The Effect of Patient Prosthesis Mismatch on Functional Mitral Regurgitation in Patients with Mechanical Aortic Valve Replacement

Mehmet Emir Erol[1], Sertan Özyalçın[2], Sinan Sabit Kocabeyoğlu[2], Kerem Vural[2]

[1] University of Marmara, Faculty of Medicine, Department of Cardiovascular Surgery, Istanbul, Turkey
[2] Turkey High Specialty Training and Research Hospital, Department of Cardiovascular Surgery, Ankara, Turkey

ABSTRACT

Introduction: The aim of this study was to investigate the effects of patient prosthesis mismatch on functional mitral regurgitation after mechanical aortic valve replacement.

Patients and Methods: Total 59 patients were enrolled. All the echocardiographic assessments were performed by a single cardiologist. The patients were divided into two subgroups as per the presence of patient prosthesis mismatch. Group 1 comprised patients with mismatch, and group 2 included those without mismatch.

Results: There were no significant differences between the two groups in terms of postoperative mitral regurgitation development, postoperative left ventricular mass regression, postoperative pulmonary arterial pressure, and postoperative functional capacity.

Conclusion: Patient prosthesis mismatch is not a predictive factor for the development of functional mitral regurgitation after mechanical aortic valve replacement.

Key Words: Aortic valve stenosis; heart valve diseases; mitral insufficiency

Mekanik Aort Kapak Replasmanı Yapılan Hastalarda Hasta Kapak Uyumsuzluğunun Fonksiyonel Mitral Yetmezliğine Etkileri

ÖZET

Giriş: Bu çalışmanın amacı, hasta protez uyumsuzluğunun mekanik aort kapak replasmanı sonrası fonksiyonel mitral yetersizliği üzerine etkilerini araştırmaktır.

Hastalar ve Yöntem: Çalışmaya 59 hasta dahil edildi. Tüm ekokardiyografik değerlendirmeler tek bir kardiyolog tarafından yapıldı. Hastalar, hasta kapak uyumsuzluğunun varlığına göre iki alt gruba ayrıldı. Grup 1, uyumsuzluğu olan hastalardan oluşurken, kalan hastalar uyumsuzluğu olmayan grup 2'yi oluşturdu.

Bulgular: Postoperatif mitral yetmezlik gelişimi, postoperatif sol ventrikül kitle regresyonu, postoperatif pulmoner arter basıncı ve postoperatif fonksiyonel kapasite açısından iki grup arasında anlamlı fark yoktu.

Sonuç: Hasta protez uyumsuzluğu, fonksiyonel mitral yetmezlik gelişimi için mekanik aort kapak replasmanı sonrası öngörücü bir faktör değildir.

Anahtar Kelimeler: Aort kapak darlığı; kalp kapak hastalıkları; mitral yetmezlik

INTRODUCTION

Aortic valve replacement is the gold standard treatment for aortic stenosis with acceptable mortality and morbidity[1]. Several studies have shown that aortic valve replacement improves the postoperative cardiac function and clinical status[2]. Depending on the severity of the underlying pathology and anatomic differences, optimal valve replacement may not be possible for each patient at each instance; therefore, the short-term and long-term results of the surgical procedure and symptom reduction may not be observed. Thus, the "patient prosthesis mismatch (PPM)" hypothesis has been described[3,4]. PPM acts as a residual aortic stenosis in the postoperative period, causing intraventricular pressure overload and ventricular hypertrophy. In aortic stenosis, due to pressure overload and remodeling, functional mitral valve regurgitation (FMR) can coexist[1]. The treatment of patients with FMR in aortic ste-

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Correspondence

Mehmet Emir Erol

E-mail: erolm91@gmail.com
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nosis remains controversial; some authors have recommended concomitant valve replacement, while others have recommended the observation of FMR[1].

The goal of this study was to evaluate the effect of PPM on FMR after isolated mechanical aortic valve replacement for aortic stenosis. We retrospectively collected data from 189 patients who had undergone aortic valve replacement for aortic stenosis from January 2007 to June 2013; patients with concomitant surgical procedures were excluded. The remaining 59 patients were examined for their functional status, left ventricular mass regression, functional mitral regurgitation, PPM, and left atrial diameter.

PATIENTS and METHODS

Ethics committee approval was received for this study from the Turkey High Specialized Training and Research Hospital Educational Planning Council (Decision Number: 314; Decision Date: February 6, 2014).

From January 2007 to June 2013, 189 patients underwent isolated AVR for aortic stenosis. Preoperative and postoperative data of these patients were reviewed. In addition to aortic valve replacement, patients with supracoronary graft interposition, coronary artery bypass grafting, or intervention in other valves were excluded from the study to enable accurate assessment of FMR. Total 59 patients who met the inclusion criteria were followed up routinely after the operation. A single cardiologist performed postoperative transthoracic echocardiography for all the patients. EOA was calculated according to hydraulic equation ($TPG= Q^2/[k \times EOA^2]$; TPG is transvalvular pressure gradient, Q is transvalvular current and k is constant value), and effective orifice area index (EOAI) was obtained by dividing the EOA as per the body surface area[7]. Valve prosthesis-patient mismatch was determined in 19 of the 89 patients as per the EOAI (EOAI < 0.85/m^2 body surface area) (Group 1). In the other 40 patients, prosthesis-patient mismatch was not determined as per this criterion (Group 2). We compared the FMR, left ventricular mass regression, postoperative pulmonary hypertension, postoperative left atrial diameter, and postoperative functional capacities of the patients.

Echocardiographic Evaluation

For the follow-up, transthoracic echocardiography (Vivid 7 Dimension, GE Medical Systems, Horten, Norway) was performed for all patients by a single operator using a 2.5-3.5 MHz transducer. Standard M-mode measurements were made as per the recommendations of the American Society of Echocardiography. Left ventricular regional wall movements were analyzed according to the 17 segment model. The ejection fraction was calculated in two modified apical (2 and 4 chamber) images using the modified Simpson method. Aortic valve prosthesis was evaluated in apical four-chamber images. The left ventricular mass was calculated using the Devereux formula. The definition of FMR was based on the absence of organic pathology in the mitral annulus, leaflets, and papillary muscles[3].

Statistical Analyses

Statistical analysis was performed using a suitably and commercially available software package. Continuous variables are expressed as mean ± standard deviation values. Categorical variables are presented as frequency percentiles. The homogeneity between the groups was assessed using compliance tests. The statistical difference between the groups was analyzed using Student's t-test for continuous variables and chi-square test for categorical data. A p value < 0.05 was considered statistically significant.

RESULTS

The demographic data of the patients are shown in Table 1. According to this table, there was a difference between the groups in terms of the ejection fractions (p= 0.007) and Effect, vs. Orifice Area Index (p= 0.001). There was no statistically significant difference in terms of age, sex, and other preoperative variables.

Operative data of the patients is presented in Table 2. There was a significant difference (p= 0.03) between groups 1 and 2 in terms of aortic cross clamp times, but there was no difference in cardiopulmonary bypass time and valve size use in surgery.

Postoperative data of the patients are presented in Table 3. When the postoperative data of the groups were compared, the functional capacity was found to have improved in both the groups, and there was no significant difference between the groups (p= 0.78). There was no difference in the left ventricular mass regression, pulmonary artery pressure change, and diastolic functions of the two groups.

DISCUSSION

Aortic valve replacement is the preferred treatment option for severe aortic valve disease patients with low or intermediate surgical risk from the time it was first performed by McGoin at Mayo Clinic in 1961[1]. In heterogeneous patient groups, after aortic valve replacement, the 5-year survival rate is 75%, the 10-year survival rate is 60%, and the 15-year survival rate is about 40%[2]. Long-term survival after AVR for aortic stenosis depends on the timing of the surgery and the natural course of the disease. Except for few selected patients who did not qualify for repair in case of aortic valves, better hemodynamic profiles of prosthetic valves today and low reoperations rates after prosthetic valve replacement make AVR the preferred treatment option[2]. Some clinical situations that can be seen after aortic valve replacement limit the beneficial effects of this

Table 1. Comparison of the preoperative data of the groups

	Total (n= 59)	Group 1 (n= 19)	Group 2 (n= 40)	p
Length of follow-up (month)	38.1 ± 28.6	37.5 ± 29.4	38.4 ± 28.5	0.75
Age (year)	61.6 ± 12.2	63.2 ± 11.7	60.9 ± 12.5	0.22
Sex (male)	41 (32%)	23 (39%)	18 (26%)	0.08
EF (%)	56.1 ± 12.8	62.9 ± 5.3	53.0 ± 14.1	0.007
LVEDD(mm)	49.8 ± 5.4	48.9 ± 5.1	50.2 ± 5.6	0.1
LVESD(mm)	34.3 ± 4.9	32.3 ± 4.9	35.2 ± 6.8	0.38
SPAB (mmHg)	27.8 ± 5.0	27.1 ± 4.7	28.2 ± 5.1	0.43
EOAI (cm^2/m^2)	0.84 ± 0.15	0.72 ± 0.22	0.90 ± 0.46	0.001
Preoperative NYHA-2	19	8	9	0.13
Preoperative NYHA-3	40	11	31	
Preoperative 0 MR	34	14	20	0.06
Preoperative 1 MR	20	3	17	
Preoperative 0 TR	42	15	27	0.54
Preoperative 1 TR	17	4	13	

Group 1: Patients with PPM; Group 2: Patients without PPM. EOAI: Effective orifice area index, EF: Ejection Fraction, LVEDD: End-diastolic diameter of left ventricle, LVESD: End-systolic diameter of left ventricle, SPAB: Systolic pulmonary artery pressure, NYHA: New York Heart Association functional capacity class, MR: Mitral regurgitation, TR: Tricuspid insufficiency.

Table 2. Comparison of the operative data of the groups

	Group 1 (n= 19)	Group 2 (n= 40)	p
CPB duration	89.3 ± 11.7	92.9 ± 11.7	0.27
Cross clamp time	65.4 ± 5.8	71.3 ± 10.9	0.03
Valve No 21	13	20	0.43
Valve No 23	5	17	
Valve No 25	1	3	

CPB: Cardiopulmonary bypass.

Table 3. Comparison of the postoperative data of the groups

	Group 1 (n= 19)	Group 2 (n= 40)	p
Postoperative MR development	13	31	1
Postoperative NYHA 0	0	1	0.78
Postoperative NYHA 1	10	20	
Postoperative NYHA 2	9	19	
Left ventricular mass regression (%)	20.9 ± 6.6	21.6 ± 10.2	0.8
SPAB change (%)	18.8 ± 24.1	24.1 ± 26.7	0.46

NYHA: New York Heart Association functional capacity class, MY: Mitral regurgitation, SPAB: Systolic pulmonary artery pressure.

treatment option. PPM and FMR are the main causes of these undesirable clinical conditions.

FMR associated with aortic valve disease is often mild and does not require surgical treatment. However, in patients with moderate to severe FMR, there is currently no clear consensus or guidelines for treatment. Increased afterload and left ventricular remodeling in aortic stenosis may be the cause of FMR, and the severity of mitral regurgitation is related to the transaortic pressure gradient[3]. In this clinical table, the mitral valve is morphologically normal. Previous studies have shown that FMR declines after AVR[4]. However, recent studies have shown that left untreated, FMR reduces survival, decreases functional capacity, and impairs the quality of life in the postoperative period[5]. In the same studies, it was also shown that FMR did not decrease after AVR, increased in some patients; further, patients with increased FMR after AVR showed low long-term survival and high need for second operation[6]. Untreated FMR during AVR has been shown to reduce late-stage survival[1,5]. In our study, mortality was not investigated, and no sign of poor life quality was detected in group 1.

After the AVR, the effective orifice area of the replanted valve smaller than the body surface area of the patient results in PPM. Two hemodynamic states that are confronted by prosthesis-patient mismatch (PPM) prevent FMR retraction. The first one of the hemodynamic states is increased transaortic pressure, and the second one is the deterioration of left ventricular remodeling due to increased left ventricular pressure and persistence of FMR due to impaired left ventricular geometry[7]. In the literature, few studies have compared PPM with FMR. Angeloni et al showed that FMR regression decreases in patients with PPM in the postoperative period, functional capacity worsens, and these findings are independent of the preoperative and postoperative variables[8]. In our study, there was a statistically difference in the EOAI of the groups (p= 0.001); however, this result was not associated with FMR development. Moreover, it was determined that functional capacity improved in the both groups postoperatively (p= 0.001). However, there was no significant difference in the improvement in the functional capacity of the groups (p= 0.78).

One of the most important physiologic benefits of AVR for aortic stenosis is decreased gradient in the left ventricular outflow tract and restenosis with increased left ventricular mass. These beneficial effects are expected to improve the functional capacity and reduce the symptoms during the postoperative period[9]. Owing to PPM, the residual gradient in left ventricular outflow tract obstructs left ventricular mass retraction[8]. PPM is defined as a situation wherein EOAI of a prosthetic valve measured in vivo after aortic valve replacement is < 0.85 cm^2/m^2[11]. A value < 0.65 cm^2/m^2 indicates severe/strong PPM. In most studies, the presence of PPM was associated with lower long-term survival after AVR, decreased exercise capacity, and a lack of adequate symptom relief[9,12-14]. The same studies have shown that PPM is closely related to the first year of survival[12]. This has been interpreted as a consequence of the response of the ventricle with increased sensitivity to postoperative high hemodynamic resistances. However, in other studies, PPM reportedly has no effect on survival[13]. In studies that have shown that PPM is not associated with long-term survival, long-term survival was more closely associated with left ventricular hypertrophy regression[9]. In our study, left ventricular mass regression was detected as 20.9% ± 6.6% in group 1 and 21.6% ± 10.2% in group 2. There was no difference in the left ventricular mass regression between the two groups (p= 0.8). This result may be due to the relatively lower sample size, absence of severe PPM in the studied population (EOAI < 0.65 cm^2/m^2), and nonuniform distribution of the follow-up duration in the groups. In addition, aortic cross clamp time in our study was significantly shorter in group 1 than in group 2 (p= 0.03). In group 1, wherein patients with PPM were grouped, shorter cross clamp time may demonstrate that the aortic dilatation techniques and other approaches that allow the selection of the prosthesis at the optimal size during the operation are not used sufficiently.

In conclusion, because of the pathophysiology of aortic valve diseases, factors affecting the recovery of left ventricular pathologic changes after AVR affect the postoperative survival and functional capacity. PPM, a leading factor, adversely affects early-stage survival and left ventricular mass regression. As per our literature review, the use of the most appropriate prosthesis for the patient's BSA improves the early and late results by preventing PPM. None of our study subjects had severe PPM. This situation is expected to affect our findings. This could be due to the nature of our clinical practice and the physical structure of the Turkish community. In our study, 74% of patients had mitral regurgitation. No significant relationship was found between PPM and the development of mitral regurgitation because FMR is a pathology that occurs during the preoperative period and may occasionally regress postoperatively.

Limitations of the Study

Our clinic caters to the national population, and there are important obstacles involved in the patients to come to the postoperative controls, the number of patients whose data could be analyzed was relatively low. In addition, no patients had severe PPM in our series because the importance of prosthesis–patient mismatch in aortic valve is known.

CONCLUSION

PPM and FMR that can be seen after aortic valve replacement may mask the beneficial effects of AVR. In order to prevent this consequence, during the operation, the development of FMR can be blocked by preventing PPM with the replenishment of the cover at the optimal size for BSA of the patient. Further research on this subject is needed on more subjects with severe PPM for a deeper understanding of the subject.

Ethics Committee Approval: Ethics committee approval was received for this study from the Turkey High Specialized Training and Research Hospital Educational Planning Council (Decision Number: 314; Decision Date: February 6, 2014).

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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Author Contributions: Concept/Design – MEE, KV; Analysis/Interpretation – SÖ; Data Collection – MEE; Writing – MEE; Critical Revision – KV, SSK; Final Approval – KV; Statistical Analysis – SÖ; Overall Responsibility - MEE

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