

Preservation of the Mitral Valve Apparatus: Bileaflet Versus Monoleaflet (Midterm Results)

Mitral Kapak Aparatusunun Korunması: Bileaflet ve Monoleaflet Karşılaştırması (Orta Dönem Sonuçları)

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ABSTRACT Objective: The aim of this study was to compare the midterm results in terms of cardiac mechanics and clinical outcomes for monoleaflet versus bileaflet protection in preserving the subvalvular apparatus in patients who underwent mitral valve replacement. **Material and Methods:** This study consists of the retrospective analysis of 51 consecutive non-randomized patients who underwent mitral valve replacement (MVR) between 2001 and 2007 in our clinic. Twenty five of them had total (group I) and 26 had partial (group II) chordal preservation operation. We compared clinical preoperative and postoperative conditions as well as the characteristics of the valve and left ventricle between the groups. The choice of the chordal preservation method depended on the surgeon's decision. **Results:** At the end, all patients were in functional class I-II. No in-hospital mortality was observed. Clinical improvement was observed in both groups, but reductions in percentage of (preoperative/mid-term postoperative period) change of left ventricular end-systolic (LVES), left ventricular end-diastolic (LVED), left atrial (LA) diameters (all of $p < 0.001$) and pulmonary artery pressure (PAP) ($p < 0.01$) were more prominent in patients with complete preservation of the mitral apparatus. In-group comparisons showed no significant difference in terms of ejection fraction between percentage of change values in both groups ($p = 0.144$). **Conclusion:** Although no significant difference was observed in cardiac performance between the two groups, echocardiographically determined superior reductions of LVESD, LVEDD, LAD and PAP in patients with complete preservation of the mitral apparatus may suggest that whenever possible, preservation of whole subvalvular apparatus in mitral valve replacement confers a significant advantage to the patients.

Key Words: Mitral valve; ventricular ejection fraction; chordae tendineae; surgical procedures/operative

ÖZET Amaç: Bu çalışmanın amacı, mitral kapak replasmanı geçiren hastalarda subvalvüler aparatın monoleaflet ve bileaflet korunmasının, klinik sonuçlar ve kardiyak mekanikler bakımından orta dönem sonuçlarının karşılaştırılmasıdır. **Gereç ve Yöntemler:** Kliniğimizde 2001'den 2007'ye kadar, 25'inde tam (grup I) ve 26'sında kısmi (grup II) korda korunarak mitral kapak replasmanı (MKR) geçiren, ardışık ve randomize olmayan 51 hasta retrospektif incelenmiştir. Biz her iki grupta ameliyat öncesi ve ameliyat sonrası klinik durumların yanısıra, sol ventrikül ve kapak özelliklerini karşılaştırdık. Korda koruma yönteminin seçimi cerrahın kararına bağlıydı. **Bulgular:** Takip sonunda bütün hastaların fonksiyonel kapasitesi sınıf I-II idi. Hastane mortalitesi gözlenmedi. Klinik iyileşme iki grubun tüm hastalarında gözlemlendi. Fakat sol ventrikül sistol sonu çapı (SVSSÇ), sol ventrikül diyastol sonu çapı (SVDSC), sol atriyum çapı (SAÇ) (hepsi için $p < 0,001$) ve pulmoner arter basıncındaki (PAB) ($p < 0,01$) yüzdesel değişimdeki (ameliyat öncesi/ameliyat sonrası orta dönem) azalma, mitral aparatın tam korunduğu hastalarda anlamlı olarak daha belirgindi. Gruplar karşılaştırıldığında, yüzde değişim (ameliyat öncesi/ameliyat sonrası orta dönem) değerleri arasında ejeksiyon fraksiyonu bakımından anlamlı farklılık göstermedi ($p = 0,144$). **Sonuç:** İki grup arasında kardiyak performansta anlamlı farklılık gözlenmemesine rağmen, mitral aparatın tam korunduğu hastalarda, SVSSÇ, SVDSC, SAÇ ile PAB'deki azalmanın ekokardiyografik olarak daha üstün saptanması, mitral kapak replasmanında mümkünse subvalvüler aparatın tam korunmasının bu hastalara önemli bir avantaj sağladığını gösterebilir.

Anahtar Kelimeler: Mitral kapak; ventriküler ejeksiyon fraksiyonu; korde tendine; cerrahi yöntemler

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The first reported mitral valve replacement (MVR) procedure with complete excision of mitral leaflets, chordae tendineae and the tips of the papillary muscles was done with the improvement of first prosthetic valve by Starr and Edwards in 1960s.¹ The principle of posterior mitral leaflet preservation in mitral valve replacement was introduced by Walton Lillehei in 1964 in contemplation of prevention of deterioration in the left ventricle function and demonstrated reduction in operative mortality from 37% to 14%.² Renewed interest in MVR chordal-sparing techniques was provoked by the report of Miller et al. in 1979 and followed by Hetzer et al. demonstrating improved outcomes and left ventricular function with chordal preservation.³⁻⁵ Finally, Gams et al. and Moon et al. showed that chordal preservation is superior and no significant differences were found between anterior or posterior preservation groups in 1990s.^{6,7}

The clinical confirmation of annulo-papillary continuity preservation improves survival, enhances functional status, preserves left ventricular geometry and function, stating better cardiac performance.^{8,9} Disruption of the papillary-annular continuity impairs counterclockwise torsional deformation of the apex during systole thereby causing abnormal diastolic function and disruption of normal LV stress-strain patterns.⁷ Sub-valvular apparatus preservation after mitral valve replacement is not a new concept. After acceptance of chordal preserving has positive effect on left ventricle function, new discussions such as different chordal preservation methods, have raised on preserving subvalvular apparatus. Studies by Hansen et al. have clearly demonstrated that LV function was superior with an intact subvalvular apparatus, intermediate with preservation of either the AML or PML and poorest with loss of all chordae tendinae.¹⁰ In an experimental evaluation of chordal preservation methods during MVR, there was no statistically significant difference between the results of different chordal preserving techniques in terms of global LV systolic and diastolic function.^{9,11} Current study aimed to compare the midterm results between total preservation and selective preservation (posterior leaflet) of the chordopapillary apparatus in terms of hemodynamic valvular characteristics and

left ventricular performance in patients underwent mitral valve replacement.

MATERIAL AND METHODS

Between 2001 and 2007, 51 patients undergoing MVR for degenerative mitral regurgitation at Kartal Koşuyolu Heart Research and Training Hospital were included into either partial (posterior leaflet) or complete (anterior and posterior leaflet) chordal preservation groups. Of the patients, 25 underwent MVR with complete preservation of the subvalvular apparatus (group I), and 26 underwent MVR with partial preservation of the subvalvular apparatus (group II). Mechanical prosthetic valve was implanted in all patients (in 38 patients St. Jude, in 9 patients Carbomedics and in 4 patients Sorin). The preoperative and postoperative clinical history, clinical examinations and investigations were complete in all patients. Their ages ranged from 23 to 81 years (mean, 48.90 ± 15.41 years). Thirty-one (%60.8) were men and twenty (%39.2) were women. The surgical indication was decided on clinical, doppler echocardiographic, hemodynamic and angiographic criteria. Physical activity was classified according to the four functional classes (FC) of the New York Heart Association and FC was recorded at the time of operation and at follow-up. The postoperative follow-up ranges from 13 to 71 months (mean 23.41 ± 17.98 months). Echocardiography was performed preoperatively, at discharge from the hospital and at the latest follow-up to determine dimensions, wall stress, and ejection fraction. The following measurements were recorded: left ventricular systolic diameter (LVSD); left ventricular diastolic diameter (LVDD); left ventricular ejection fraction (EF); left ventricular end-diastolic volume (EDV); and left ventricular end-systolic volume (ESV). The choice of the chordal preservation method depended on the surgeon's decision.

SURGICAL TECHNIQUES

All surgical procedures were performed through a median sternotomy. Extracorporeal circulation was established through cannulation of the ascending aorta and both vena cava separately, and membrane oxygenators were used. Standard moderate hy-

pothemic (28°C to 32°C) cardiopulmonary bypass was used. Myocardial protection consisted of intermittent antegrade cold blood cardioplegia. The surgeon deemed all valves non-repairable at the time of operation. In patients randomized to complete chordal preservation (group I), the entire subvalvular apparatus was preserved in an anatomic fashion as described by Khonsari et al.¹² In those randomized to group II technique, the anterior leaflet and its attached chordae tendineae were excised. The posterior leaflet and its chordal attachments were preserved.

Statistical Analysis

SPSS (Statistical Package for Social Sciences) for Windows 20.0 was used in the statistical analysis of the data. In the descriptive statistics; mean, standard deviation, frequency, rate, median, minimum and maximum values were used. The distribution of the data was investigated by Kolmogorov-Smirnov test. Student t test was used in the intergroup comparison of variables presenting normal distribution and Mann Whitney U test was used in the intergroup comparison of variables not presenting normal distribution. Chi-Square was used in the comparison of qualitative data. Fisher's exact test was used in case of chi-square conditions can not established. Significance was accepted as $p < 0.05$.

RESULTS

Of the 51 patients operated, 25 (group I) patients comprised the group of both leaflet preservation and 26 (group II) comprised the posterior leaflet preservation group. There were no significant differences in age, New York Heart Associations (NYHA) functional class and valve pathology between the patient groups. In all groups, the majority of patients were in NYHA functional class III preoperatively. No significant difference was observed among the groups regarding the demographic variables ($p > 0.05$) (Table 1).

In regard to the evolution of variables, intergroups comparisons revealed insignificant difference in terms of ejection fraction when percentage of (preoperative/mid-term postoperative period) change values compared in both groups ($p=0.144$).

TABLE 1: Demographic variables of the patients.

	Group I (n=25)	Group II (n=26)	p
Age, year (mean±s.d)	48.6±18.7	49.2±11.7	0.890
Sex			
Female, n (%)	8 (32)	12 (46.1)	0.454
Male, n (%)	17 (68)	14 (53.8)	
HT, n (%)	5 (25)	5 (19.2)	1
DM, n (%)	0 (0)	0 (0)	-
CAD, n (%)	4 (16)	3 (11.5)	0.703
Smoke, n (%)	6 (24)	8 (30.7)	0.823
COPD, n (%)	2 (8)	1 (3.8)	0.609
NYHA FC III-IV, n (%)	21 (84)	23 (88.5)	0.703

Student t test/Chi-square test (fisher exact)

DM: Diabetes mellitus; HT: Hypertension; COPD: Chronic obstructive pulmonary disease; CAD: Coronary artery disease; NYHA FC: New York Heart Association Functional Class.

In partial preservation group, although there was a reduction in LVESD, LVEDD, LAD and PAP measures when percentage of change values compared, intergroup comparisons also revealed that in complete preservation group (group I) there was a significant reduction of the LVESD, LVEDD, LAD and PAB when percentage of (preoperative/mid-term postoperative period) change values compared (respectively; $p < 0.001$, $p < 0.001$, $p < 0.001$, $p = 0.005$) (Table 2). The patients undergoing partial preservation had a shorter time of extracorporeal circulation and of aortic cross-clamping ($p < 0.05$). Although no significant difference, duration of stay in intensive care unit was shorter in patients with partial preservation of the mitral apparatus. ($p = 0.429$) (Table 3). Postoperatively 22 patients from group I and 21 patients from group II had sinus rhythm, while the others had atrial fibrillation and total atrio-ventricular block was occurred in 1 patient from each group. The postoperative follow-up ranges from 13 to 71 months (mean 23.41 ± 17.98 months). No in-hospital mortality was observed. No significant difference in functional class distribution was observed in the groups after surgery and all of the patients were improved to NYHA class I-II at postoperative controls.

DISCUSSION

The early days of MVR were complicated by an increased incidence of low output cardiac failure as-

TABLE 2: Percentage of change (preoperative/mid-term postoperative period) of the patients for echocardiographic variables

Variables	Percentage of (Preoperative/Mid-term postoperative period) change			p
	Median	Min.	Max.	
EF, %				
Group I	-0.2%	-1.2%	1.3%	0.144
Group II	1.4%	-0.2%	4.1%	
LVEDD, cm				
Group I	-18.6%	-11.4%	-23.1%	p<0.001
Group II	-9.3%	-2.4%	-15.2%	
LVESD, cm				
Group I	-18.4%	-6.5%	-26.1%	p<0.001
Group II	-2.6%	0.2%	-6.4%	
LAD, cm				
Group I	-17.2%	-10.1%	-24.1%	p<0.001
Group II	-4.6%	-1.1%	-11.4%	
PAP, mmHg				
Group I	-19.6%	-8.4%	-22.1%	0.005
Group II	-12.4%	-1.2%	-16.1%	

EF: Ejection fraction; LVEDD: Left ventricle end-diastolic diameter; LAD: Left atrium; LVESD: Left ventricle end-systolic diameter; PAP: Pulmonary artery pressure; Mann-Whitney u test.

TABLE 3: Perioperative variables.

	Group I (n=25)	Group II (n=26)	p
	Mean±s.d.	Mean±s.d.	
ACC (min.)	100.80±38.80	79.26±31.70	0.035
CPB (min)	126.04±48.36	94.80±37.85	0.013
Extubation time (hour)	17.87±9.02	14.08±5.09	0.069
Stay in ICU (day)	3.37±1.28	3.13±0.83	0.429
Follow-up (month)	17.97±20.38	25.83±15.51	0.127

ACC: Aortic cross clamp; CPB: Cardiopulmonary bypass; ICU: Intensive care unit. Student t-test.

sociated with mortality, but since then several methods have been implemented to improve myocardial protection strategies, wider application of mitral valve repair techniques and sub-valvular apparatus preservation in mitral valve replacement. In choosing the chordal preservation technique, the factors to be considered are the simplicity and reproducibility of the method, prevention of postoperative left ventricular outflow track obstruction (LVOTO) due to systolic anterior motion of the remaining AML and risk of interference with the

prosthetic valve function. The technique should also allow for implantation of adequate size prosthesis to prevent post-operative patient-prosthesis mismatch. Preservation techniques could potentially reduce the operative mortality; in fact it may not only impact left ventricular function, but also right ventricular function.¹³ Consequently, it can be of important as many patients undergoing MVR also suffer from right ventricular dysfunction, pulmonary hypertension, end-volume overload.

Researches by Kansiz and associates have clearly demonstrated that LV function was superior with an intact subvalvular apparatus, intermediate with preservation of either the AML or PML and poorest with loss of all chordae.¹⁴ In another study revealed that severing the chordae of the anterior leaflet (posterior leaflet chordae intact) reduced the slope of the pressure volume relation by 27% (p=0.005) in 10 dogs; the slope decreased by an additional 16% (p=0.017) when the posterior chordae were subsequently severed.¹⁰ In the meantime, Hennein et al. showed that there was no significant difference between posterior chordal preservation alone and the total chordal preservation group. In patients in whom the chordae were excised, exercise capacity, LVSD and cardiac index did not improve after MVR, and left ventricular function deteriorated (p=0.0007).¹⁵ In contrast, exercise capacity improved after MVR in patients in whom the entire apparatus was spared (p=0.05), LVSD decreased (p=0.03), and left ventricular function was maintained or improved. As a conclusion, no statistically significant differences between posterior chordal resection only and preservation of the entire apparatus were found.

In some studies shown that left ventricular fractional shortening decreased significantly in patients whose valves had been excised completely, whereas it remained unchanged in patients with either or complete chordal preservation.⁹ In another study by Yun et al. the superiority of complete chordal preservation was demonstrated in terms of larger decline in chamber volumes due to reduced systolic wall stress and smaller decreases in long-axis fractional shortening and ejection fraction.¹⁶

In our study clinical improvement was observed in both groups of patients. As shown in our data, although in-group comparisons revealed insignificant difference between percentage of change ejection fraction values in both groups, LV end-systolic and end-diastolic diameters, LA diameter and PAP was diminished in patients with both complete and partial preservation of the mitral apparatus. However, in the group with completely preserved subvalvular apparatus had significantly larger decrease LV chamber size and LA chamber size. We think that significantly larger decline LV and LA diameters in this group due to MY and compliant LA the majority of patients in group I. Compared to the mid-term results of the two groups; echocardiographically determined reductions of LVESD, LVEDD, LAD and PAP were statistically significantly in patients with complete preservation of the mitral apparatus (respectively; $p < 0.001$, $p < 0.001$, $p < 0.001$, $p = 0.005$).

The most significant limitation of our study; the choice of the partial or complete preservation

of mitral apparatus was to be left the surgeon's decision entirely. Also it would be better if we could included in our study the patients undergoing conventional MVR.

As a results, despite the advantages of complete chordal preservation, many surgeons still retain only the posterior leaflet because of greater technical difficulty, longer operating time, and fear of the possibility of LVOTO. The preserved ejection fraction measures and clinical improvement at the last follow-up, clearly demonstrates the preserving the subvalvular mitral apparatus, either partial or complete. Further long-term follow-up data, comparing preservation techniques, is clearly needed to compare function or quality of life after chordal preservation in MVR.

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