EFFECTS OF MITRAL VALVE REPLACEMENT WITH AND WITHOUT CHORDAL PRESERVATION ON CARDIAC FUNCTION: EARLY AND MID-TERM RESULTS

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Background: Convention mitral valve (MV) replacement is known to cause deterioration in the left ventricle function, the major mechanism responsible being disruption of the annulo-papillary continuity, thus favoring preservation of the mitral subvalvular apparatus. The aim of this study was to compare the early and midterm results, in terms of cardiac mechanics and clinical outcomes, of preserving the subvalvular apparatus (partial/complete) verses resection during mitral valve replacement. **Methods:** This was a prospective non randomised trial**.** One hundred and twenty-two patients (mean age 40.36±14.27 years) admitted for MV replacement from January 2009 to September 2009 were included in the study. They were divided into 3 groups: complete excision of the subvalvular apparatus (group 1=32); preservation of the posterior leaflet (group 2=54) and total chordal preservation (group 3=36). Echocardiography was done preoperatively, at discharge, and at 6 months follow-up. **Results:** The preservation groups 2, 3 revealed marked improvements with respect to the End-diestolic Volume (EDV) and End-Systolic Volume (ESV) as compared to the non-preservation group 1 at discharge from hospital. At follow-up, the preservation groups showed improved EDV and ESV in contrast to the non-preservation group, where the ventricular volumes had a declining pattern. Ejection fraction remained below the baseline preoperative level in all three groups at discharge from hospital. In the follow-up, chordal preservation groups showed significant improvements in the ejection fraction as compared to the resection group. An interesting finding was that of PA pressures and LA size between the groups. It was significantly improved in the preservation groups as compared to the resection group. At follow-up, 43.5% of patients in group 1 were in AF compared with 27.5% in group 2 and 21.4% in group 3. More patients in group 1 were in NYHA functional class III or IV at follow-up: 30.4% versus 7.5% and 7.1% respectively. **Conclusion:** Preservation of the mitral subvalvular apparatus resulted in a greater decrease of ventricular dimensions at discharge which was maintained at follow-up; complete resection resulted in ventricular dilatation at follow-up. Furthermore, the ejection fraction improved in the preservation groups compared to the complete resection group which showed a decline at follow-up.

Keywords: Mitral valve, MV preservation, MV replacement, chordal preservation, MV surgery, subvalvular apparatus

INTRODUCTION

Convention mitral valve replacement is known to cause deterioration in the left ventricle function, the major mechanism responsible being disruption of the annulo-papillary continuity, thus favouring preservation of the mitral subvalvular apparatus. On the other hand, preservation of the mitral apparatus has been associated with the hazards of implantation of a smaller sized prosthesis causing patient prosthesis size mismatch and entrapment of the prosthetic valve. Left ventricular outflow tract obstruction (LVOTO), longer operating time and greater technical complexities have also been the concerns.[1–5]

Some studies have shown an insignificant difference between complete and partial preservation[3,6], while others have shown a significant difference between the two[7,8]. Yet there is a consensus over preservation of the mitral apparatus to be superior to complete resection.[9,10] This difference in outcomes in the preservation groups(complete vs partial) may be related to the underlying pathology of the mitral valve. There is a paucity of data over this issue in our local population. Therefore we sought to evaluate effects of chordal preservation on left ventricular size and function and clinical outcomes on an early and midterm basis.

MATERIAL AND METHODS

This was a prospective non-randomised study. One hundred and twenty-two consecutive patients, undergoing mitral valve replacement, from January 2009 through September 2009, at National Institute of Cardiovascular Diseases (NICVD), Karachi, Pakistan were included in this study. Patients who had undergone a previous mitral valve operation (repair or commissurotomy) were also included. Concomitant procedures, i.e., coronary artery bypass grafting and tricuspid valve repair were considered. Exclusion criteria were mitral valve repair, previous mitral valve replacement, multiple valve replacement,

and approaches other than median sternotomy. Approval for the study was obtained by the institutional review board with all patients having had given informed consent for operation and for use of their medical records for research purposes.

All patients received a mechanical bileaflet valve. It was ensured that the preserved chordae tendinae were not interfering with the prosthesis function by checking disc movement. The technique for preservation of the chordopapillary apparatus was decided after intraoperative visual inspection of the mitral valve. Three groups were made: Group 1 (n=32), complete resection of the native valve along with the subvalvular apparatus (non-chordal group); Group 2 (n=54), excision of the anterior mitral leaflet and chordopapillary apparatus along with preservation of the posterior mitral leaflet and attached chordae tendinae (posterior chordal group); Group 3 (n=36), preservation of both mitral leaflets along with the chordae tendinae and papillary muscles (total chordal group).

Techniques of Chordal Preservation

Total Chordal Preservation: The anterior leaflet was predominantly managed by Khonsari I and II techniques.[11] In some patients, the Miki's technique[12] or the Feike's technique[13] were used. The posterior leaflet was managed as below:

Partial Chordal Preservation: This technique involved excision of the whole of the anterior leaflet and chordae tendinae with preservation of the posterior leaflet and associated subvalvular apparatus. The posterior leaflet was imbricated to the annulus. Alternatively, the leaflet was incised from edge to base at two or three points in between the scallops.

No Chordal Preservation: In cases of calcified mitral valves or severe subvalvular fusion, the whole of the mitral valve including the leaflets and subvalvular apparatus were completely excised.

Electrocardiograms and echocardiography were done at discharge and follow-up. The functional class was also assessed at follow-up. All patients received warfarin and/or received aspirin where indicated[14] to maintain an international normalised ratio (INR) between 2.5 and 3.5.

Transthoracic two-dimensional (2D), colour flow and Doppler echocardiography was performed using the Nimio Toshiba machine with 2.5–3.7 MHz transducer. Prosthetic valve function was assessed on 2D and Doppler with multiple views. Preoperative studies were performed within 7 days before surgery. Postoperatively, patients were followed echocardiographically seven days after surgery or at discharge and at 6 months follow-up. Echocardiographic data were measured according to the criteria of the American Society of Echocardiography.[15]

Data were entered and analysed with SPSS 16.0. Descriptive statistics were calculated for continuous and categorical variables. One Way Analyses Of Variance (ANOVA) with the Bonferroni post-hoc test were used to identify differences among groups of continuous variables. The Chi-square test was used to identify association among the groups for categorical variables. Mann-Whitney U test was to compare numerical measurement between dead and survive. Repeated measures two-way analysis of variance was used to assess the influence of time for type of operative procedure on all echocardiographic data. For qualitative repeated measurement, MeNemar test and Marginal Homogeneity test were also applied for atrial fibrillation and NYHA status.

RESULTS

The demographic and clinical profiles of the patients are predicted in Table-1. There was no statistically significant difference in the patient population among the groups.

The groups were comparable with regard to the severity of symptoms and the medications given preoperatively. Eighty-one (66.4%) patients were in NYHA functional class III or IV. An interesting finding was that more patients in groups 2 and 3 were in NYHA class III and IV than in group 1.

The 3 groups were also comparable with respect to hypertension, diabetes, chronic obstructive pulmonary disease and previous stroke. The predominant mitral pathology was mitral regurgitation followed by stenosis and lastly, mixed mitral disease.

The mean cardiopulmonary bypass time was 73.19 (19.4) min (95% CI: 69.71 to 76.67). The mean aortic cross-clamp time was 57.68 (17.17) min (95% CI: 54.60 to 60.67). The bypass time and clamping time were statistically significant.

The mechanical valve prosthesis size was 27 mm in 43 patients (8 in Group 1, 20 in Group 2, 15 in Group 3), 29 mm in 49 patients (16 in Group 1, 18 in Group 2, 15 in Group 3) and 31 mm in 30 patients (8 in Group 1, 16 in Group 2, 6 in Group 3). The frequency of reoperation was more in group1 because more had had a previous commisurotomy.

Table-2 shows the preoperative and postoperative echocardiographic data which is summarised as follows:

1. Left ventricular diameters (LVESD and LVESD) were decreased in group 1 postoperatively ((p<0.001); however, the dimensions were increased at follow-up (p<0.001).The other groups (2 and 3) had higher preoperative LV dimensions and demonstrated a significant reduction both at discharge and follow-up (p<0.001).
2. The LVEF decreased in the nonchordal group (group 1) at discharge and continued to decline

significantly over time (p<0.001). In the chordal preservation groups (p<0.001), the LVEF decreased postoperatively but showed an improvement at follow-up (Group 3, 2).

3. The pulmonary artery systolic pressures showed a statistically significant decrease in all three groups both at discharge and follow-up (**p**<0.001), marked reduction being observed in the chordal preservation groups.
4. The left atrial diameter decreased significantly in all 3 groups (p<0.001), again this decrease was marked in the preservation groups both at discharge and at follow-up.

No statistically significant differences with respect to postoperative complications were observed (Table-3). There were 7 (5.6%), in-hospital deaths (Table-4). Perioperative mortality was lower in the preservation groups compared to the non-preservation group (9.4% vs 5.6% vs 2.8% respectively). The causes of death were sepsis (3 patients), LCOS (2 patients), stroke (1 patient) and acute renal failure (1 patient).

Age was the only preoperative variable that was statistically significant with respect to mortality (p=0.023). The preoperative echocardiographic variables were analysed with respect to mortality; none of them were found to be statistically significant.

Follow-up (Table-4) was 79% complete; 24 patients were lost to follow-up. At follow-up, 30.4% of the survivors in group1 were in NYHA functional classes III or IV vs 7.5% and 7.1% in the other 2 groups respectively (p=0.17). There was an overall improvement in NYHA functional class, with more patients in class I and II at follow-up (p<0.01). Forty-three percent patients in the resection group were in atrial fibrillation at follow-up, vs 27.5% in the posterior chordal group and 21.4% in the total chordal group (p=0.21). Overall, atrial fibrillation showed a statistically significant improvement both at discharge and at follow-up (p<0.01).

Table-1: Preoperative and operative characteristics of study groups

Characteristics	Group 1 (n=32)	Group 2 (n=54)	Group 3 (n=36)	*p*
Age (Years)	40.13±10.50	39.28±15.68	42.19±15.14	0.63
Body surface area(m^2)	1.43±0.10	1.4793±0.11	1.46±0.10	0.11
Mitral valve prosthesis size	29.0±1.44	29.00±2.13	28.5±1.46	0.37
Bypass time (min)	82.75±25.45	72.46±15.74	65.78±14.61	0.001*
Clamping time (min)	67.72±22.84	56.28±13.31	50.86±12.08	0.0005*
Gender				
Male	10 (31.3%)	15 (27.8%)	12 (33.3%)	0.84
Female	22 (68.8%)	39 (72.2%)	24 (66.7%)	
NYHA				
III	9 (28.1%)	19 (35.2%)	13 (36.1%)	0.71
IV	9 (28.1%)	18 (33.3%)	13 (36.1%)	
Atrial Fibrillation	19 (59.4%)	34 (63%)	17 (47.2%)	0.32
Chronic renal failure	1 (3.1%)	5 (9.3%)	1 (2.8%)	0.33
Mitral Valve Disease				
Regurgitation	7 (21.9%)	23 (42.6%)	15 (41.7%)	0.095
Stenosis	17 (53.1%)	14 (25.9%)	10 (27.8%)	
Mixed lesion	8 (25%)	17 (31.5%)	11 (30.6%)	
Urgency	2 (6.3%)	9 (16.7%)	2 (5.6%)	0.16
Reoperation	7 (21.9%)	8 (14.8%)	3 (8.3%)	0.29
Surgical Approach				
Left Atrial	30 (93.8%)	49 (90.7%)	30 (83.3%)	0.34
Trans-Septal	2 (6.3%)	5 (9.3%)	6 (16.7%)	
Tricuspid Repair	5 (15.6%)	10 (18.5%)	6 (16.7%)	0.93
CABG	3 (9.4%)	8 (14.8%)	4 (11.1%)	0.73

CABG=Coronary artery bypass grafting, *significant

Table-2: Echocardiographic characteristics at baseline, discharge and follow-up

Variables	Preoperative	Discharge	At 6th Months	*p*-value Within Groups	*p*-value Between groups	Interactive *p*-value (time x group)
Left Atrium						
Group 1 (n=23)	58.87±8.03	53.13±9.74[a]	51.65±9.12[ab]	<0.001	0.06	<0.001
Group 2 (n=40)	69.33±17.54	60.60±17.21[a]	58.38±16.99[ab]	<0.001		
Group 3 (n=28)	67.64±13.44	60.57±14..2[a]	56.00±13.36[ab]	<0.001		
Left Ventricular End Diastolic Dimension						
Group 1 (n=23)	48.91±13.46	45.04±12.5[a]	47.83±11.96[b]	<0.001	0.12	<0.001
Group 2 (n=40)	60.75±11.89	52.38±11.19[a]	50.38±11.19[ab]	<0.001		
Group 3 (n=28)	60.18±19.94	51.00±16.32[a]	51.00±16.32[ab]	<0.001		
Left Ventricular End Systolic Dimension						
Group 1 (n=23)	35.30±9.97	31.00±9.28[a]	33.78±8.67[b]	<0.001	0.078	<0.001
Group 2 (n=40)	45.58±8.93	37.88±8.47[a]	35.75±7.28[ab]	<0.001		
Group 3 (n=28)	46.75±15.46	36.46±15.33[a]	31.96±13.64[ab]	<0.001		
Ejection Fraction (%)						
Group 1 (n=23)	62.35±6.53	56.22±5.68[a]	52.78±5.13[ab]	<0.001	0.002	<0.001
Group 2 (n=40)	58.83±9.05	53.10±8.86[a]	54.83±8.46[ab]	<0.001		
Group 3[d] (n=28)	63.89±9.08	59.43±8.27[a]	63.36±7.88[b]	<0.001		
Pulmonary artery pressure						
Group 1(n=23)	63.38±15.97	51.17±15.55[a]	49.75±15.14[ab]	<0.001	0.005	0.01
Group 2[e] (n=40)	54.80±8.00	42.60±9.32[a]	40.43±9.14[ab]	<0.001		
Group 3 (n=28)	61.50±7.82	47.54±7.95[a]	42.96±7.77[ab]	<0.001		

Adjustment for multiple comparisons: Bonferroni.
Within Groups: [a]p< 0.01 with respect to preoperative, [b]p<0.01 with respect to discharged;
Between Groups: [d] p<0.01 Group 3 vs. group 2, [e]p<0.01 Group 2 vs. Group 1

Table-3: Postoperative complications

Complication	Group 1 n=32	Group 2 n=54	Group 3 n=36	*p*
Low CO syndrome	4 (12.5%)	2 (3.7%)	1 (2.8%)	0.15
Stroke	1 (3.1%)	1 (1.9%)	1 (2.8%)	0.92
Atrial fibrillation	11 (34.4%)	23 (42.6%)	13 (36.1%)	0.75
Mediastinitis	0 (0%)	1 (1.9%)	0 (0%)	0.53
Ventilation >48 hrs	4 (12.5%)	3 (5.6%)	1 (2.8%)	0.25
Reintubation	2 (6.3%)	1 (1.9%)	1 (2.8%)	0.53
Acute renal failure	2 (6.3%)	2 (3.7%)	1 (2.8%)	0.75
Pacemaker	1 (3.1%)	2 (3.7%)	1 (2.8%)	0.97
Pneumonia	2 (6.3%)	1 (1.9%)	1(2.8%)	0.53
Reopening	3 (9.4%)	1 (1.9%)	1 (2.8%)	0.21
Sepsis	1 (3.1%)	2 (3.7%)	1 (2.8%)	0.97

Table-4: Survival mortality and loss to follow-up

Characteristics	Group 1 n=32	Group 2 n=54	Group 3 n=36	*p*
Death	3 (9.4%)	3 (5.6%)	1 (2.8%)	0.50
Loss To Follow-up	6 (18.8%)	11 (20.4%)	7 (19.4%)	0.98
Survival	23 (71.9%)	40 (74.1%)	28 (77.8%)	0.85

DISCUSSION

The first reported MVR (Starr-Edwards prosthetic valve) in 1961 involved complete excision of mitral leaflets, chordae tendineae and tips of the papillary muscles.[16] Initially, there was an increased incidence of low cardiac output syndrome and associated mortality. The concept of annulo-ventricular continuity was initially proposed by Wiggers and Katz[17] and later on by Rushmer *et al*[18]. According to this concept, there exists a dynamic interaction between the mitral annulus and left ventricular wall which is responsible for the LV function and geometry.

In canine experiments, Rastelli showed that after replacement with Starr-Edwards prosthesis the cardiac performance was unaffected irrespective of whether the chordae were preserved or resected.[19] The concept of chordal preservation during MVR to reduce postoperative low cardiac output syndrome was adapted by Lillehei, in 1964[20]; a reduction in operative mortality from 37% to 14% was reported.[21–23)] However, he was met with strong opposition.[19,24–26]

Hansen hypothesised that improved LV systolic performance after subvalvular apparatus preservation was due to a reduction of LV afterload; chordal transection resulted in chamber dilatation and dykinesia at the sites of insertion of the severed papillary muscles.[27] In 1994, David, in a randomised trial, showed that chordal preservation resulted in better LV function than those with no preservation, even after 7 years.[28]

Hansen and associates demonstrated that LV function was more affected when the chordae to the AML were excised as compared to those of the PML.[27] The superiority of chordal sparing over conventional MVR in terms of exercise capacity, LV systolic dimensions and ejection fraction was shown by Hannein and colleagues[3] and Rozich and colleagues[6]; however, no significant differences were noted between those receiving posterior or bileaflet chordal preservation.

Hansen observed poorest LV function with transection of all chordae, reasonable with preservation of either the AML or PML and best with preservation on the entire subvalvular apparatus.[27] A review article published in 2005 from New Delhi highlighted the following advantages of complete chordal preservation:[8]

1. preservation of LV geometry and function;
2. reduction of operative mortality;
3. reduction of risk of ventricular rupture;
4. mprovement of early and long term survival and
5. improvement in RV function.

A study was conducted by Chowdhury *et al* to evaluate the outcome of MVR in rheumatics. Three groups were formed, i.e., total excision, partial preservation and complete preservation. Echocardiographically determined indices of LV function were superior in the complete preservation group; however, clinical improvement was found in all three groups.[10] Another feature highlighted in their study was that total chordal preservation with implantation of an appropriate sized prosthesis was possible in the majority of these rheumatic patients. Similar results were shown by Wasir *et al*.[29]

A retrospective analysis to study the impact of preservation techniques in rheumatic patients undergoing MVR concluded that: complete chordal preservation is possible in a large percentage of rheumatic patients; in MR higher reductions in LV volumes may be obtained; in MS postoperative increase of LV volume may be avoided; LV ejection and pulmonary hypertension may improve with time and that clinical outcomes may also improve with subvalvular preservation.[9]

Improvement of left ventricular systolic function, functional capacity and survival after subvalvular apparatus preservation have been demonstrated in our study in concordance with other studies.[1–4,6,7,29] Consistent with the studies carried out in New Delhi[10] and in Valencia[9], our results coordinate with them in the early and midterm postoperative periods. Improvements in the ejection fractions and LV dimensions revealed comparative results with the above two studies. We refer these comparable results as secondary to the similar class of patients, as the predominant disease in our region is rheumatic heart disease. Another interesting finding discovered in this study was an improvement in Pulmonary artery pressures and Left Atrial Dimensions. These salient features may be responsible for the improved postoperative performance and cardiac function.

There was a lower incidence of low cardiac output syndrome and other postoperative complications in the preservation groups compared with the resection group. The preservation groups also showed a greater

improvement in functional class (NYHA) and postoperative AF than those undergoing conventional MVR, consistent with the above studies.[9,10] These findings were purely clinical observations as they were statistically insignificant.

Strong support in favour of preservation was highlighted in a meta-analysis, in which the incidence of LCOS requiring ionotropic support, early and mid-term survival were compared. It also stated that surgeons should be familiar with a number of preservation techniques and that these techniques require echocardiographic quality control and follow-up to diagnose any complications earlier, related to the technique.[30]

CONCLUSION

We conclude that mitral valve preservation (partial or complete) is a preferred and possible method in a large subset of diseased mitral valve with a predominance of Rheumatic heart disease. It improves cardiac function, reduces cardiac chamber size, improves ejection fraction, thereby facilitating remodelling of the left ventricle. It not only modifies pulmonary artery pressure but also improves clinical outcomes.

LIMITATIONS

The study is based on echocardiographic analysis which has an observer's limitation. We lacked geometrical analysis of the left ventricle as these complex parameters were not available at our institute. This study was based on a single centre with a mid-term follow up of 6 months, lacking morbidity and mortality as end points and outcomes in the long term.

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