, the choice between the 2 techniques was left to the surgeon performing each operation. Two high-volume senior surgeons (PF, MM) with special interest in mitral valve surgery and similar operative outcomes were involved in all the surgical procedures. Both groups received the same preoperative, operative, and postoperative care.

FIMR was defined by echocardiographic and coronary angiographic findings using the following criteria: MR occurring more than 1 week after myocardial infarction, as previously defined,[11] 1 or more left ventricular (LV) segmental wall motion abnormalities, significant coronary artery disease in the territory supplying the wall motion abnormality, and structurally normal mitral valve leaflets and chordae tendinae.[11]

Exclusion criteria were as follows: acute ischemic mitral regurgitation (MR); previous cardiac surgery or cardiac resynchronization therapy procedure; other significant valve disease (aortic, pulmonary, and tricuspid valve); concomitant ventricular procedures; inadequate preoperative echocardiogram; patients unable to exercise or unwilling to cooperate; chronic lung disease; and patients with recurrent MR, defined as a postoperative MR jet vena contracta width greater than 3 mm, at the follow-up.

After the exclusion criteria were applied, the total population included 118 patients (MVA: n = 72; MVR: n = 46). There were 4 (3.4%) perioperative deaths (deaths within 30 days or before discharge from the index hospitalization) without a significant difference between the patients receiving MVR or MVA (MVR: n = 1 [2.2%] vs MVA: n = 3 [4.2%], $P = .94$).

The eligible population of 114 patients was prospectively contacted from June 2010 to August 2010 to perform both baseline resting and exercise Doppler echocardiography. These patients were then matched on a 1:1 basis in the following order: (1) indexed effective orifice area (IEOA), (2) SPAP, and (3) LV ejection fraction (LVEF). We accepted a positive match when the differences between 2 patients were less than 0.1 cm^2/m^2 in IEOA, less than 5 mm Hg in SPAP, and less than 5% in LVEF. The final matched population included 70 patients. All data regarding the whole unmatched population are provided in Tables E1 to E3.

Data Collection and Outcome Measures

Coronary angiographic findings, preoperative clinical data, intraoperative clinical data, postoperative clinical data, and Doppler echocardiographic findings were prospectively collected in our institutional database and retrospectively analyzed.

Surgical Technique

Both procedures were performed by median sternotomy. In the MVA group, the ring sizer was selected by measuring the intercommissural distance of the mitral valve and positioned to cover the surface of the stretched middle scallop of the anterior leaflet. A Carpentier-Edwards Physio ring (Edwards Lifesciences, Irvine, Calif) undersized by 2 sizes was then inserted. In the MVR group, biological or mechanical prostheses were inserted with systematic preservation of the subvalvular apparatus. All coronary vessels with significant stenosis on the preoperative angiogram were grafted. Intraoperative transesophageal echocardiography was routinely used.

Echocardiographic Protocol

Resting and exercise echocardiography studies were performed using commercially available instruments (Vivid 7 imaging device; GE Healthcare, Little Chalfont, Buckinghamshire, United Kingdom). The echocardiographic and Doppler data were obtained at rest and at peak exercise in digital format and stored on a workstation for offline analysis (EchoPAC, GE Vingmed Ultrasound AS, Horten, Norway). Measurements were indexed to body surface area, when necessary, and the Doppler tracings were averaged from 3 to 5 beats.

According to the recommendations of the American Society of Echocardiography,[12] the following parameters were measured: LV end-diastolic and end-systolic diameters; LVEF was measured using the modified biplane Simpson method; MR severity was assessed with the vena contracta width. LV outflow tract (LVOT) area was determined as $\pi D^2/4$, where D is the diameter measured from a zoomed systolic freeze-frame in the parasternal long-axis view. LV stroke volume (SV) was determined by multiplying the LVOT area to the time integral of the outflow tract velocity (pulsed-wave Doppler). Because LVOT area has been shown to remain constant during exercise, the resting value was used to calculate both rest and exercise SV. Cardiac output was calculated by multiplying the SV and the heart rate.