Evaluation of hemodynamic changes in patients with mitral valve replacement using dobutamine stress echocardiography

Mitral kapak replasmanı yapılan hastalarda dobutamin stres ekokardiyografi ile hemodinamik değişikliklerin değerlendirilmesi

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ABSTRACT

Objective: The aim of this study was to investigate the response of heart to stress according to the size of the prosthetic valve in patients who had undergone mitral valve replacement by using dobutamine stress echocardiography (DSE) and to evaluate the relationship between the size of the prosthetic valve and cardiac recovery-remodeling process.

Methods: Thirty-nine patients, who had undergone mitral valve replacement were compared in terms of left ventricular diameters, systolic functions and cardiac mass indexes in order to investigate the effect of the mechanical valve size on postoperative cardiac remodeling in this longitudinal study. They were divided into three groups according to their valve size: Group 1 (valve size<29 mm, n=11), Group 2 (valve size=29 mm, n=11) and Group 3 (valve size>29 mm, n=17). Statistical analysis was performed using Chi-square and one-way ANOVA tests to determine the statistical differences between the groups. The repeated measurements of two-way ANOVA test was used to analyze effects during long-term follow-up.

Results: Only Group 1 patients achieved a significant decrease in terms of left ventricular mass index and end-diastolic diameter (138.3±29.7 g/m^2 vs 86.6±15.6 g/m^2 and 5.1±0.5 cm vs. 4.4±0.4 cm, $p<0.05$). Group 3 patients' left ventricular ejection fraction become worse after the operation (64.0±5.6% vs. 55.9±6.5%, $p<0.05$). Maximum and mean pressure gradients across the mitral prosthesis as well as pulmonary artery pressure were significantly increased in all groups during DSE. Maximum gradients increased from 14.2±4.6 to 20.7±7.5 mmHg in Group 1 ($p<0.05$), 11.6±4.7 to 16.2±6.8 mmHg in Group 2 ($p<0.05$), and 10.6±3.1 to 20.8±12.7 mmHg in Group 3 ($p<0.05$). Isovolumic relaxation time decreased in all groups following the dobutamine infusion, as expected, but this decline was not significant in Group 3.

Conclusion: A worsening in left ventricular systolic function was observed in large- sized valve prosthesis group. Only the patients who had undergone MVR with small-sized valve prosthesis achieved a decrease in cardiac mass index and preservation of the systolic function. The echocardiographically determined differences and mass index that appeared after the operation may point out that, the effect of the operation on cardiac remodeling can be related with the ventricular size. *(Anadolu Kardiyol Derg 2007; 7: 397-403)*

Key words: Dobutamine stress echocardiography, mitral valve replacement, ventricular remodeling

ÖZET

Amaç: Bu longitüdinal çalışmada, mitral kapak replasmanı yapılan hastalarda prostetik kapak çaplarının kardiyak strese cevabı ve cerrahiyi takiben kapak çapının iyileşme-yeniden yapılanma üzerine etkilerinin araştırılması planlanmıştır.

Yöntemler: Mitral kapak replasmanı yapılan 39 hasta, mekanik kapak çapının postoperatif kardiyak yeniden yapılanma üzerine etkisinin araştırılması amacı ile ventrikül çapları, sistolik fonksiyonları ve kardiyak kitle indeksleri açısından karşılaştırılmıştır. Hastalar protez kapak çapına göre 3 gruba ayrılmıştır. Grup 1- kapak çapı 29 numaranın altı hastaları (n=11), Grup 2- 29 numara olan hastaları (n=11) ve Grup 3- kapak çapı 29 numaranın üstünde olan hastaları içermektedir (n=17). İstatistiksel analiz için Ki-kare ve ANOVA testleri kullanılmıştır.

Bulgular: Sadece Grup 1'deki hastalarda sol ventrikül kitle indeksi ve diyastol sonu çapında istatistiksel açıdan anlamlı azalma tespit edilmiştir (138.3±29.7 gm/^{2} ile 86.6±15.6 g/m^2 ve 5.1±0.5 cm ile 4.4±0.4 cm, $p<0.05$). Grup 3'deki hastalar da sol ventrikül ejeksiyon fraksiyonu cerrahiyi takiben gerilemiştir (64.0±5.6% ile 55.9±6.5%, $p<0.05$). Dobutamin stres ekokardiyografi sırasında, mitral protez kapak maksimum ve ortalama gradiyentleri ve pulmoner arter basınçları önemli miktarda artmıştır. Maksimum gradiyent Grup 1'de 14.2±4.6'dan 20.7±7.5 mmHg'ya ($p<0.05$), Grup 2'de 11.6±4.7'dan 16.2±6.8 mmHg'ya ($p<0.05$) ve Grup 3'de 10.6±3.1'dan 20.8±12.7 mmHg'ya ($p<0.05$) yükselmiştir. İzovolümik relaksasyon zamanı dobutamin infüzyonunu takiben tüm gruplarda azalmıştır, ancak bu azalma 3. grupta anlamlı değildir.

Sonuç: Büyük çaplı kalp kapak protezi taşıyan grupta mitral kapak replasmanını takiben sol ventrikül sistolik fonksiyonlarında bozulma görülmektedir. Sadece küçük çaplı protez ile replasman yapılan grupta kardiyak kitle indeksinde azalma saptanmış ve sistolik fonksiyonlar korunmuştur. Cerrahiden sonra yapılan ekokardiyografi ile tespit edilen kitle indeks ve sistolik-diyastolik fonksiyon değişiklikleri, kullanılan kapak çaplarının kardiyak yeniden yapılanma üzerine etkilerinin olabileceği yönde olmuştur. *(Anadolu Kardiyol Derg 2007; 7: 397-403)*

Anahtar kelimeler: Dobutamin stres ekokardiyografi, mitral kapak replasmanı, ventriküler yeniden yapılandırma

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Introduction

Rheumatic heart valve disease remains to be a serious problem for cardiac surgery, especially in developing countries. Technological developments in the cardiac prosthetic valves and the improvements in surgical techniques led to a noticeable decline in operative mortality and morbidity. Furthermore, the exercise capacity after mechanical valve replacement depends on the myocardial status before the operation, the degree of the myocardial damage occurred before or after the operation, the ability of the mechanical prosthesis to establish the normal valve function and the appropriateness of the valve size for patient's body-surface area (1). The most important indicators of a patient's post-operative functional status are the subjective recovery of the patient, the hemodynamic state at rest and during exercise and the systolic and diastolic ventricular function (2). Determining the hemodynamic effects of prosthetic valves according to the valve size, therefore, plays an important role in evaluating their function. Cardiac catheterization and Doppler echocardiography are the two established methods for the evaluation of prosthetic valve function and the hemodynamic state at rest (3). However, assessment under laboratory conditions, that is in resting supine position, does not necessarily reflect the patient's and the valves' hemodynamic state during exercise (4). Dobutamine infusion has been used to increase cardiac output by its b1 adrenergic agonist effect. Hecker et al. (5), demonstrated that, the data obtained through dobutamine stress echocardiography (DSE) and the data obtained through cardiac catheterization were similar (5). Moreover, they showed that the former method could provide a reliable non-invasive evaluation (5). A study in which hemodynamic changes of aortic prosthesis were assessed demonstrated that both treadmill exercise and DSE were equally effective in evaluation of prosthetic valve function (6).

The aim of this study was to investigate the response of heart to stress according to the size of the prosthetic valve in patients who had undergone mitral valve replacement by using dobutamine stress echocardiography and to evaluate the relationship between the size of the prosthetic valve and cardiac recovery-remodeling process.

Methods

Between 2003-2004, 578 patients had undergone mitral valve replacement (MVR) with St. Jude medical mechanical valves because of rheumatic valve disease. Forty-five of them who had applied to our policlinic for routine follow-up were recruited in this longitudinal study randomly. Those who had had a diagnosed atherosclerotic coronary artery disease before the operation, and those who had left ventricular dysfunction and prosthetic valve dysfunction (pannus formation, abnormal mobility of leaflets) at the time of study, were excluded. Six patients were also excluded because of inadequate echocardiographic views.

The approval of Ethical committee (Hospital Education Planning and Coordination Committee) and the informed consent of patients were obtained.

Thirty-nine patients whose echocardiographic imaging quality were adequate and who agreed to participate in the study were investigated 4.0±2.2 years after the operation. The patients were divided into three groups according to the size of implanted valve. Patients with valve size <29 mm were classified as Group 1 (n=11 (female/male ratio: 9/2, mean age: 42.4±12.6 years), patients with valve size=29 mm were included into the Group 2 (n=11 (female/male ratio: 10/1, mean age: 45.4±11.4 years), and patients with valve size >29 mm were referred to the Group 3 (n=17 (female/male ratio, 12/5, mean age: 44.7±12.6 years).

Patients had had a functional capacity of NYHA (New York Heart Association) class 3 or 4 before the operation and they had functional class 1, during the follow-up. All patients underwent routine general physical examinations. Nobody of patients had contraindications for performing dobutamine stress test.

We searched for the medical records of the patients retrospectively and noted down the demographic, clinic, operative variables and preoperative echocardiographic findings. All of the patients had suffered from rheumatic valve disease. One patient in Group 1, two patients in Group 2 and three patients in Group 3 had had pure mitral insufficiency whereas the others had had pure stenosis or combined type of lesions,

Table 1. Demographic and operative variables

Variables	Group 1	Group 2	Group 3	F**	p
Age, years	42.4±12.6	45.4±11.4	44.7±12.6	1.2	0.84
Sex, female/male, n *	9/2	10/1	12/5		0.41
Body surface area, m^2	1.56±0.09	1.58±0.08	1.64±0.22	1.0	0.63
Aortic cross-clamp time, min	73.3±19.5	79.1±32.6	58.9±26.8	1.5	0.24
Cardiopulmonary bypass time, min	102.3±32.1	117.9±42.0	84.8±32.0	2.2	0.13
Mitral valve replacement, n *	7	1	14		0.001
Double valve replacement, n *	4	10	3		0.001
Mitral valve pathology*					
Mitral stenosis, n	7	6	4		0.23
Mitral insufficiency, n	1	2	3		
Mitral stenosis and insufficiency, n	3	3	10		
Atrial fibrillation, n (%) *	7 (63.6)	9 (51.8)	11 (64.7)		0.57

* - Chi-square test
** - one way ANOVA test

preoperatively. Most of them were in atrial fibrillation. Of 39 patients included into the study, 22 had undergone MVR, while 17 had undergone both AVR and MVR together (4 patients in Group 1, 10 patients in Group 2 and 3 patients in Group 3) (Table 1).

Echocardiography

The patients' preoperative and postoperative (4 years after operation) echocardiographic records were obtained.

All patients were examined in the left lateral decubitus position by M-mode, two- dimensional, Doppler and tissue Doppler echocardiography with use of a Aloka SSD-5500 (Japan) echocardiography device and 35 MHz transducer. A one lead electrocardiogram was recorded continuously. The left atrium diameter (LA), left ventricular end-diastolic (LVEDD) and end-systolic (LVESD) diameters, interventricular septum (IVS) and posterior wall (PW) thicknesses at diastolic phase were measured from the parasternal long-axis views according with the standard techniques recommended by American Echocardiography Association for two-dimensional and M-mode examinations (7). The fractional shortening (FS) was derived using left ventricular diameters values. Left ventricular end-diastolic (LVEDV) and end-systolic (LVESV) volumes and ejection fraction (EF) were calculated using Simpson method. Left ventricular mass (LVM) was calculated using

following equation:

$1.04x\ ((LVEDD+IVS+PW)^3-LVEDD)^3/14$,

and further was indexed to body surface area (LVMI).

The mechanical valve prosthesis were examined from parasternal, apical and suprasternal windows and maximum and mean velocities were measured. Using Bernoulli equation, maximum and mean valve gradients were calculated. Mitral valve area (MVA) was calculated with the pressure half time method. Peak and mean diastolic transmitral gradients (MVG) were measured by continuous wave Doppler echocardiography. The pulmonary artery pressure (PAP) was derived from the tricuspid regurgitant jet velocity with the modified Bernoulli equation and assuming the right atrial pressure of 10 mmHg.

Dobutamine Stress Test Protocol

The DSE was performed after obtaining the written permission of the patient.

The DSE evaluation of all patients was performed by an experienced echocardiographer in order to minimize the interobserver variation.

Patients underwent stress echocardiography after a 3-hour fasting and they were allowed to take any prescribed medications. After a detailed history and physical examination to exclude the presence of any contraindication to stress testing, complete pre-stress two-dimensional echocardiography was performed to exclude prosthetic valve malfunction, other valvular disease, or severe left ventricular dysfunction. Apical four-chamber views were obtained, and baseline (resting) Doppler echocardiographic measurements of transvalvular peak and mean gradients, pulmonary artery pressure, left ventricular systolic and diastolic diameters were performed. We also measured isovolumetric relaxation time (IVRT) in order to evaluate the left ventricular diastolic function.

Using a peripheral venous cannula, a graded infusion of dobutamine was administered intravenously, starting with 5 mg.kg-1.min-1 dosage. Increments of 10, 20, 30 and 40 mg.kg-1.min-1 of dobutamine at 3-minute intervals were applied. During the study, patients underwent continuous electrocardiographic monitoring, and blood pressure was recorded both before starting the infusion and at 5-minute intervals with an automatic cuff. Criteria for discontinuing the dobutamine infusion included hypotension (systolic blood pressure <100 mmHg), dyspnea, significant ventricular or supraventricular arrhythmias. After the completion of the final investigation at dose of 40 mg.kg-1.min-1, or reaching the 85% of the target heart rate calculated for each patient according to their age (220-age), dobutamine infusion was stopped and the patient was monitored for a minimum of 20 minutes or until the heart rate had returned to the pre-stress test values. Two-dimensional and Doppler echocardiographic measurements were obtained just before each incremental increase in the infusion rate and at the peak of the stress test.

Surgical Intervention

Surgical approach was made via median sternotomy. After placement of sternal spreader, standard aorto-bicaval cannulation was performed. Cardiopulmonary bypass was instituted. After cross-clamping of the ascending aorta, cardiac arrest and myocardial protection was achieved by antegrade and retrograde cardioplegia. The mitral valve was exposed through interatrial incision. The surgeon decided the size of the mechanical prosthesis intraoperatively taking patients' body mass index and the size of the orifice into consideration. Mitral valve replacement was performed and the incision was closed with prolene. None of the patients had posterior leaflet preservation. Of these patients, 22 had undergone MVR, while 17 had undergone both AVR and MVR together. Following removal of the cross-clamp, dearing of the heart was achieved and the cardiopulmonary bypass was ended.

Statistical Analysis

The patients' preoperative and postoperative echocardiographic parameters were compared between the groups and within the groups. Shapiro-Wilk test was performed in order to analyze the distribution of the parameters. Chi-square and one-way ANOVA tests were used to determine the statistical differences between the groups. Bonferroni test was used as a post hoc test. Paired-t-test was used to evaluate the differences in the same group before and 4 years after operation, before and after DSE. P value less than 0.05 was considered statistically significant ($p<0.05$). All values reported are mean±SD.

Results

Patients' demographic and operative variables according to the groups are shown in Table 1. There were no statistically significant differences between the groups in terms of age, gender, body surface area, aortic cross-clamp time and cardiopulmonary bypass time. The mean age was 44.2±11.9 years and the mean postoperative time of investigation was 4±2.2 years (range 1.5 to 9.8 years). The patients in Group 3 had mostly undergone MVR, whereas the patients in Group 2 had mostly undergone double valve replacement (DVR) ($p<0.05$). The preoperative atrial fibrillation rates of the groups were similar.

The preoperative and postoperative echocardiographic data are shown in Table 2, Figures 1 and 2. The preoperatively measured LA, MVA, MVG, EF, LVESD, LVEDD, LVEDV, LVESV, LVMI values of the patients were close to each other. A significant decrease in LA was achieved in all of the groups ($p<0.05$ for all) after the operation, but an adequate decline in PAP was observed only in Group 3 (43.1±11.2 mmHg to 31.3±9.0 mmHg, $p<0.05$). A decrease in LVEDD (5.2±1.0 cm to 4.4±0.3 cm, $p<0.05$) and LVMI (138.3±29.7 g/m^2 to 86.6±15.6 g/m^2, $p<0.05$) were seen only in Group 1, postoperatively (Fig. 1).

Although EF decreased in Group 3 at postoperative fourth year (64.0±5.6% to 55.9±6.5%, $p<0.05$), no significant alterations were observed in the other groups (Fig. 2). The postoperative EF and FS values were lower in Group 3 as compared with groups 1 and 2 (p=0.03 and p=0.04, respectively) (Fig. 2). The LVEDD and LVESD (p=0.0001, p=0.002), LVEDV and LVESV (p=0.001 and p=0.003) were greater in Group 3 as compared with the groups 1 and 2 at the postoperative fourth year (Table 2).

Mitral valve size and DSE

There were no significant differences between the groups before and after the dobutamine infusion in terms of heart rate, systolic and diastolic blood pressure. Mean heart rate increased from 80.3±19.4 beats/min to a mean of 136.2±15.8 beats/min ($p<0.0001$). The mean systolic blood pressure also increased significantly at maximum stress (109.8±16.9 mmHg at rest and 137.8±15.1 mmHg at maximum stress; $p<0.0001$). Furthermore, we obtained a significant increase in diastolic blood pressure too (67.9±7.8 mmHg at rest and; 82.1±8.1 mmHg at maximum stress; $p<0.001$) (Fig. 3).

The echocardiographic measurements recorded at rest and after dobutamine infusion are shown in Table 3. Maximum and mean pressure gradients across the mitral valve prosthesis as well as PAP were significantly increased in all groups under stress ($p<0.05$ for all). The IVRT decreased in groups 1 and 2 ($p<0.05$ for both) following the dobutamine infusion, as expected, but this decline was not of statistical significance in Group 3 ($p>0.05$). Additionally, IVRT values during stress test were longer in Group 3 patients in comparison with groups 1 and 2 ($p<0.03$) (Table 3).

Discussion

Our study demonstrated that left ventricular end-systolic and end-diastolic diameters and volumes decreased 4 years after operation in patients with mitral valve size ≤29 mm (groups 1 and 2), except patients with large-sized mitral valve prosthesis (Group 3). This decrement was significant in patients with the smallest valve size (Group 1). The patients with mitral valve size <29 mm had also decrease in LVMI and significant improvement in EF. Mitral valve gradients significantly increased after the DSE in Group 1 and 2 patients, but the increment was less in Group 3 patients. There was a significant reduction in IVRT following the DSE only in patients with mitral prosthesis valve size ≤29 mm, while it was markedly prolonged after DSE in patients with valve size >29 mm.

Mitral valve replacement with Bicarbon mechanical valve

Table 2. Echocardiographic variables measured before and after the operation

Variables	Group 1	Group 2	Group 3	F	p**	p1-3***	p2-3***
LA, cm							
before operation	5.1±0.5	4.9±0.8	5.6±2.2	0.7	0.52	-	-
after operation	4.4±0.4 *	4.4±0.5 *	4.7±1.9 *	0.5	0.62	-	-
LVEDD, cm							
before operation	5.2±1.0	4.9±0.9	5.3±0.7	0.7	0.49	-	-
after operation	4.4±0.3 *	4.6±0.7	5.3±0.5	9.8	0.0001	0.001	0.006
LVESD, cm							
before operation	3.5±0.9	3.1±0.6	3.5±0.6	0.9	0.38	-	-
after operation	3.0±0.4	3.0±0.6	3.7±0.5	7.9	0.002	0.006	0.008
PAP, mmHg							
before operation,	44.6±13.6	51.9±26.6	43.1±11.2	0.7	0.49	-	-
after operation,	39.0±8.4	34.5±10.6	31.3±9.0 *	2.1	0.14	-	-
LVEDV, cm^3							
before operation	121.5±43.9	117.0±53.4	149.0±46.4	0.9	0.42	-	-
after operation	98.6±15.9	92.7±15.6	130.2±23.9	9.5	0.001	0.022	0.002
LVESV, cm^3							
before operation	42.5±19.3	42.9±26.3	54.1±20.9	0.6	0.57	-	-
after operation	34.2±13.5	34.9±13.2	58.1±16.8	7.7	0.003	0.019	0.009
LVMI, g/m^2							
before operation	138.3±29.7	107.3±27.3	123.1±24.8	0.3	0.26	-	-
after operation	86.6±15.6*	96.9±38.4	116.5±38.9	2.8	0.24	-	-
MVA preoperative, cm^2	1.2±0.2	1.3±0.4	1.2±0.3	0.4	0.69	-	-
Mitral gradient maximum before operation, mmHg	20.4±5.3	19.0±4.8	20.4±5.5	0.2	0.82	-	-
Mitral gradient minimum before operation, mmHg	10.6±4.2	11.3±3.9	11.4±3.3	0.1	0.88	-	-

*- p<0.05 - paired Students t test for intragroup comparison of values before and after operation
** - One-way ANOVA test for comparison of three groups values before and after operation
*** - post hoc Bonferroni test for comparison of between groups values before and after operation
LA- left atrium diameter, LVEDD- left ventricular end-diastolic diameter, LVESD- left ventricular end-systolic diameter, LVEDV- left ventricular end-diastolic volume, LVESV- left ventricular end-systolic volume, LVMI- left ventricular mass index, MVA- mitral valve area, PAP- pulmonary artery pressure

prosthesis provides very good results for the patients with mitral valvular stenosis (8). Patients who have undergone valve replacement are not totally cured and may still have serious heart disease (9). They have exchanged native valve disease for prosthetic valve disease and must be followed with the same care as patients with native valve disease (10). The clinical course of patients with prosthetic heart valve is influenced by several factors including left ventricular dysfunction, pulmonary hypertension and clinical heart failure (11). Transthoracic Doppler echocardiography is the most useful noninvasive test for the outpatient evaluation after valve surgery (9). It provides information about prosthesis stenosis/regurgitation, valve area and allows assessment of other valve disease(s), pulmonary hypertension, atrial size, LV and right ventricular hypertrophy, their size and function, and pericardial effusion/thickening (9).

Cardiac remodeling process is one of the most important concerns during the progression of the disease and after the surgery. In this study, using Doppler echocardiography, we tested the hypothesis that prosthetic mitral valve size has an effect on cardiac remodeling.

It was proved that the ejection fraction measured at resting state tended to decrease after standard MVR procedure (12-18). After mitral valve replacement procedures, when the preoperative diagnosis was mitral insufficiency, this situation is explained by the chordal apparatus damage or the disappearance of the low impedance ejection pathway via left atrium and increment of the afterload (12, 19). Chordal transection has been shown to lead to a more spherical chamber geometry at end-systole in dog models

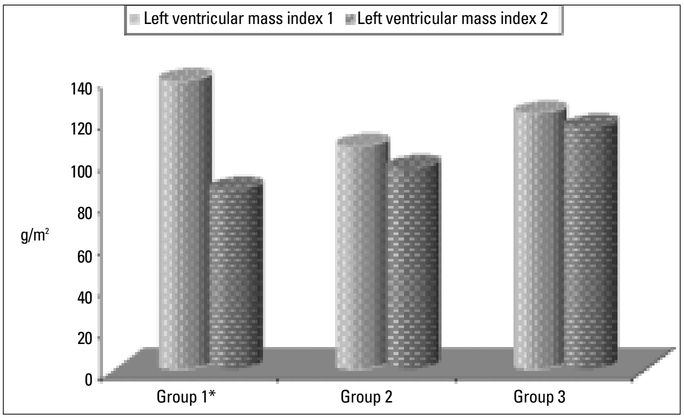

Figure 1. Left ventricular mass index measured before (1) and after (2) the operation

*- $p<0.05$ only for Group 1, paired Student's t-test

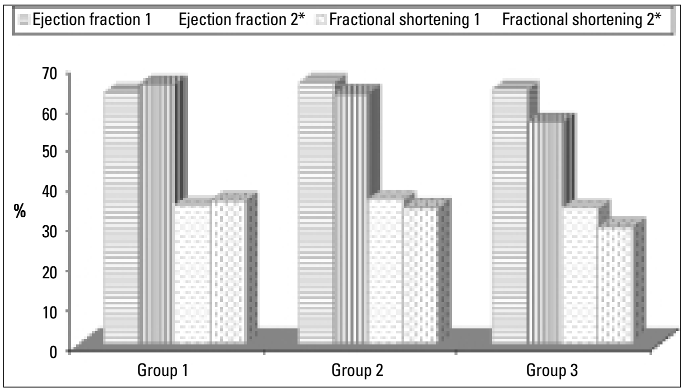

Figure 2. Ejection fraction and fractional shortening measured before (1) and after (2) the operation

*Intragroup comparison - paired-t-test $p>0.05$ for each group
** Between groups comparisons – ANOVA test:
Ejection fraction- F-3.8, p=0.03; Fractional shortening - F-3.6, p=0.04

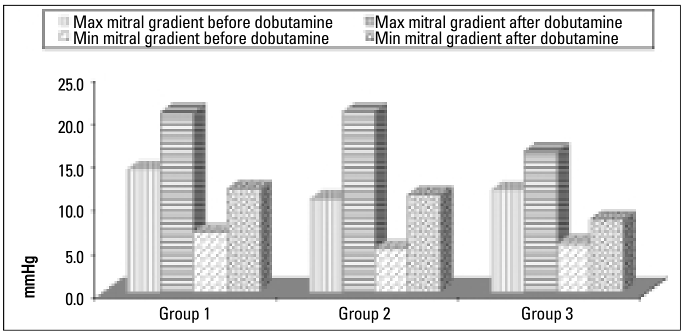

Figure 3. Maximum and minimum mitral valve gradients before and after dobutamine stress echocardiography

*- $p<0.05$- for intragroup comparison of both maximum and minimum gradients, paired- Student's t-test

Table 3. Systolic and diastolic function parameters according to dobutamine stress echocardiography

Variables	Group 1	Group 2	Group 3	F**	p**	p1-3***	p2-3***
IVRT, ms							
before DSE	90.9±12.9	107.4±10.2	92.9±18.5	2.8	0.07	-	-
after DSE	53.0±9.9 *	52.0±8.5*	76.9±11.5	5.2	0.03	0.01	0.01
PAP, mmHg							
before DSE	38.6±8.1	32.8±10.9	31.7±8.6	2.0	0.15	-	-
after DSE	53.7±15.6 *	47.9±11.7 *	43.5±10.8*	1.8	0.18	-	-
LVEDD, cm							
before DSE	4.5±0.4	4.5±0.5	5.3±0.5	11.1	0.001	-	-
after DSE	4.3±1.1	4.4±1.3	5.2±0.5	1.6	0.23	-	-
LVESD, cm							
before DSE	3.1±0.5	3.0±0.5	3.8±0.6	8.5	0.001	-	-
after DSE	3.0±0.7	3.1±0.8	3.2±0.7	0.2	0.78	-	-

*- $p<0.05$ - paired Student's t-test for comparison of values before and after DSE
** - One-way ANOVA test for comparison of three groups values before and after DSE
*** - post hoc Bonferroni test for comparison of between groups values before and after DSE
DSE- dobutamine stress echocardiography, IVRT- isovolumetric relaxation time, LVEDD- left ventricular end-diastolic diameter, LVESD- left ventricular end-systolic diameter, PAP- pulmonary artery pressure

(20-22). Chordal transection was also applied to the patients who was recruited in our study. Rozich et al. (19) reported that at peak exercise, MVR patients had significantly more spherical ventricles at end-systole, a greater change in sphericity from rest to exercise (19). The functional advantages at rest were maintained and even potentiated during exercise (12). In another study, it was shown that the alteration in the ejection fraction is correlated with the alteration in ventricular geometry (18). In our study, a decrease in left ventricular EF was observed in patients whose prosthetic mitral valve size was larger than 29 mm. Another factor that may affect this result was that the patients in this group were mostly suffering from mitral insufficiency (76.5%). No significant decreases were observed in postoperative EF values of the patients in groups 1 and 2. Furthermore, it was interesting that in Group 3, the proportion of the patients who had undergone only MVR was higher than in the other groups. The LVMI decreased following the surgery and this decrement reached statistical significance only in Group 1. As it is seen from the Table 2, the patients with larger valve sizes had larger ventricles, while patients with smaller prosthesis had the smaller ventricles, which may allow them to wean faster than patients with larger sized prosthesis.

In all three groups, it was observed that the size of the left atrium decreased. Although pulmonary artery pressure decreased in all groups during the postoperative period, this was only significant in Group 3. In a previous study, it was pointed out that MVR with Bicarbon mechanical valve prosthesis provides very good results for the patients with mitral valvular stenosis accompanied by serious pulmonary hypertension (8). In the patients with mitral prosthesis, significant differences were not observed between St. Jude Medical and Medtronic-Hall prosthesis in mean gradients at rest and during exercise using Doppler echocardiography (23).

Skudicky et al. (24) studied the patients who had undergone double valve replacement and reported that, the EF decreased in the early postoperative period and returned to the normal values after 1 year. In the same study, it was stated that end-systolic diameter and EF are the only independent markers of postoperative left ventricular performance (24). In our research, left ventricular end-diastolic diameter decreased after operation in groups 1 and 2 but not in Group 3. This reduction in LVEDD was statistically significant only in patients with mitral prosthesis size <29 mm. Left ventricular end-systolic diameter and end-systolic volume increased following the surgery only in patients with large-sized prosthetic valves. As it was mentioned before, Group 3 patients had a greater degree of mitral insufficiency rather than stenosis before the surgery. Their ventricles may be effected more than in Group 1 and 2 patients, so the making results following the surgery different from other groups. On the other hand, we could not observe significant changes during DSE in systolic and diastolic diameters. Since all of the patients with echocardiographically proved prosthetic valve dysfunction had been excluded from our study, this finding was thought to be related with the reduced contractile reserve.

Every prosthetic heart valve has an intrinsic degree of obstruction (9). The gradient varies among different types of prosthetic valves. In the previous studies, the transmitral mean gradients across the St. Jude Medical prosthesis measured with Doppler echocardiography at resting state and during exercise were 2.5 mmHg and 5 mmHg, approximately (23). However, according to current knowledge mitral valve gradients are affected by heart rate (25) and in the assessment of the prosthetic valve function, resting state Doppler echocardiography fails to reflect the patient's daily activities (26). Exercise Doppler echocardiographic measurements can provide additional important information about the patient, whose resting state measurements show limited information (27).

Dobutamine stress echocardiography can be used in order to evaluate hemodynamic performance of the valve in vivo under stress and it is a simple, safe and easily available method (3). The dobutamine infusion technique for stress echocardiography was first reported by Izzat et al. (3, 28). The advantage of dobutamine stress testing is that it stimulates the hemodynamic effect of isotonic exercise but does not depend on patient effort (29). Furthermore, diagnostic images can be obtained from almost all patients because of the absence of patient motion as well as limited respiratory interference (29). A study in which hemodynamic changes of aortic prosthesis were evaluated, indicated that both treadmill exercise and dobutamine stress were equally effective in the echocardiographic assessment (6). It is also reported that dobutamine application is useful in the evaluation of mitral valve obstruction during the catheterization (30).

In our study, echocardiography that was carried out at rest and after dobutamine infusion in patients who had undergone MVR after 4-year follow-up, demonstrated that maximum and mean transmitral gradients increased significantly with dobutamine infusion in all groups when compared with their basal measurements. This finding is similar to the result of the study by Fan CM who evaluated the prosthetic mitral valves with exercise Doppler echocardiography (3). In another study, it was pointed out that valve type (mechanical or bioprosthesis) does not affect hemodynamics in exercise Doppler echocardiography in normal mitral prosthesis, and it was also stated that small-sized mitral prosthesis tended to worsen exercise hemodynamics in contrast to large-sized valves (31).

In our study, it was noted that maximum and minimum mitral gradients increased following the dobutamine infusion especially in patients with mitral valve prosthesis size ≤29 mm. The patients who had valves greater than >29 mm had experiences this increment less than patients with smaller valve size. This increase was not statistically different among the groups and is concordant with the literature. In patients with large-sized valves, not only left ventricular systolic parameters but also diastolic parameters worsened with DSE as compared with patients with smaller valve size. The isovolumetric relaxation time was prolonged in Group 3 patients as compared with patients of groups 1 and 2.

Limitations of the study

Although all of the patients recruited in our study had had rheumatic valve disease, it could be thought that the effects of dobutamine stress test on cardiac functions did not represent a homogeneous group because the study group included the patients who had undergone operation due to mitral stenosis-insufficiency and aortic stenosis or insufficiency. Additionally, the number of patients was limited and less than calculated before the study. The number of mitral valve replacement surgery according to valve sizes and their analyses with DSE prevented us to increase the number of patients in each group. We did not measure the functional orifice area of the patients; which could be considered as a limitation of our study.

Conclusion

The patients with large-sized mitral prosthetic valves had worse LV contracitility and higher LV volumes during 4 years of follow-up as compared with patients with small-sized valves. A significant decrease was observed in the resting ejection fraction values of the patients whose valve size were >29 mm, postoperatively. On the contrary, the patients with small-sized valves (<29 mm) had a preserved LV contractility response to DSE and a noticeable decrease of left ventricular mass index 4 years after operation was determined. The patients with valve size equal to 29 mm did not show any significant alteration in postoperative resting ejection fraction. Mitral valve gradients increased in the response to DSE but the increase was less significant in patients with mitral prosthetic valves >29 mm.

In conclusion, this study indicates that prosthetic mitral valve size has an effect on cardiac remodeling in the late postoperative period. However, further investigations with more homogeneous groups and more patients should be carried out to put forward more definite results.

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