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Original Article

Clinical and echocardiographic evaluation of patients undergoing total leaflets preservation during mitral valve replacement; Does it make a difference?

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Abstract

Background: The effect of anterior and posterior leaflet preservation on left ventricular function after mitral valve replacement is still the subject of ongoing research. The objective of this study is to analyze the early outcomes of total leaflets preservation compared to posterior and non-leaflet preservation during mitral valve surgery on cardiac function and dimensions measured by echocardiography and on the clinical outcomes.

Methods: This prospective cohort study recruited 155 patients who had mitral valve replacement (MVR) from April 2016 to March 2018 at Assiut University Hospital. Patients were divided into three groups according to the technique of leaflets preservation; Group I (no leaflet preservation-N-MVR), Group II (total leaflet preservation- T-MVR) and Group III (posterior leaflet preservation-P-MVR). Patients who underwent redo mitral valve replacement (MVR) or those with endocarditis and had combined coronary artery bypass grafting with the MVR were excluded from the study.

Results: There were nine early deaths (6%); eight patients were in Group I (N-MVR). Causes of mortality were massive intracranial hemorrhage (n= 2) and left ventricular failure (n=6). One patient died in Group III (P-MVR) from intracranial hemorrhage (1.3%). Hospital stay was significantly longer in N-MVR group compared to T-MVR and P-MVR (10.6±2.13 days in N-MVR group; p= 0.03 and 0.011 respectively). Postoperative low cardiac output occurred in all patients in N-MVR group. Left ventricular function (ejection fraction= 61.28±6.02%) and dimensions (end-diastolic diameter= 5.18±0.69 mm, end-systolic diameter= 3.58±0.78 mm) improved significantly in total leaflets preservation group.

Conclusion: Leaflet preservation during mitral valve replacement was associated with improved clinical and echocardiographic outcomes. Non-leaflets preservation increased the risk of postoperative complications and length of hospital stay. Leaflet preservation is recommended as the standard approach during mitral valve replacement.

KEYWORDS

Leaflet preservation; Mitral valve replacement; Left ventricular function

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Introduction

The principle of posterior mitral leaflet preservation during mitral valve replacement (MVR) was introduced by Walton Lillehei and associates in the mid-sixties [1]. They found that operative mortality and morbidity diminished significantly compared to those with no leaflet preservation; moreover, the functional status of the patients was enhanced. David and coworkers performed MVR with preservation of both anterior and posterior leaflets; in addition to the chordae tendinea. As a result of their technique, the postoperative ejection fraction (EF) was augmented with exercise, and the left ventricular performance was improved after surgery [2].

Total leaflet preservation is technically demanding with it extensively increases the duration of surgery and required the implantation of comparatively smaller-sized mitral valve prosthesis [3]. It was believed that the subvalvular structures lead to obstruction of left ventricular outflow and interfere with the movement of mechanical valve leaflets which promoted non-leaflet preservation approach [4]. The current trend is to spare the chordae tendinae during MVR [3, 5]. This trend is due to the observation that chordal-sparing improved patient's survival secondary to reducing the risk of future left and right ventricular dysfunction [6]. It was proved that left ventricular geometry changes after MVR because of the interruption of the annulo-ventricular continuity which interferes with the mechanics of cardiac muscle and leads to reduced exercise tolerance and decreased stroke volume [7].

The objective of the current study is to compare the clinical and echocardiographic outcomes after mitral valve replacement with total leaflet preservation, posterior leaflet preservation, and non-leaflet preservation techniques.

Patients and Methods:

A prospective cohort study recruited 155 patients who had rheumatic mitral valve disease either regurgitation, stenosis or double lesion and surgically treated with mitral valve replacement (MVR) at Cardiothoracic surgery Department, Assiut University Heart Hospital from April 2016 to March 2018. The Ethical Committees of the Faculty of Medicine, Assiut University, Egypt approved the study protocol. Informed consent was obtained from all patients.

There were 55 male (35.5%) and 100 females (64.5%). Their age ranged from 18 to 67 years with a mean ± SD of 42.5 ± 24.5 years old. Patients who had redo MVR or MVR for native or prosthetic valve endocarditis were excluded from the study. The demographic and clinical profile of the patients is shown in Table 1.

Those 155 patients who met the criteria required for this study and completed six months of follow up were divided into three groups according to surgeon's preference:

Group I (N-MVR) included 15 patient who had MVR without any leaflet or chordea preservation. **Group II (T-MVR)** included 60 patients who had MVR with total leaflet preservation and complete chordal preservation. **Group III (P-MVR)** included 80 patients who had MVR with posterior leaflet preservation and partial chordal preservation.

Surgical Technique:

Median sternotomy approach was used in 148 patients, and seven patients had a minimally invasive approach with femoral arterial and venous cannulation. Systemic cooling to 28°C-30°C was initiated on cardiopulmonary bypass (CPB). The aorta was cross-clamped, and the heart was arrested with intermittent cold crystalloid antegrade cardioplegia. Surgical exposure of the mitral valve was done through a vertical left atriotomy incision in Sondergaard's groove. Once it is determined that mitral valve repair was not feasible due to excessive leaflets calcification, MVR was performed either without leaflet preservation (Group I) or with chordal preservation in Group II, III according to the status of the native valve.

In Group II (T-MVR), we used five different methods for total leaflets preservation; 38 patients had Miki technique [8] (an incision was made few millimeters from the annulus along the anterior mitral ring), 12 patients had khonsari II technique [9] (the anterior leaflet (AML) was detached 3 mm from the annulus and a central elliptically shaped portion excised, leaving a 5- to 10-mm rim of leaflet free edge attached to the primary (first-order or marginal) chordae tendineae. This strip of leaflet was then

Table 1: Demographic data of the study population grouped according to valve preservation strategy during mitral valve replacement. Categorical data are presented as number and percent.

	(N-MVR)	*(T-MVR)*	*(P-MVR)*	P value
Male	4(26.7%)	28(46.7%)	23(28.8%)	0.068
Female	11(73.3%)	32(53.3%)	57(71.3%)	
Hypertensives	3(20%)	14(23.3%)	16(20%)	0.885
DM	2(13.3%)	8(13.3%)	5(6.3%)	0.329
COPD	1(6.7%)	4(6.7%)	3(3.8%)	0.714
NYHA I	2(13.3%)	0	3(3.8%)	0.063
NYHA II	0	0	4(5%)	
NYHA III	10(66.7%)	44(73.3%)	59(73.8%)	
NYHA IV	3(20%)	16(26.7%)	14(17.5%)	
Associated valve lesion				
Severe TS	0	0	2(2.5%)	0.523
Moderate AS	0	0	2(2.5%)	
Severe AS	1(6.7%)	4(6.7%)	7(8.75%)	
Mild AR	0	0	2(2.5%)	<0.001
Moderate AR	0	0	6(7.5%)	
Severe AR	6(40%)	0	2(7.5%)	
Mild TR	0	4(5%)	0	0.120
Moderate TR	3(20%)	4(5%)	8(10%)	
Severe TR	7(46.7%)	13(21.7%)	14(17.5%)	
Sinus rhythm	6(40%)	58(96.7%)	66(82.5%)	<0.01
AF	9(60%)	2(3.3%)	14(17.5%)	

N-MVR: Non-preservation; T-MVR: Total preservation; P-MVR: Posterior preservation; DM: Diabetes mellitus; COPD: Chronic obstructive lung disease; NYHA: New York American heart association; TS: tricuspid stenosis; AS: Aortic stenosis; AR: Aortic regurgitation; TR: tricuspid regurgitation; AF: Atrial fibrillation.

reattached to the annulus in the corresponding location with the valve sutures) , 6 patients had Rose and OZ technique [10] (instead of reattaching the rim of anterior leaflet to the annulus with the valve sutures, one can close the defect in the anterior leaflet primarily using a running 4-0 polypropylene suture) , 2 patients had Feikes technique [4] (the anterior leaflet was split into two halves radially from the free edge to the annulus then completely detached from the anterior mitral annulus, and the two segments were transposed toward the posterior annulus, with the ventricular side facing the atrium, and any excessive myxomatous leaflet tissue extending above the plane of the posterior annulus was excised) and 2 patients had Vander

Table 2: Comparison of the operative and early postoperative variables among groups. (Continuous variables are presented as mean± SD)

	N-MVR (n=15)	T-MVR (n=65)	P-MVR (n=80)	P1	P2	P3
Size of prosthetic MV (mm)	27.4±2.16	28.15±1.64	27±1.68	0.133	0.410	<0.001
Cross clamp time (minutes)	63.2±13.7	64.17±14.09	57.5±13.17	0.806	0.138	0.005
Bypass time (minutes)	118±18.5	110.5±22.13	103±17.02	0.180	<0.001	0.024
ICU stay (days)	3.73±0.8	3.87±3.07	3.51±0.64	0.816	0.692	0.297
Hospital stay (days)	10.6±2.13	9.13±3.25	8.93±1.27	0.030	0.011	0.599
mechanical ventilation (hours)	2.6±1.04	4.22±12.71	2.24±0.99	0.483	0.872	0.147

MV: Mitral valve, ICU: Intensive care unit
P1: comparison between Total preservation (T-MVR) and Non-preservation (N-MVR)
P2: comparison between Total preservation (T-MVR) and Posterior Preservation (P-MVR)
P3: comparison between Non-preservation (N-MVR) and Posterior. preservation (P-MVR)

Salm technique [11] (the central part of the AML was incised from the edge to the base and pledged horizontal mattress sutures were passed from the left atrium through the mitral annulus avoiding the papillary muscles and chordae around the free edge of the leaflet and up through the prosthetic sewing ring. If the AML was large, it was reefed within the sutures, and the prosthetic valve was seated and tied). In Group III (P-MVR), the anterior leaflet was excised, and the sutures were placed from the atrial to the ventricular side and back out the posterior leaflet 2 mm to 5 mm from the annulus. [12]

Intra-operative Transesophageal echocardiography was routinely performed to ensure mitral valve leaflets remain away from left ventricular outflow tract (LVOT) during systole and exclude systolic anterior motion (SAM).

Table 3: Comparison of the clinical outcomes among groups. Categorical variables are presented as number and present.

	Preoperative			Six months postoperative		
	N-MVR	T-MVR	P-MVR	N-MVR	T-MVR	P-MVR
Congestive lung symptoms	15 (100%)	60 (100%)	80 (100%)	14 (93.3%)	0 (0%)	3 (3.8%)
	P1= <0.001	P2=0.108	P3<0.001	P1<0.001	P2=0.354	P3<0.001
Low COP	15 (100%)	20 (33.3%)	63 (78.8%)	15 (100%)	0 (0%)	1 (1.3%)
	P1 <0.001	P2<0.001	P3=0.109	P1<0.001	P2=0.885	P3<0.001
Dysphagia	8 (53.3%)	4 (6.7%)	35 (43.8%)	2 (13.3%)	0 (0%)	1 (1.3%)
	P 1<0.001	P2<0.001	P3=0.688	P1=0.049	P2=0.885	P3=0.099

COP: cardiac output
P1: comparison between Total preservation (T-MVR) and Non-preservation (N-MVR)
P2: comparison between Total preservation (T-MVR) and Posterior Preservation (P-MVR)
P3: comparison between Non-preservation (N-MVR) and Posterior Preservation (P-MVR)

Sample size calculation

The sample size was calculated using G*power, version 3.1.9.2. Based on previous studies [13, 14] the ejection fraction (EF) was 53.29 ± 8.34%, the end-diastolic diameter was 78.89 ± 8.99 mm, and end-systolic diameter was 29.83 ± 1.27 mm. With a power of 80% (using a two-sided test and α of 0.5) the sample needed for the study was estimated to be about 30 patients. In this study, all patients presented to Assiut University Heart Hospital from April 2016 to March 2018 were included.

Statistical analysis:

Statistical analyses were performed using (SPSS) program version 20 (IBM Corporation; Endicott, New York, USA). We used One-way Analysis of Variance (ANOVA) to compare continuous variables and Chi-squared to compare categorical variables among the three groups. Bonferroni test was used for post-hoc analysis. A p-value of less than 0.05 was considered statistically significant.

Results

One hundred fifty-five patients had mitral valve replacement; 62 patients had mitral regurgitation, 74 patients had mitral stenosis, and 19 patients had double mitral lesions. The surgery was uneventful in 150 patients, five patients exhibited difficult weaning from cardiopulmonary bypass, and there was no operative mortality. The duration of cardiopulmonary bypass and cross-clamp was comparable among groups. The operative and early postoperative results are shown in Table 2.

The clinical outcomes including congestive lung symptoms, low cardiac output (COP) symptoms, and dysphagia were not statistically different between total and posterior leaflets preservation groups and statistically different between both leaflet preservation groups and the non-preservation group (Table 3).

Preoperative left ventricular end diastolic diameter (EDD), end systolic diameter (ESD), ejection fraction (EF) and left atrial (LA) diameter were significantly different among groups preoperatively (ANOVA p< 0.001). Post hoc analysis was used to test the difference among groups. (Table 4) Follow-up echocardiography was performed six months later and compared with the perioperative findings. The ejection fraction and dimensions were significantly different between leaflets preservation groups and non-preservation group after six months follow-up (within groups ANOVA p< 0.001). Post hoc analysis is shown in Table 4. The changes in EDD, ESD, and EF were significantly different among groups (Table 5).

There were nine cases of early death; eight patients were in Group I (N-MVR), two from warfarin toxicity resulting in massive intracranial hemorrhage and 6 of them from left ventricular failure, while one patient died in Group III (P-MVR) from intracranial hemorrhage associated with elevated INR.

Discussion

This study compared the clinical and echocardiographic outcomes after total or posterior leaflets preservation during MVR compared to non-leaflet preservation technique. We found that leaflets preservation groups were superior to non-leaflets preservation group as regards to end-diastolic, end-systolic dimension, ejection fraction; in addition to the clinical outcomes such congestive lung symptoms, low cardiac output symptoms, and dysphagia. This could be explained by the loss of geometry of left ventricle which led to decrease in the pumping action of LV and low COP symptoms with an accumulation of the blood in left atrium compressing the esophagus and stagnation of blood in pulmonary veins producing congestive lung symptoms.

Several studies were published in the early 90s and revealed the superiority of total leaflet preservation during MVR over the standard MVR method (conventional or non-leaflet preservation method) [15-18]. Currently, posterior leaflet preservation is the commonly used approach. Despite the good results achieved by the total preservation technique, the technique is more demanding and not routinely used by many surgeons [19, 20].

Yun and colleagues [15] found that no superiority of total leaflet preservation over posterior leaflet preservation on LV diameter and EF. Hennein and coworkers [21] compared total

Table 4: Comparison of the echocardiographic data among groups. Continuous variables are presented as mean± SD

	Preoperative			Post 6 month		
	N-MVR	T-MVR	P-MVR	N-MVR	T-MVR	P-MVR
EDD (cm)	4.42±1.06	6.13±0.9	4.74±0.78	6.13±0.91	5.18±0.69	5.43±0.61
	P1<0.001	P2<0.001	P3=0.184	P1<0.001	P2=0.029	P3<0.001
ESD (cm)	3.05±0.8	4.17±0.97	3.19±0.71	4.13±0.65	3.58±0.78	3.81±0.56
	P1<0.001	P2<0.001	P3<0.001	P1<0.001	P2=0.041	P3=0.092
EF (%)	60.73±6.25	58.23±7.69	62.93±5.5	42.6±7.72	61.28±6.02	58.64±5.51
	P1=0.185	P2<0.001	P3=0.233	P1<0.001	P2=0.01	P3<0.001
LA (cm)	5.16±0.72	4.8±0.91	4.53±0.59	4.87±0.78	3.98±0.79	3.65±0.39
	P1=0.090	P2=0.04	P3<0.001	P1<0.001	P2<0.001	P3<0.001

EDD: end diastolic diameter, ESD: end systolic diameter, EF: ejection fraction, LA: left atrium

P1: comparison between Total preservation (T-MVR) VS Non-preservation (N-MVR)

P2: comparison between Total preservation (T-MVR) VS Posterior Preservation (P-MVR)

P3: comparison between Non-preservation (N-MVR) VS Posterior Preservation (P-MVR)

leaflet preservation, posterior leaflet preservation, and non-leaflets preservation and found that total leaflet preservation and posterior leaflet preservation were superior over non-leaflets preservation in terms of exercise capacity, systolic dimensions, and fractional shortening. On the other hand, they found no significant difference between their total leaflet preservation and posterior leaflet preservation groups. Rozich and coworkers [16] compared total leaflet preservation and posterior leaflet preservation with non-leaflets preservation technique and evaluated the patients in terms of ventricular volume, wall stress, and ejection fraction. There was no change in LV end-diastolic volume in patients with no leaflets preservation, and the study revealed significant increases in LV end-systolic volume and stress and a significant decrease in LVEF. On the other hand, significant decreases in LV end-diastolic and end-systolic volumes and a reduction in wall stress were observed in the preservation groups; and no change was observed in LVEF. A meta-analysis of studies on different preservation techniques was performed but failed to show the superiority of total leaflet preservation over posterior leaflet preservation [22].

The results of the current study are consistent with the studies mentioned above. However, we found improvement in LVEF in T-MVR group, additionally; LVEF decreased from 62.93±5.5 to 58.64±5.51 in the P-MVR group, and markedly deteriorate from 60.73±6.25 to 42.6±7.72 in N-MVR group (P= <0.001). Both techniques of leaflets preservation resulted in significant decreases in LVES and LVED dimensions during the postoperative period, such decrease in LV size could lead to the contact between subvalvular structures and the mechanical prosthetic valve leaflets, and consequently LVOT obstruction. For that reason, if total leaflet preservation was performed, an appropriate preventive measure should be taken to prevent LVOT obstruction. Several methods have been proposed to avoid postoperative LVOT obstruction, and Sintek and coworkers described their technique of AML resection to prevent SAM [17,18], and intraoperative transesophageal echocardiography is used routinely to ensure mitral valve leaflets remain away from LVOT during systole as we performed with our patients.

In the current study, total leaflet preservation achieved good results; in addition, the preservation of the posterior leaflet had satisfactory results, apart from a small decline in postoperative LVEFs in few patients. Despite the lack of complications associated with total leaflet preservation in the current study, there are many reports of LVOT obstruction and impaired prosthetic-valve leaflet function [23,24].

Table 5: Comparison of the echocardiographic changes among groups

	Group A	Group B	Mean difference (group A-B)	p-value	95% Confidence Interval
EDD change	N-MVR	P-MVR	1.02	<0.001	0.75- 1.29
	N-MVR	T-MVR	2.66	<0.001	2.38- 2.94
	P-MVR	T-MVR	1.64	<0.001	1.48- 1.80
ESD change	N-MVR	P-MVR	0.46	<0.001	0.23- 0.96
	N-MVR	T-MVR	1.67	<0.001	1.44- 1.91
	P-MVR	T-MVR	1.22	<0.001	1.08- 1.36
EF change	N-MVR	P-MVR	13.85	<0.001	11.18- 16.51
	N-MVR	T-MVR	21.18	<0.001	18.44- 23.92
	P-MVR	T-MVR	7.34	<0.001	5.72- 8.95

EDD: End diastolic diameter; EF: Ejection fraction; ESD: End systolic diameter; N-MVR: non-leaflet preservation group; P-MVR: posterior leaflet preservation; T-MVR: total leaflet preservation

Total leaflet preservation is recommended to prevent further decrease in LVEF in patients who present with significantly impaired LV function.

Study limitations:

The study has several limitations. First, our study performed in a single center and leaflets preservation was the most preferred technique in our center; therefore, the number of patients in the control group was small. This is a non-randomized study that could lead to different baseline patients' characteristics among groups. There was a difference among the groups in terms of preoperative LVEF and LVESD and the combined valve disease which may affect the outcome either clinically or echocardiographic. The number of events is small, so the multivariable analysis is not well powered. We excluded from the study all patients who underwent additional coronary artery bypass surgery, which particularly affected our small T-MVR group. On the other hand, the study is a prospective cohort study, so it eliminates the biases of retrospective studies.

Conclusion

Leaflet preservation during mitral valve replacement was associated with improved clinical and echocardiographic outcomes. Non-leaflets preservation increased the risk of postoperative complications and length of hospital stay. Leaflet preservation is recommended as the standard approach during mitral valve replacement especially in patients with reduced ejection fraction. Posterior leaflet preservation had satisfactory outcomes but was associated with reduced ejection fraction.

Conflict of interest: None declared

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