Echocardiographic Evaluation of Patients Undergoing Mitral Valve Replacement with Crossed Papillopexy

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Summary

Background: Techniques for mitral valve replacement with preservation of the subvalvular apparatus have proven their superiority, and crossed papillopexy is a new technical option which, besides allowing preservation of the anatomical structures, provides contractility support and protection to the myocardium during ventricular diastole. The technique requires further studies that document its results.

Objectives: To evaluate the left atrial and ventricular function by Doppler echocardiography in patients who have undergone mitral valve replacement with crossed papillopexy.

Methods: Fifteen patients underwent mitral valve replacement, 9 (60%) of them male, and the mean age was 45.7 years. As to the etiology of aortic valve disease, nine (60%) cases were degenerative, three (20%) were rheumatic, two (13.3%) were ischemic, and one patient (6.7%) had infectious endocarditis. After closure of the atriotomy and anatomical evaluation of the valvar apparatus, the anterior leaflet was detached from the annulus and centrally split in halves, each one with its complex tendinous chords attached to the opposing commissure by its medial extremity. Biological (13 cases) or mechanical prosthetic valves were implanted and secured with separate stitches. Reduction of the valvar annulus was performed in patients with dilated cardiomyopathy. Patients underwent clinical and Doppler echocardiographic examinations before surgery and six months after the procedure.

Results: All patients were clinically stable at discharge. A significant reduction in ventricular and atrial diameters was demonstrated ($p < 0.001$) without impairment of the entry and exit points of the left ventricle.

Conclusion: Mitral valve replacements performed with the crossed papillopexy technique showed favorable results with a positive effect on the recovery of left atrial and ventricular morphology. (Arq Bras Cardiol 2009; 93(2) : 87-91)

Key Words: Mitral valve insufficiency/surgery; cardiomyopathy, dilated; papillary muscles/surgery.

Introduction

There is evidence of the advantages of valvoplasty over prosthetic valve replacement for the treatment of mitral valve insufficiency[1]. However, indications for surgery in patients with advanced mitral valve degeneration, requiring replacement with artificial valves, are still relatively frequent. The concept of not excising all chordal and papillary muscles has been established and divulged; now, new discussions focus on defining technical options for better use of the advantages of maintaining papillary muscle-annular continuity. Recent publications have agreed on the preservation of both leaflets[2,3], so as to not interfere with the function of the prosthesis; echocardiography is an efficient method for performing this evaluation[4].

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Manuscript received February 04, 2008; revised manuscript received May 08, 2008; accepted June 18, 2008.

Moreover, evidence has also accumulated of the benefits of valve replacement using ventricular remodeling techniques in treating advanced heart failure with significant mitral functional insufficiency[5,6], since exclusive interventions on the annulus are subjected to the recurrence of mitral insufficiency secondary to the progression of myocardial degeneration.

Based on previously described procedures of the subvalvar approach, Gomes et al.[7] introduced the crossed papillopexy[8] method in an attempt to optimize ventricular performance following mitral valve replacement, reestablishing ventricular geometry even in hearts with significant dilation. The aim of this study is to describe the progression of left atrial and ventricular function according to echocardiographic parameters in the sixth postoperative month of patients who underwent mitral valve replacement with the crossed papillopexy technique.

Method

This is a prospective study of 15 patients who consecutively underwent mitral valve replacement with crossed papillopexy

at the *Serviço de Cirurgia Cardiovascular da Santa Casa de Misericórdia de Goiânia*.

The study was approved by the institution's Research Ethics Committee (CONEP register number 12507), and was conducted after the formal informed consent of the patients.

Nine (60%) patients were men and 6 (40%) were women. Patients' ages ranged from 17 to 69 years (49.9 ± 10.2).

Inclusion criterion was the presence of severe mitral insufficiency (defined as a regurgitation flow >40%) with atrial e ventricular repercussions. The most frequent cause of valvar dysfunction was fibroelastic degeneration in nine cases (60.0%), rheumatic valvar lesion in three (20.0%), ischemic mitral insufficiency in two (13.3%), and valvar degeneration secondary to endocarditis in one case (6.7%) (Table 1).

All patients were receiving clinical treatment, although without an adequate response, and all were operated on by the same surgical team.

Clinical and Doppler echocardiographic evaluation was performed before surgery and in the first, third, and sixth months after surgery**;** the aim of this study was the comparison between pre- and postoperative evaluations (at sixth months).

The functional grade of heart failure was determined according to the Criteria Committee of The New York Heart Association[9].

Doppler echocardiograms were performed by the same professional using the HDI 5000 device with P4-2 MHz transducer (Philips, Einthoven - Holland). The left ventricular ejection fraction was calculated as per the volumes obtained using the Teichholz formula. There were seven cases (46.7%) of ruptured tendinous chordae in the posterior mitral leaflet and one case in the anterior leaflet (6.7%). The preoperative left ventricular function was preserved in ten cases (66.6%) and impaired in five cases (33.4%). In the postoperative evaluation, transprosthetic and aortic gradients were assessed to detect potential obstructions.

Table 1 - Patient data

N Note	Diagnosis	Associated Procedure	Mitral Prosthesis
1	DRML +mild AoI + mild TI	MVR+CP	Labcor 29
2	MP	MVR+CP	Labcor 29
3	FIMI +severe TI +CI	MVR+ CP+TP + MR	Labcor 29
4	MI + moderate TI	MVR+CP+TP	Labcor 29
5	FIMI +mild AoI +CI	MVR+CP+MR	Labcor 29
6	MP	MVR+CP	CarboMedics 29
7	MP+ DAoL	MVR+CP+AVR	CarboMedics 29
8	MP	MVR+CP+AFCS	Labcor 31
9	MP	MVR+CP	Labcor 29
10	MP + moderate TI	MVR+CP+TP	Labcor 29
11	DRML + mild AoI	MVR+CP	Labcor 29
12	MP	MVR+CP	Labcor 31
13	DRML	MVR+CP	Labcor 29
14	MP + mild AoI + mild TI	MVR+CP	Labcor 29
15	AoI + MI	MVR+CP+AVR	CarboMedics 29

N - number, MP – Mitral prolapse, FIMI – Functional ischemic mitral Insufficiency, DRML – Double rheumatic mitral lesion, AoI – Aortic insufficiency, DAoL – Double aortic lesion, CI – Coronary insufficiency, TI – Tricuspid insufficiency, TP – Tricuspid plasty, AVR – Aortic valve replacement, SAFC – Surgical atrial fibrillation correction CP - crossed papillopexy

Operative technique

All surgeries were performed by standard median sternotomy with cannulation of the ascending aorta and of both caval veins separately, after systemic heparinization and mild hypothermia (32°C). Antegrade blood cardioplegia was used to protect the myocardium from damage.

The mitral valve was exposed through left atriotomy with an incision parallel to the interatrial sulcus. The need for valve replacement was confirmed after direct inspection and analysis as to the presence of leaflet calcification, fusion, fibrosis, or prolapse, chordal rupture, fibrosis, or elongation, and annular dilation.

The anterior leaflet was lifted with two repair stitches on its free edge, and its subvalvar apparatus was carefully inspected. Depending on A circular incision was made at the base of the anterior leaflet approximately two millimeters away from the mitral annulus and extending slightly below the commissural points. The anterior leaflet was centrally divided and each half, with its chordae tendineae complex, was attached to the opposite commissure by its medial extremity (Figure 1).

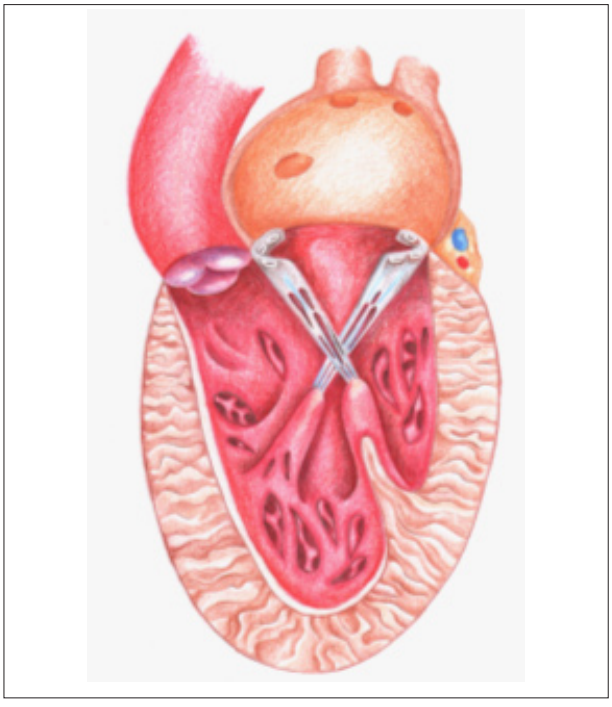

***Figure 1** - Schematic representation of crossed papillopexy.*

The use of valvar prostheses with diameters smaller than the native annulus helped reduce the size of the base of the heart. The sutures were then passed through the prosthetic ring and sutured to the valvar annulus. Biological prostheses (Labcor - Belo Horizonte - MG) and mechanical prostheses (CarboMedics – Austin –Texas - USA) were used, as per the indication for each case. With the patient's heart beating, the prosthesis was carefully examined to check for perfect function. Associated procedures were indicated for seven patients (Table 1).

After the end of the surgery, patients who were hemodynamically stable were transferred to the intensive care unit where they remained under continuous monitoring.

All patients were followed during hospitalization and as outpatients according to the protocol for obtaining and comparing data.

Statistical analysis of the paired data obtained involving normal distribution variables was performed with Student's *t* test.

Results

No deaths occurred in hospital or during the six-month follow-up. Four patients (26.6%) had a diagnosis of mild aortic insufficiency, which persisted during the follow-up period. There were no hemorrhagic or infectious complications.

Mean end-diastolic ventricular diameters were reduced from 65.3 ± 8.7 mm to 51.5 ± 8.9 mm ($p<0.001$), whereas the end-systolic diameters were reduced from 44.3 ± 9.1 mm to 35.2 ± 1.1 mm ($p<0.001$). Atrial diameters varied favorably from 55.1 ± 8.6 mm to 45.3 ± 8.9 mm ($p< 0.001$). The end-diastolic volume was reduced from 229.7 ± 85.0 ml to 130.5 ± 51.7 ml ($p<0.001$), and the end systolic volume from 91.6 ± 64.2 ml to 58.7 ± 50.3 ml ($p = 0.001$). The systolic volume decreased from 138.0 ± 41.0 ml to 78.5 ± 30.8 ml ($p = 0.002$). The percentage of systolic shortening ranged from 32.1 ± 9.4 % to 32.2 ± 8.7% ($p=0.917$), and the ejection fraction had a slight drop compared to preoperative levels, from 62.9 ± 14.0 % to 61.9 ± 11.7 % ($p=0.684$) (Figure 2).

Cardiac mass was reduced from 294.9 ± 115.5 g to 214.9 ± 64.4 g ($p= 0.001$). Pulmonary artery pressure improved significantly, decreasing from 53.4 ± 13.1 mmHg to 32.9 ± 7.9 mmHg ($p< 0.001$). (Table 2).

The mean transprosthetic gradient was 3.9 ± 1.3 mmHg, and no impairment was observed in the entry pathways and the aortic subvalvar region of the left ventricle. All patients experienced significant clinical improvement. Six (40.0%) patients were in NYHA IV functional class, eight (53.3%) in functional class III, and one (6.7%) in class II. After the six-month follow-up, two patients (13.3 %) are in functional class II and 13 (86.7%) are in functional class I.

Discussion

Several techniques for subvalvar preservation have been published confirming improvement in ventricular performance, including cases of severely impaired systolic function[10-12].

Only a few studies do not report benefits from preservation of the tendinous chordae[13,14].

Echocardiographic evaluation is considered an adequate method to provide information about the geometry and functional status of the heart after mitral valve replacement; moreover, the noninvasive nature of the method in assessing myocardial performance is a favorable aspect[15].

In this study, changes in left ventricular morphology translated into a significant reduction of ventricular diameters. Papillary muscle traction prevents passive diastolic dilation, and the loss of this restraining force is reflected in the ventricular wall, since annulus-papillary muscle continuity regulates ventricular preload, thus determining the contraction force[16]. A reduction in ventricular wall shortening and dyskinesia was observed in the zone underlying the base of the papillary muscles during

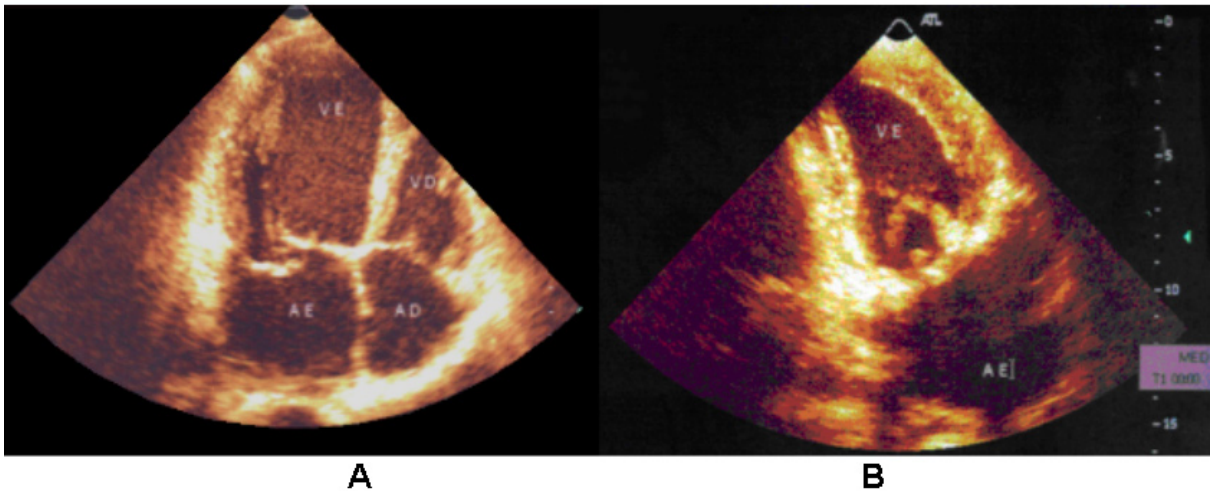

Figure 2 - Echocardiographic images highlighting recovery of a more elliptical shape of the left ventricle six months after mitral valve replacement with crossed papillopexy. A - Preoperative; B - Postoperative.

Table 2 - Results

Echocardiographic parameters	Preoperative		Postoperative		
	Mean	SD	Mean	SD	*p*
LVDd (mm)	65.3	8.7	51.5	8.6	<0.001
LVSd (mm)	44.3	9.1	35.2	11.1	<0.001
LAD (mm)	55.1	8.6	45.3	8.9	<0.001
EDV (ml)	229.7	85.0	130.5	51.7	<0.001
ESV (ml)	91.6	64.2	58.7	50.3	0.001
SV (ml)	138.0	41.0	78.5	30.8	0.002
LVEF (%)	62.9	14.0	61.9	11.7	0.684
D (%)	32.1	9.4	32.2	8.7	0.917
LV mass (g)	294.9	115.5	214.9	64.4	0.001
PASP (mmHg)	53.4	13.1	32.9	7.9	<0.001

LVDD – Left ventricular diastolic diameter, LVSD – Left ventricular systolic diameter, D% - Percentage of left ventricular systolic shortening, LVEF – Left ventricular ejection fraction, LAD – Left atrial diameter, EDV – End-diastolic volume, ESV – End-systolic volume. Sv – Systolic volume, CM – Cardiac mass, PASP – Pulmonary artery systolic pressure, SD – Standard deviation.

the postoperative period of valve replacement by standard technique; this directly reflects the impairment caused by the lack of tension of the papillary muscle to the ventricular wall[17].

Recovery of the shortening percentage has been described for hearts with a preserved subvalvar apparatus[18], which, associated with the behavior of the torsional deformation, reflects cardiomyocyte contractility[19]. In this study, the evaluation of the systolic shortening percentage showed a slight improvement. Although not significant, these results can be considered satisfactory in face of the short six-month follow-up.

Reduction of cardiac mass reflects positive left ventricular remodeling, and a 27.1% ($p = 0.001$) reduction in hypertrophy was observed using left ventricular mass variation analysis.

On the other hand, myocardial dysfunction in patients with mitral insufficiency is generally disguised because part of the ventricular ejection is discharged into a low-pressure and low-resistance chamber, the left atrium. Therefore, the ejection fraction of patients with mitral insufficiency in the preoperative phase can be overestimated[20]. This detail accounts for a 1.6% ($p=0.684$) reduction in the ejection fraction after six months of follow-up in this study, despite the improvement in the clinical conditions and ejection volume, findings which have been described in other studies as well[16]. Moreover, elimination of mitral valve regurgitation leads to an immediate increase in post-load, and the non-adapted left ventricle starts to eject blood against systemic resistance, which has been considered an important cause of deterioration of the ventricular function in the postoperative phase of patients with mitral insufficiency. On the other hand, ventricular impairment is less marked in mitral valvuloplasties, which shows that the increase in post-load is not self-explanatory. It is believed, therefore, that the preservation of the subvalvar apparatus in mitral repair is fundamental to achieve the best results.

Such evidence thus justifies the efforts in research to enhance the correlated operative techniques.

The feasibility of crossed papillopexy can also be confirmed for not having generated restriction of the implanted prosthetic leaflets and for not having caused obstruction in the left ventricular entry pathway, which is also reflected in the recovery of the pulmonary artery systolic pressure and in left atrial remodeling. A significant reduction was observed in the left atrial diameters ($p< 0.001$) and in the pulmonary artery systolic pressure of 38.5%. Left atrial remodeling can be considered a prognostic factor of clinical improvement and survival after valve replacement surgery[21].

In the presence of aortic valve regurgitation, which was the case in 26.6% of this group of patients, the benefit of employing the technique has been confirmed. In these cases, there was no progression of ventricular dysfunction, a pathological condition in which the potential of dilation and harmful diastolic remodeling is much greater.

In excessively dilated hearts, with increased interpapillary distance and its higher repositioning in ventricular cavity, the support provided by papillary muscles to longitudinal shortening is limited.

In the valve replacement technique originally described by MIKI et al[22], the papillary muscles become parallel to the ventricular wall, thus favoring wider displacement of the wall and undesirable sphericity. Crossed papillopexy, with the implantation of each half of the leaflet in the opposing commissure, has the objective of increasing the tension of the papillary muscles acting more intensely in reverse left ventricular remodeling. Perhaps the benefits may be even more marked in cases of dilated myocardiopathy, aimed at making the papillary muscles participate in ventricular contraction again. The technique employed in this study, which corrects mitral insufficiency, tends to promote internal remodeling of the ventricular cavity and reduce the diameter at the base of the heart, thus reducing mitral annulus circumference through the implantation of a prosthesis one or two sizes smaller than the left atrioventricular annulus.

Conclusion

Taking into consideration that this is non-randomized, non-comparative, small-sized sample study with only six months of follow-up, crossed papillopexy is a feasible technical alternative for promoting geometric recovery of the left cardiac chambers.

Acknowledgements

We wish to thank the Department of Cardiology of the *Santa Casa de Misericórdia de Goiânia*: Ana Claudia Nogueira, Delzirene Pinheiro Botelho, Rômulo Sales, Luiz Rassi Júnior, and Antônio Calzada Machado, for their continuous and valuable support.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This article is part of the thesis of master submitted by Geraldo Paulino Santana Filho, from Núcleo de pós-graduação e pesquisa da Fundação Cardiovascular São Francisco de Assis - Servcor.

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