Original Article

Does Patient-Prosthesis Mismatch Affect Long-term Results after Mitral Valve Replacement?

Hiroaki Sakamoto, MD, PhD, and Yasunori Watanabe, MD, PhD

Background: Recently, some articles about patient-prosthesis mismatch (PPM) of the mitral valve have been published. However, the outcome of PPM of the mitral valve remains controversial. The objective of this study was to determine the impact of mitral valve PPM on clinical results after mitral valve replacement (MVR).

Methods and Results: Eighty-four patients underwent MVR from 1992 to 2005. They were divided into a PPM group and a non-PPM group. Preoperative, perioperative, and postoperative variables were analyzed retrospectively. The indexed effective orifice area (IEOA) was provided by postoperative echocardiography and body surface area. PPM was defined as an IEOA of 1.2 cm^2/m^2 or less, and 25 patients had PPM. Thirty-day mortality was 0% in both groups. Postoperative pulmonary artery pressure and residual mitral valve pressure gradient had no significant differences. There was no significant difference in freedom from recurrence of heart failure or from cardiac death between the two groups.

Conclusion: The present study revealed that PPM does not affect the short- or long-term outcome after MVR. But the clinical result when the definition of PPM is made more severe, such as IEOA of 1.0 cm^2/m^2 or less, was not examined. Further research is required to establish the allowable range of IEOA. (Ann Thorac Cardiovasc Surg 2010; 16: 163–167)

Key words: patient prosthesis mismatch, mitral valve, heart failure

Patient-prosthesis mismatch (PPM) is a term that was used by Rahimtoola for the first time in 1978.[1] Currently, it is recognized that PPM is the condition in which the effective orifice area (EOA) of the prosthetic valve implanted in the patient does not match the area of the native valve, and the long-term survival rate and freedom rate from recurrence of heart failure worsens in PPM patients. Many reports about PPM have been described previously; however, nearly all of this research has focused on PPM of the aortic valve position. PPM of the aortic valve gets the most attention from surgeons.

From Department of Cardiovascular Surgery, Hitachi General Hospital, Hitachi, Ibaraki, Japan

Received December 4, 2009; accepted for publication March 3, 2009
Address reprint requests to Hiroaki Sakamoto, MD, PhD: Department of Cardiovascular Surgery, Hitachi General Hospital, 2–1–1, Jonan, Hitachi, Ibaraki, 317-0077, Japan.

Nevertheless, articles about PPM of the mitral valve have recently been published.[2-9] Some researchers described that in mitral valve PPM patients, the recurrence rate of heart failure is higher, survival rate is worse, and postoperative pulmonary artery pressure (PAP) is higher. In contrast is an article revealing that mitral valve PPM occurs less frequently and that smaller prosthesis has no affect on hemodynamic performance.[7]

The clinical results of PPM of the mitral valve remain controversial. The objective of this study was to determine the impact of mitral valve PPM on short- and long-term outcomes after mitral valve replacement (MVR).

Materials and Methods

Patient population

From January 1992 to December 2005, a total of 84 patients underwent MVR with cardiopulmonary bypass through median sternotomy at the Hitachi General Hospital.

Concomitant aortic valve surgery was excluded from this study. Concomitant tricuspid annuloplasty (TAP), coronary artery bypass graft (CABG), and the history of previous cardiac surgery, including CABG and all valve surgery, were included. Patient data were collected and analyzed retrospectively. The patients were divided into two groups: PPM and non-PPM. Preoperative, perioperative, and late results were compared between these two groups.

At our institution, we routinely select Carbomedics (Sorin Biomedica, Via Crescentino, Italy) for work concerning mechanical valves and Carpentier-Edwards Perimount (Edwards Lifesciences, Irvine, Calif.) (CEP) for the bioprosthesis valve.

Definition of PPM

Both the geometric orifice area (GOA) provided by the manufacturer and the EOA measured in vivo were indexers of the prosthesis valve area. In this study, we used EOA to identify PPM. In a previous report, the indexed EOA (IEOA) was the independent predictor of postoperative mortality in univariate and multivariate analyses, but the indexed GOA (IGOA) and label prosthesis sizes were not significantly associated with higher mortality on univariate or multivariate analysis.[3] All of our 84 patients underwent an echocardiographic examination at our institution 1 year after MVR. At that time, mitral valve EOA (cm^2) was determined by the pressure half-time method. IEOA (cm^2/m^2) was obtained by dividing the EOA by the patient's calculated body surface area (m^2). PPM was defined as an IEOA of 1.2 cm^2/m^2 or less as suggested in a previous study.[2]

Follow-up

All patients had IEOA calculated 1 year after MVR. Moreover, 44 patients (52%) had systolic PAP measured by echocardiogram 1 year after MVR. Right ventricular systolic pressure (RVSP) was assessed with continuous wave Doppler. The maximum peak tricuspid regurgitation velocity (V) was used to calculate RVSP with this equation, $RVSP = 4V^2$ + right atrial pressure, with right atrial pressure assumed to be 10 mmHg. Systolic PAP was assumed equal to RVSP in the absence of pulmonary stenosis. Follow-up data on the clinical course and functional status of survivors were collected from the clinical and outpatient records. If this approach was not feasible, we performed a telephone questionnaire. In total, 81 patients (96%) were followed up completely. The mean follow-up was 102 ± 47 months (range 22–78 months).

Statistical methods

Continuous variables are presented as mean ± standard deviation. Categorical data were described by using percentages. Differences between PPM and non-PPM for preoperative, perioperative, and postoperative variables were compared for statistical significance by t-test, χ^2 test, or one-way ANOVA, as appropriate. Time-related changes in freedom from recurrence of congestive heart failure (CHF) and from cardiac death were analyzed with the Kaplan-Meier method and compared with the log-rank test. All analyses were performed using the SPSS statistical software version 11.0 for windows (SPSS Inc., Chicago, Ill.). A ρ value of less than 0.05 was considered statistically significant.

Results

Preoperative and perioperative data

Twenty-five of all patients (30%) had PPM defined as an IEOA of 1.2 cm^2/m^2 or less, and 59 patients (70%) had no significant PPM. Preoperative and perioperative patient characteristics are shown in Tables 1 and 2. Statistical analyses showed that the PPM group contained significantly more males, the body surface area was larger, and the prevalence of preoperative atrial fibrillation was less than in the non-PPM group. As for mitral lesions, PPM had more regurgitation and less stenosis than non-PPM did. There was no significant difference in the use frequency of the bioprosthetic valve or in the use frequency of each size of the prosthesis valve between these two groups. Further, there was no significant difference in the rate of the concomitant CABG and concomitant TAP. Thirty-day mortality was 0% in both groups.

Outcome

Postoperative pulmonary hypertension

We could measure the postoperative transmitral pressure gradient in 19 patients (76%) in PPM and in 43 patients (73%) in non-PPM by echocardiography. There was no significant difference between PPM and non-PPM (12.1 ± 2.86 vs. 11.8 ± 5.26) (Fig. 1). The postoperative transmitral pressure gradient of each valve size is shown in Fig. 2. There is no significant difference among any of the sizes from 25 to 31 mm with the residual maximum pressure gradient. But two patients who each had a 23-mm valve implanted had a high pressure gradient of 20.1 ± 3.46 mmHg.

Table 1. Preoperative patient characteristics

	PPM (n = 25, 30%) IEOA ≤ 1.2 cm^2/m^2	Non PPM (n = 59, 70%) IEOA > 1.2 cm^2/m^2	P Value
Age	57.0 ± 10.8	60.4 ± 10.9	NS
Male	18(72%)	18(30%)	0.001
Mitral lesion			
Regurgitation	19(76%)	25(42%)	0.008
Stenosis	4(16%)	24(41%)	0.042
Mixed dysfunction	2(8%)	7(12%)	NS
Valve dysfunction origin			NS
Myxomatous	9(36%)	28(42%)	
Rheumatic	3(12%)	13(22%)	
Calcification	2(8%)	7(12%)	
Endocarditis	4(16%)	3(5%)	
Prolapse	3(12%)	4(7%)	
Prosthesis dysfunction	3(12%)	2(3%)	
NHYA ≥ 3,4	4(16%)	8(14%)	NS
Body surface area (m^2)	1.65 ± 0.15	1.49 ± 0.14	<0.001
Coronary artery disease	2(9%)	6(11%)	NS
Hypertension	5(20%)	15(25%)	NS
Hyperlipidemia	3(12%)	13(22%)	NS
COPD	6(32%)	11(20%)	NS
Diabetes mellitus	1(4%)	6(10%)	NS
Renal failure	0(0%)	2(2%)	NS
Atrial fibrillation	11(44%)	42(71%)	0.026
Cerebrovascular disease	7(28%)	15(25%)	NS
Previous cardiac surgery	6(24%)	11(19%)	NS
CTR (%)	57.6 ± 9.1	58.2 ± 10.4	NS
Preoperative catheterization			
SPAP (mmHg)	46.0 ± 14.4	39.7 ± 14.2	NS
PCWP (mmHg)	20.2 ± 9.4	18.0 ± 7.9	NS
CI (l/min/m^2)	2.08 ± 1.2	2.04 ± 1.2	NS
Preoperative echocardiography			
EF (%)	64.4 ± 13.1	64.8 ± 10.6	NS
SPAP (mmHg)	40.2 ± 11.0	45.1 ± 20.4	

PPM, patient-prosthesis mismatch; IEOA, indexed effective orifice area; COPD, chronic obstructive lung disease; CTR, cardiothoracic ratio; SPAP, systolic pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure; CI, cardiac index; EF, ejection fraction.

Table 2. Perioperative variables

	PPM (n = 25, 30%) IEOA ≤ 1.2 cm^2/m^2	Non PPM (n = 59, 70%) IEOA > 1.2 cm^2/m^2	P Value
Bioprosthesis	3(12%)	6(10%)	NS
Prosthesis size			NS
23	1(4%)	1(2%)	
25	2(8%)	8(14%)	
27	7(28%)	26(44%)	
29	7(28%)	15(25%)	
31	8(32%)	9(15%)	
Concomitant CABG	1(4%)	3(5%)	NS
Concomitant TAP	6(24%)	10(17%)	NS
IEOA (cm^2/m^2)	1.04 ± 0.09	1.75 ± 0.44	<0.001
OPE time (min)	410 ± 112	402 ± 97	NS
CPB time (min)	217 ± 38	219 ± 37	NS
ACC time (min)	147 ± 34	149 ± 32	NS
PaO2/FiO2	283 ± 125	310 ± 120	NS
Ventilation (hour)	19.3 ± 27.2	19.6 ± 23.4	NS
ICU stay (day)	5.3 ± 1.7	5.0 ± 2.2	NS

PPM, patient-prosthesis mismatch; IEOA, indexed effective orifice area; CABG, coronary artery bypass graft; TAP, tricuspid annuloplasty; OPE, operation; CPB, cardiopulmonary bypass; ACC, aortic cross-clamp; ICU, intensive care unit.

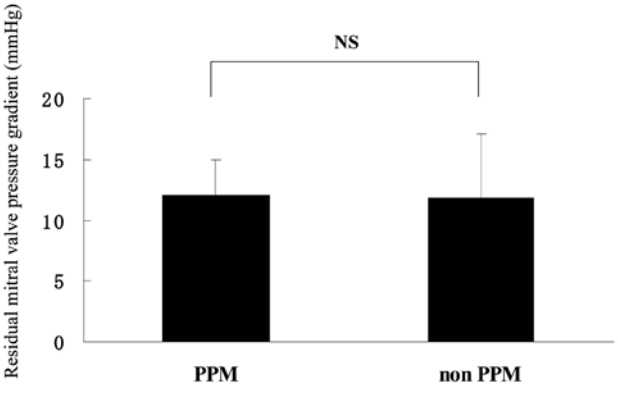

Fig. 1. Postoperative residual mitral valve pressure gradient between PPM and non-PPM.
There is no significant difference between PPM and non-PPM.

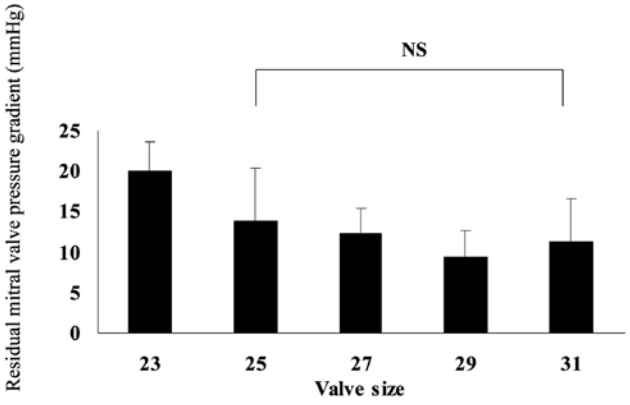

Fig. 2. Postoperative residual mitral valve pressure gradient of each valve size.
The pressure gradient of a 23-mm valve is higher than the other size. But there is no significant difference among each valve size from 25 to 31 mm.

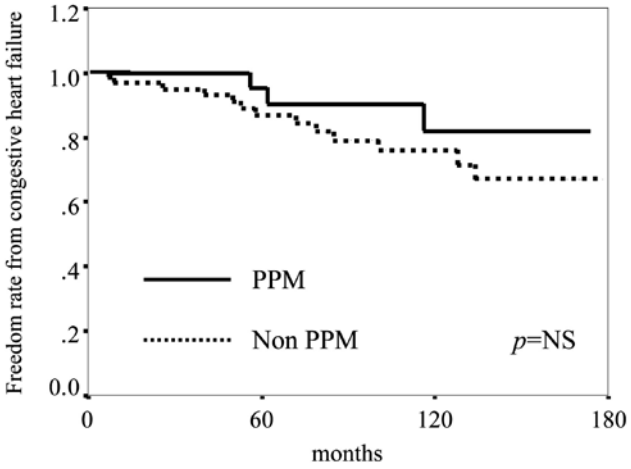

Fig. 3. Freedom rate from recurrence of congestive heart failure. There is no significant difference in freedom of congestive heart failure between PPM and non-PPM.

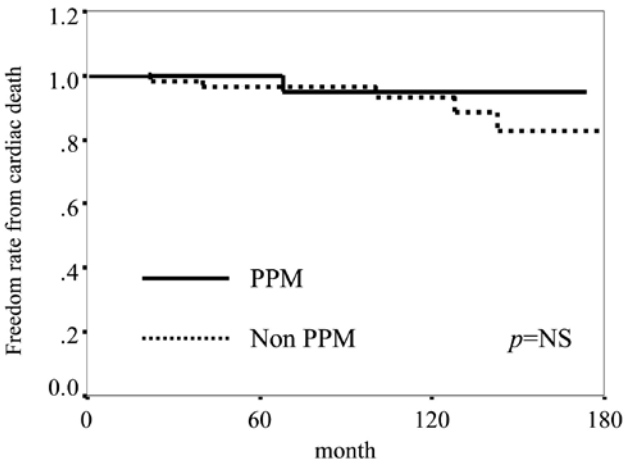

Fig. 4. Freedom rate from cardiac death. There is no significant difference in freedom of cardiac death between PPM and non-PPM.

Recurrence of congestive heart failure

In this study, a recurrence of CHF was defined as a condition that required hospitalization for more than 7 days. It occurred in 3 patients (12%) in PPM and in 13 (22%) in non-PPM. The overall freedom from recurrence of CHF at 5, 10, and 14 years was 95%, 82%, and 82% in PPM, and 86%, 76%, and 67% in non-PPM. The log-rank test revealed no significant difference in freedom of CHF between these two groups (Fig. 3).

Late survival

During follow-up, we had one cardiac death patient in PPM and five in non-PPM. The overall freedom from cardiac death at 5, 10, and 14 years was, respectively, 100%, 95%, and 95% in PPM and 96%, 93%, and 82% in non-PPM. The log-rank test revealed no significant difference between the two groups (Fig. 4).

Discussion

Rahimtoola and colleagues also reported the first case of PPM of the mitral valve in 1981, so this concept is not new.[8] PPM of the mitral valve received less attention and was not really investigated. In recent years, however, some reports about PPM of the mitral valve have been reported.[2-9] Here we report on the late outcomes of PPM of the mitral valve in Japanese. Our paper could be used as a reference in the future as data for Asian adults; most previous reports are from Europe and North America.

As for the preoperative factor, PPM has a significantly larger body surface area (BSA) and occurs more in males. There is more PPM in males than in females because the body surface area of males is generally greater than in females.

As for perioperative factors, there is no significant difference between two groups in simultaneous CABG, simultaneous TAP, operation time, postoperative ventilation time, and intensive care unit stay. Moreover, 30-day mortality was 0% in both groups. These data suggest that there is no significant difference between the two groups with regard to short-term outcome.

Concerning the size of the prosthetic valve, Magne and colleagues described that the use frequency of equal to or less than 27 mm is more in PPM.[3] However, in our data there was no significant difference between the two groups in the use frequency of each size of 23, 25, 27, 29, and 31 mm. Twenty-two patients (88%) in PPM had the large prosthetic valve (27 to 31 mm) implanted, but the IEOA of PPM was quite small, 1.04 cm^2/m^2. We considered this reason related to the significantly large BSA, 1.65 m^2, of the PPM group. Lam and colleagues reported that many PPMs occurred in patients who had bioprosthetic valves implanted[4], but in our cases there is no significant difference between the two groups in the use of bioprosthetic valves. We routinely use CEPs for bioprosthetic valves. The sewing-cuff diameter of CEP is bigger than equal-sized Carbomedics. Moreover, thr EOA of CEP provided by the manufacturer is smaller than Carbomedics. There is a possibility that PPM occurs more easily in patients with CEP than in Carbomedics. However, the

reason there was no significant difference in the use frequency of the CEP between the two groups in our research is because the low usage rate of CEP, 11% of all patients, may be related.

Some previous articles described that the postoperative PAP in the PPM group was higher than in the non-PPM.[2,3] In our research, the postoperative PAP, which was estimated from echocardiogram data, had no significant difference between two groups. But we must consider that patients whose PAP could be measured 1 year after the operation totaled only about 50% of all patients.

Regarding the postoperative residual mitral valve pressure gradient, Magne and Li reported that the pressure gradient was higher in the PPM group,[2,3] but Totaro and colleagues reported no difference among each size of the prosthetic valves.[7] In our echocardiogram data, there was no significant difference between two groups with the residual pressure gradient. As for each valve size, we used a Carbomedics 23-mm valve in two patients, and the average of the maximum residual pressure gradient of these cases was calculated at 20 mmHg, which was high. If these two 23-mm cases are excluded from the statistical analysis, there is no significant difference among any of the sizes from 25 to 31 mm with the residual maximum pressure gradient. These results may support Totaro's report.[7]

In regard to the late outcome, some papers reported that the recurrence rate of heart failure was higher and the late survival rate lower in the PPM group than in the non-PPM group[3,4,6]; in our research, however, neither item had significant difference between the two groups.

The outcome when the definition of PPM is made more severe, such as an IEOA of 1.0 cm^2/m^2 or less, was not examined. The exercise test to evaluate hemodynamics was not performed. We should accumulate more data, and further detailed research, including exercise tests, is required.

Nevertheless, the present study demonstrated that PPM defined as an IEOA of 1.2 cm^2/m^2 or less does not affect the short- or long-term outcomes after MVRs in our patients.

References

1. Rahimtoola SH. The problem of valve prosthesis-patient mismatch. *Circulation* 1978; **58**: 20–4.
2. Li M, Dumesnil JG, Mathieu P, Pibarot P. Impact of valve prosthesis-patient mismatch on pulmonary arterial pressure after mitral valve replacement. *J Am Coll Cardiol* 2005; **45**: 1034–40.
3. Magne J, Mathieu P, Dumesnil JG, Tanné D, Dagenais F, et al. Impact of prosthesis-patient mismatch on survival after mitral valve replacement. *Circulation* 2007; **115**: 1417–25.
4. Lam BK, Chan V, Hendry P, Ruel M, Masters R, et al. The impact of patient-prosthesis mismatch on late outcomes after mitral valve replacement. *J Thorac Cardiovasc Surg* 2007; **133**: 1464–73.
5. Masuda M, Kado H, Tatewaki H, Shiokawa Y, Yasui H. Late results after mitral valve replacement with bileaflet mechanical prosthesis in children: evaluation of prosthesis-patient mismatch. *Ann Thorac Surg* 2004; **77**: 913–7.
6. Yazdanbakhsh AP, van den Brink RB, Dekker E, de Mol BA. Small valve area index: its influence on early mortality after mitral valve replacement. *Eur J Cardiothorac Surg* 2000; **17**: 222–7.
7. Totaro P, Argano V. Patient-prosthesis mismatch after mitral valve replacement: myth or reality? *J Thorac Cardiovasc Surg* 2007; **134**: 697–701.
8. Rahimtoola SH, Murphy E. Valve prosthesis--patient mismatch. A long-term sequela. *Br Heart J* 1981; **45**: 331–5.
9. Ruel M, Rubens FD, Masters RG, Pipe AL, Bédard P, et al. Late incidence and predictors of persistent or recurrent heart failure in patients with mitral prosthetic valves. *J Thorac Cardiovasc Surg* 2004; **128**: 278–83.