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Original article

Prosthesis–patient mismatch due to small ring annuloplasty in patients with degenerative mitral insufficiency

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ABSTRACT

Background: Avoidance of prosthesis–patient mismatch (PPM) is important when selecting a mitral valve prosthesis. This study investigated the effect of PPM after small ring mitral valve annuloplasty on postoperative hemodynamics and the clinical course.

Methods: This study retrospectively reviewed 227 patients with symptomatic severe mitral insufficiency (MI) who underwent mitral valve repair for degenerative MI using an Edwards ring or band (size: 26–32 mm) between 2003 and 2012. Echocardiography was performed postoperatively and at follow-up to evaluate cardiac function, including residual MI, mean transmitral pressure gradient, left atrial diameter (LAD), and tricuspid regurgitant pressure gradient (TRPG).

Results: There were no operative deaths. Actuarial freedom from major adverse cardiac events was 91% at 10 years. The postoperative MI grade was not significantly different between different sizes of prosthesis (26 mm, 0.67 ± 0.8; 28 mm, 0.73 ± 0.9; 30 mm, 0.85 ± 0.9; 32 mm, 0.3 ± 0.6). LAD and TRPG were significantly lower for each size of prosthesis at follow-up (all $p < 0.05$). Patients with a smaller body surface area received a significantly smaller prosthesis ($p < 0.05$). The transmitral pressure gradient was significantly higher in patients with a 26-mm prosthesis than in patients with a larger size of prosthesis. Thirty-three patients had a follow-up transmitral pressure gradient $\geq$5 mmHg. The follow-up LAD was larger in patients with a transmitral pressure gradient $<$5 mmHg than in patients with that $\geq$5 mmHg (43.2 ± 9.4 mm vs 47.1 ± 9.6 mm, $p < 0.05$).

Conclusions: Mitral valve repair results in excellent clinical outcomes with significant reductions in MI, LAD, and TRPG for all sizes of prosthesis. However, use of a smaller prosthesis may result in a higher mean transmitral pressure gradient, and may inhibit reverse remodeling of the left atrium. Therefore, PPM should be avoided.

Introduction

Prosthesis–patient mismatch (PPM) refers to an inadequate prosthetic valve size relative to the patient's body surface area (BSA). Previous studies have reported that aortic PPM is associated with inferior hemodynamics, less regression of left ventricular hypertrophy, more cardiac events, and higher mortality rates [1–3].

Pibarot et al. [4,5] found that PPM after mitral valve replacement (MVR) was associated with persistent pulmonary hypertension and late functional tricuspid regurgitation. Pulmonary hypertension may cause right-sided heart failure and is an important risk factor for morbidity and mortality in patients with cardiovascular disease [6–8]. Our previous study found that PPM after MVR was associated with poorer long-term survival and an increased rate of recurrent heart failure [9]. Mitral valve repair results in superior long-term survival compared with MVR in patients with mitral valve prolapse. Established techniques using an annuloplasty ring result in excellent durability, even in patients with advanced left ventricular and left atrial remodeling [10–13]. The mitral annuloplasty ring or band size is usually selected by measuring the inter-trigon or inter-commissure distance using the attached sizers. The mitral annuloplasty ring or band size can also be measured by the height of the anterior leaflet or matching the surface of the anterior leaflet to the sizer, without considering the BSA [10–12]. Selection of the correct prosthesis size is important

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for avoiding PPM after aortic valve replacement or MVR. Therefore, selection of the correct ring size for mitral valve repair is also important. The aims of this study were to evaluate PPM after mitral valve repair, and to determine a method to correctly select the prosthetic ring or band size.

Materials and methods

Patients and study design

This retrospective analysis was approved by the Institutional Review Board of the National Cerebral and Cardiovascular Center, and the need for patient consent was waived. The study included 227 patients who underwent mitral valve repair for degenerative mitral insufficiency (MI) using an Edwards prosthetic ring or band (Edwards Lifesciences, Irvine, CA, USA) between January 2003 and May 2012. Patients with concomitant aortic valve disease were excluded from the study. The preoperative patient and hemodynamic characteristics are shown in Table 1. The study included 142 men and 85 women with a mean age of 59 ± 11 years (range, 21–81 years). Preoperatively, 20 patients (9%) were classified as New York Heart Association functional class III or IV. The prolapse area was the anterior leaflet in 45 (20%) patients, the posterior leaflet in 149 (66%) patients, anterior and posterior leaflets in 14 (6%) patients, and the commissure in 36 (16%) patients. Postoperatively, patients were followed up at the National Cerebral and Cardiovascular Center. The follow-up rate was 100% and the mean follow-up period was 6.6 ± 2.6 years.

Table 1
Patient characteristics, preoperative echocardiographic findings, and operative data.

Variable	All patients (n = 227)
Patient characteristics	
Age (years)	59 ± 11 (21–81)
Male	142 (62%)
BSA (m^2)	1.65 ± 0.4 (1.1–2.1)
Etiology type	Type II (mitral prolapse)
NYHA class III/IV	20 (9%)
Pre-operative echocardiographic findings	
Prolapse lesion	
Anterior leaflet	45 (20%)
Posterior leaflet	149 (65%)
Both leaflets	31 (14%)
Commissure	36 (16%)
LVDd (mm)	59 ± 7
LVDs (mm)	36 ± 6
LAD (mm)	51 ± 9
IVS (mm)	9.5 ± 1.7
LVPW (mm)	9.6 ± 1.7
TRPG (mmHg)	35 ± 15
LVMI (g/m^2)	168 ± 51
MI grade	3.8 ± 0.4
Operative data	
Mitral repair	
Resection and suturing	174 (76%)
Chordal replacement	63 (28%)
Commissure fixation	38 (17%)
Ring annuloplasty	227 (100%)
Cosgrove band	146 (64%)
Physio	49 (22%)
Physio II	32 (14%)
Prosthesis size	
26 mm	71
28 mm	87
30 mm	57
32 mm	12
Concomitant procedure	
CABG	12
Maze	55
TAP	33
Other	9

Data are shown as mean ± standard deviation (range), or number (%). BSA, body surface area; LVDd, left ventricular end-diastolic diameter; LVDs, left ventricular end-systolic diameter; LAD, left atrial diameter; IVS, intraventricular septum; LVPW, left ventricular posterior wall; NYHA, New York Heart Association; TRPG, tricuspid regurgitant pressure gradient; LVMI, left ventricular mass index; MI, mitral insufficiency; CABG, coronary artery bypass grafting; TAP, tricuspid annuloplasty.

Surgical procedures

The operative data are shown in Table 1. The reconstruction procedures included resection and suturing for posterior leaflet prolapse (n = 174, 77%), chordal replacement for anterior leaflet prolapse (n = 63, 29%), and commissure fixation for commissure prolapse (n = 38, 17%). All (100%) of the patients underwent mitral ring annuloplasty using an Edwards prosthetic ring or band. A Cosgrove band (Edwards Lifesciences) was used in 146 (64%) patients, a Physio ring in 49 (22%) patients, and a Physio II ring in 32 (14%) patients. The inter-trigon distance was measured using the sizer provided by the manufacturer and a same-sized prosthesis was selected without down-sizing. A Physio or Physio II ring was selected in patients with anterior leaflet prolapse. In patients with isolated posterior leaflet prolapse, a Cosgrove band was usually selected, but a Physio or Physio II ring was occasionally selected according to the surgeon's preference. The prosthesis sizes used were 26 mm (n = 71, 31%), 28 mm (n = 87, 38%), 30 mm (n = 57, 25%), and 32 mm (n = 12, 5%).

Concomitant cardiac procedures included coronary artery bypass grafting in 12 (5%) patients, tricuspid annuloplasty in 33 (15%) patients, the Maze procedure in 55 (24%) patients, and other procedures in 9 patients.

Echocardiography

Echocardiography was performed preoperatively, postoperatively, and at follow-up (mean, 430 ± 260 days after surgery) in all of the patients. Using Doppler echocardiography, MI grades were classified as follows: 0: none, 1: trivial, 2: mild, 3: moderate, and 4: severe. A severe grade was designated when Doppler echocardiography detected MI of a central jet greater than 40% of the left atrial area or MI of a holosystolic eccentric jet, vena contracta more than 0.7 cm, regurgitant volume more than 60 mL, regurgitant fraction more than 50%, or effective regurgitant orifice more than 0.40 cm^2. Trivial, mild, and moderate degrees were graded by an expert engineer and expert doctor individually. Pressure half time was measured at follow-up echocardiography.

Cardiac function was assessed for each size of prosthesis, including residual MR, mean transmitral pressure gradient (mPG), left atrial diameter (LAD), and peak tricuspid regurgitant pressure gradient (TRPG). The LAD from the M-mode was measured by a parasternal short-axis image at the level of the aortic valve at ventricular end-systole. The TRPG was defined as right ventricular systolic pressure minus central venous pressure (systolic pulmonary artery pressure). Left ventricular mass was calculated using the Devereux formula and was indexed to BSA to yield the left ventricular mass index (LVMI) [14].

Definition of PPM

The mPG was measured by Doppler echocardiography postoperatively and at follow-up. When the mPG was elevated more than 5 mmHg at rest, we considered that these patients were affected by PPM for the mitral position in this study. The pressure half time was also measured at follow-up, and when pressure half time was longer than 100 ms, we considered that these patients were affected by PPM for the mitral position according to the literature [15].