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Surgical repair of chordae tendineae rupture after degenerative valvular regurgitation using standardized bovine pericardium

Correção da ruptura de cordas tendíneas na insuficiência mitral degenerativa pelo emprego de cordas padronizadas de pericárdio bovino

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Abstract

Objective: **To evaluate clinically and by Doppler Echocardiography 22 patients submitted to mitral valve repair after valvular regurgitation using standardized bovine pericardium chordae.**

Methods: **The patients had degenerative mitral regurgitation. Fourteen (63.6%) patients were male and the age ranged from 19 to 76 years (mean 56.8 ± 13.8 years). The strings of bovine pericardium treated with glutaraldehyde were reinforced in its transverse ends forming a trapezoid.**

Results: **One patient (4.5%) died in the immediate postoperative period with in low cardiac output syndrome and three (13.6%) in the late postoperative period. One patient (4.5%) was reoperated. The actuarial curves for survival free of death from cardiovascular causes and free from reoperation for patients who left the hospital (21), showed rates of 82.0 ± 9.8% and 83.9 ± 10.4% at 70 months postoperatively, respectively. Seventeen patients (77.3%) are alive with native valves. Of the 17 patients alive with native valves 16 (94.1%) were in functional class I. The Doppler Echocardiography postoperatively (mean 41 months, 4-70 months), showed no mitral regurgitation in 11 (64.7%) patients and mild regurgitation in five (29.4%).**

Conclusion: **The technique of standard cords of bovine pericardium implantation to replace chordae tendineae of the mitral valve in patients with degenerative mitral regurgitation showed satisfactory results.**

Descriptors: **Mitral valve insufficiency. Papillary muscles. Chordae Tendineae. Pericardium.**

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Abbreviations, acronyms & symbols	
LA	Left atrium diameter
MVA	Mitral valve area
FE	Ejection fraction
MMTG	Mean Mitral Trasvalvar Gradient
NYHA	New York Heart Association
PD_2VE	Left ventricular end-diastolic pressure
PTFE	Polytetrafluoroethylene
VDFVE	Left ventricular end-diastolic pressure

Resumo

Objetivo: **Avaliar, clinicamente e pelo ecodopplercardiograma, o funcionamento da valva mitral em 22 pacientes submetidos à correção do refluxo valvar com substituição das cordas tendíneas nativas por cordas padronizadas de pericárdio bovino.**

Métodos: **Os pacientes apresentavam insuficiência mitral degenerativa. Quatorze (63,6%) pacientes eram do gênero masculino e a idade variou de 19 a 76 anos (média 56,8±13,8 anos). As cordas de pericárdio bovino foram tratadas com glutaraldeído, com reforço de suas extremidades transversais formando um trapézio.**

Resultados: **Um (4,5%) paciente faleceu no pós-operatório imediato em síndrome de baixo débito cardíaco e três (13,6%) no pós-operatório tardio. Uma (4,5%) paciente foi reoperada. As curvas atuariais de sobrevivência livre de óbitos por causa cardiovascular e livres de reoperações para os pacientes que deixaram o hospital (21) demonstraram taxas de 82,0±9,8% e 83,9±10,4%, aos 70 meses de pós-operatório, respectivamente. Dezessete (77,3%) pacientes estão vivos com a própria valva. Dos 17 pacientes vivos com a própria valva 16 (94,1%) estão em classe funcional I. O ecodoppler pós-operatório (média de 41 meses; 4 a 70 meses) demonstrou ausência de regurgitação mitral em 11 (64,7%) pacientes e regurgitação discreta em cinco (29,4%).**

Conclusão: **A técnica de implante de cordas padronizadas de pericárdio bovino para substituição de cordas tendíneas da valva mitral em pacientes com insuficiência mitral degenerativa demonstrou resultados bastante satisfatórios.**

Descritores: **Insuficiência da valva mitral. Músculos papilares. Cordas tendinosas. Pericárdio.**

INTRODUCTION

If not the most frequent, surely one of the most important causes of mitral regurgitation has been ruptured chordae, present in all etiologies, especially in degenerative. The chordae rupture, leading to prolapse of the corresponding leaflet, were surgically treated at the beginning of surgery with cardiopulmonary bypass by McGoon [1], by plication of the prolapsed portion of the leaflet.

Initial results were good, but in the long-term led to the decreased mobility of the leaflet, especially the anterior. Merendino et al. [2] proposed the resection of the posterior leaflet of the mitral valve, thus eliminating the prolapse and suturing edge to edge this leflet, preceded by plication of the mitral ring. This technique has been used to the present day, with excellent results; limited, however, to rupture of the posterior leaflet [3]. Poor results with resection of the anterior leaflet of the mitral valve led Carpentier et al. [4] to introduce the technique of transferring strings of the posterior leaflet to the anterior leaflet of the mitral valve in cases of ruptured chordae.

The creation of new chordae from tissue flap of the anterior leaflet was proposed by Gregori et al. [5], for correction of prolapse in cases of rupture of the anterior leaflet chordae. However, this technique has been reserved for those cases where there is exuberant tissue, which is common in the degenerative disease. Since January 1991, we employed a technique for correction of prolapse of the anterior leaflet of the mitral valve secondary to ruptured chordae, with good results. It consists in providing chordae from the partial transfer of the tricuspid valve to the mitral valve [6]. The valve prolapse has been treated by other techniques that try to avoid any kind of restriction on the mobility of the anterior leaflet of the mitral valve, such as the making of bovine pericardium [7] or polytetrafluoroethylene (PTFE) [8] artificial chordae.

Since 2006, we have used a prosthesis for replacement of ruptured tendineae chordae [9,10]. It deals with bovine pericardium premolded chordae preserved in glutaraldehyde. The technique is similar to the partial transfer of the tricuspid valve to the mitral valve for the supply of new chordae [6].

The aim of this study is to present the postoperative outcome of a consecutive series of patients with degenerative mitral regurgitation secondary to ruptured chordae, who had undergone reconstructive surgery with implantation of bovine pericardium premolded chordae treated in glutaraldehyde and anti-calcifying agents.

METHODS

We prospectively studied 22 patients undergoing mitral valve failure repair surgery of degenerative cause, from May 1996 to May 2012. These patients had mitral valve prolapse by chordal rupture leading to regurgitation. The patients

underwent consecutively surgery by the same surgeon, at Hospital Evangélico de Londrina (Londrina, PR, Brazil) and Hospital João de Freitas de Arapongas (Arapongas, PR, Brazil), by the technique of replacing the ruptured chordae tendineae by implantation of bovine pericardium premolded chordae treated in glutaraldehyde and anti-calcifying agents (Braile Biomédica, São José do Rio Preto, SP, Brazil).

The clinical preoperative data of patients are shown in Table 1. Fourteen (63.6%) patients were male and eight (36.4%) were female. The age of patients ranged from 19 to 76 years, mean 56.8 ± 13.8 years.

All patients had mitral regurgitation of degenerative etiology, and fibroelastic degeneration in 16 (72.7%) patients and Barlow syndrome in six (27.3%). Fifteen (68.2%) patients were in functional class III and seven (31.8%) in class IV according the New York Heart Association (NYHA).

Auscultation of the mitral regurgitation has shown murmur in all patients, being severe in 13 (59.1%) and very severe in nine (40.9%). Atrial fibrillation was present in four (18.2%) patients. The clinical diagnosis was confirmed by echocardiography and hemodynamic Doppler then when surgery was indicated. Five (22.7%) patients had tricuspid regurgitation, one (4.5%), atrial septal defect and one (4.5%), chronic coronary failure.

The preoperative hemodynamic data are shown in Table 2.

On hemodynamic examination, performed in 21 patients, mitral regurgitation was moderate in five (23.8%) and severe in 16 (76.2%) patients. As the left ventricle contractility observed by ventriculography we found: normal in eight (38.1%) patients, mild hypokinesia of the left ventricle in five (23.8%), moderate in six (28.6%) and severe hypokinesia in two (9.5%). The average left ventricular end-diastolic pressure (DP_2LV) was 19.8 mmHg (range 12-31 mmHg).

Table 1. Preoperative clinical data.

Nº.	Patients	Gender	Age (years)	Diag	Assoc Diag	Etiol	FC	SMM
1	VG	M	61	IM	TI	FD	IV	++++
2	CLSF	F	51	IM	-	FD	III	+++
3	JR	M	59	IM	-	FD	III	+++
4	AM	M	58	IM	IC	FD	III	+++
5	AMB	M	53	IM	-	FD	III	+++
6	SFN	F	23	IM	TI	FD	III	+++
7	ATF	F	68	IM	CoF	FD	III	+++
8	GMG	F	69	IM	TI	FD	III	+++
9	JAO	M	61	IM	-	FD	IV	++++
10	PSM	M	19	IM	-	FD	IV	++++
11	AC	M	72	IM	-	FD	III	+++
12	SM	M	76	IM	-	BARLOW	IV	++++
13	NAN	F	45	IM	-	FD	III	+++
14	GAL	M	55	IM	-	FD	III	+++
15	JC	M	66	IM	-	BARLOW	IV	++++
16	MAT	F	53	IM	-	FD	III	+++
17	MLPS	F	62	IM	-	FD	III	+++
18	AR	M	53	IM	-	BARLOW	IV	++++
19	HJA	M	55	IM	-	FD	IV	+++
20	JAL	F	70	IM	TI	BARLOW	III	++++
21	RF	M	62	IM	TI	BARLOW	III	++++
22	ABR	M	58	IM	-	BARLOW	III	++++
Mean ± SD			56.8 ± 13.8					

M = Male, F = Female, FC = Functional Class (NYHA) = Diag = diagnosis, Assoc Diag = Associate diagnosis, Etiol = Etiology, SMM = Systolic mitral murmur, MF = Mitral failure, TI =Tricuspid Insufficiency, IC = Interatrial communication, CoF = Coronary Failure, FD = Fibroelastic degeneration, Barlow = Barlow syndrome, SD = Standard deviation.

Table 2. Preoperative hemodynamic data.

No.	Patients	Gender	Cat date	Surg Date	LV Cont	MR	ED_2LVP
1	VG	M	15/05/06	31/05/06	Sev Hipo	Import	30
2	CLSF	F	04/08/06	29/08/06	Normal	Import	18
3	JR	M	06/06/06	20/09/06	Normal	Import	31
4	AM	M	26/09/06	09/10/06	Normal	Mod	15
5	AMB	M	17/04/06	16/10/06	Disc Hypo	Mod	16
6	SFN	F	-	14/11/06	-	-	-
7	ATF	F	08/11/06	04/12/06	Normal	Import	25
8	GMG	F	03/05/06	06/12/06	Normal	Import	20
9	JAO	M	22/12/06	29/01/07	Mod Hypo	Import	16
10	PSM	M	12/01/07	12/02/07	Mod Hypo	Import	28
11	AC	M	14/02/07	27/02/07	Disc Hypo	Import	20
12	SM	M	21/05/07	30/05/08	Disc Hypo	Import	15
13	NAN	F	02/08/08	19/08/08	Disc Hypo	Mod	14
14	GAL	M	28/11/08	15/12/08	Mod Hypo	Import	24
15	JC	M	13/07/09	19/08/09	Normal	Import	15
16	MAT	F	10/09/09	17/09/09	Disc Hypo	Import	12
17	MLPS	F	08/10/09	31/03/10	Normal	Import	24
18	AR	M	12/03/10	20/05/10	Mod Hypo	Mod	12
19	HJA	M	28/09/10	06/10/10	Mod Hypo	Import	15
20	JAL	F	20/10/10	03/11/10	Mod Hypo	Import	22
21	RF	M	05/01/11	16/03/11	Sev Hipo	Import	23
22	ABR	M	28/02/12	05/03/12	Normal	Mod	21
Mean							19.8 [12 to 31]

Disc Hypo = Discrete Hypokinesia, Mod Hypo = Moderate Hypokinesia, Sev Hypo = Severe Hypokinesia, Cat date = Date of catheterization, Surg Date = Date of Surgery, LV Cont = Left ventricular contractility, MR = Mitral regurgitation, ED_2LVP = End-diastolic left ventricular pressure

In all patients, two changes were always present, ruptured chordae and dilatation of the mitral valve annulus. In 13 (59.1%) patients, chord rupture was on the anterior leaflet of the mitral valve, in eight (36.4%), in the posterior leaflet and in one (4.5%) in both leaflets.

Prosthesis

The bovine pericardium premolded chordae were performed in monoblock (Braile Biomédica, São José do Rio Preto, SP, Brazil), trapezoid-shaped, with enhanced bovine pericardium or Dacron in their upper and lower beams. The chordae are premolded in number from five to seven, with lengths ranging from 20 to 35 mm. Its width is 2 mm and are distant from each other by 3 mm. The standardization of the chordae was confirmed by the use of steel meters corresponding to the size of the prostheses. The pericardium was treated with 0.5% glutaraldehyde, subjected to anti-calcification treatment with glutamic acid and preserved in 4% formaldehyde solution. Strength and durability tests showed levels of rupture of about 15 kg/cm^2 [11].

The prostheses implanted were in numbers 35, 30, 25 and 20 in one (4.5%), 12 (54.5%), seven (31.8%) and two (9.1%) patients, respectively. The size of the graft was determined based on the distance from the top of the papillary muscle to the free edge of the leaflet in its original position, not prolapsed. Thirteen (59.1%) patients received prostheses to the anterior leaflet, eight (36.4%) to the posterior leaflet and one (4.5%) for both. The implant prosthesis begins with setting the lower part of the trapezoid at the top of the papillary muscle associated with the chordae using a U-section 5-0 polypropylene, anchored in a Dacron pad. In sequence, the larger beam of the trapezoid will be sutured on the free edge of the compromised mitral leaflet with interrupted sutures using 5-0 polypropylene. The prosthesis with five to seven chordae in their original form can be reduced up to two chordae if necessary. It can also have its upper stem (larger) divided, and thus can be both tops sutured to the anterior and posterior leaflets while correcting occasional prolapse of two leaflets.

Associated repair techniques (Table 3)

Annuloplasty - The dilatation of the mitral annulus, present in all cases, was corrected with the use of Gregori-Braile® prosthetic ring [12]. In association, in two (91%) cases, was performed plicature of the mitral annulus near the posteromedial commissure using technique by Wooler et al. [13]. This is a hemi-ellipse prosthesis industrialized and commercially available (Braile Biomédica, São José do Rio Preto, SP, Brazil). Its shape resembles the Carpentier ring without the anterior segment, and presents a modification in its right half. This is a correction of the ring curve. Thus, the prosthesis is hemi-ellipse-shaped, and the right curvature is rectified. The material used is 316 stainless steel, medical grade coated with a layer of silicone rubber, and finally by Dacron. It presents in various sizes, according to various dimensions of the mitral annulus. Choosing the ideal ring was based solely on the distance between the fibrous trigones, which generally correspond to the projections of the commissures in mitral annulus of the patient, regardless of the anteroposterior diameter.

The fixation of the prosthesis in the mitral annulus was performed usingh U-section 2-0 polyester thread in the mitral annulus 1-2 mm apart and then on the outside of the prosthetic ring. The two thresholds which correspond to the ends of the prosthesis are applied to the mitral annulus, at the height of the commissures of the projection, so that after the fixation of the prosthesis, the posterior leaflets moves to the anterior, and what is important, the posteromedial portion moves more sharply in the anterior-lateral directon, thus correcting existing dilation. In two (9.1%) patients, annuloplasty was performed according Wooler et al. [13] to correct the excessive dilation of the posterior annulus of the mitral valve near the posteromedial commissure.

Table 3. Surgical data.

No.	Patients	Surg Date	Annulus	Techniques	Chordae No.	CBT	TMA
1	VG	05/31/06	Ring	DeVega	A 30	94	41
2	CLSF	08/29/06	Ring	SHORT GREGORI CHORDAE	A 20	98	63
3	JR	09/20/06	Ring	RES. CALCIF SHORT. CHORDAE FRATER/CARP	A 30	98	66
4	AM	10/09/06	Ring	SHORT. CHORDAE CARP/ IAC CLOS	P 30	92	52
5	AMB	10/26/06	Ring	MERENDINO + RES. ANT LEAF	P 30	117	62
6	SFN	11/14/06	Ring	SHORT. CHORDAE FRATER	P 20	90	27
7	ATF	12/04/06	Ring	MERENDINO + MMDA	P 30	87	48
8	GMG	12/06/06	Ring	SHORT. CHORDAE CARP+DeVega	P 30	75	26
9	JAO	01/29/07	Ring	MERENDINO + SHORT GREGORI CHORDAE	A 30	100	58
10	PSM	02/12/07	Ring	MERENDINO	P 35	81	44
11	AC	02/27/07	Ring	ENL POST LEAF	A 25	182	123
12	SM	05/30/08	Ring	-	A+P 30	120	61
13	NAN	08/19/08	Ring	SHORT. CHORDAE FRATER	A 25	71	37
14	GAL	12/15/08	Ring	-	A 30	99	52
15	JC	08/19/09	Ring	-	P 25	97	57
16	MAT	09/17/09	Ring	-	A 25	67	22
17	MLPS	03/31/10	Ring	-	A 25	82	42
18	AR	05/20/10	Ring	MERENDINO	P 30	100	41
19	HJA	10/06/10	Ring	-	A 25	85	34
20	JAL	11/03/10	Ring+ WOOLER	DeVega	A 30	86	51
21	RF	0316/11	Ring	MERENDINO SHORT. CHORDAE CARP + DeVega	A 25	121	59
22	ABR	03/05/12	Ring + WOOLER	MERENDINO	A 30	151	79
Mean						100	52

Surg Date = Date of surgery, Annulus = Type of annuloplasty, CBT = Cardiopulmonary bypass time, TMA = Time of myocardial anoxia, Short = Shortenings, RES = Resection, Calcif = Calcification, Carp = Carpentier, AntLeaf = Anterior leaflet, Post leaf = Posterior leaflet, MMDA = Mammary/anterior descending coronary artery, Enl post leaf = Enlargement of posterior leaflet, A = Anterior, P = Posterior, IAC Clos = Interatrial communication closure.

Chordal shortening - The chordal shortening was performed in eight (36.4%) patients. In two (9.1%) of these patients, chordal shortening was performed according to Carpentier et al. [14] with longitudinal incision of the papillary muscle and burial intrapapillar stretched chord. In two (9.1%) patients was used the method described by shortening according Gregori Jr. et al. [15]. We performed a small incision in the anterior leaflet near the elongated cords beam being pulled through the incision and then fixed to the surface of the anterior leaflet. In four (18.2%) patients, we used the technique by Frater et al. [7], or that is, fixing the elongated chordae on the inner face of the anterior leaflet. Minor shortenings are achieved with this technique. Eventually, we use the three methods described for the shortening of elongated chordae in the same patient.

Leaflet resection - In eight (36.4%) patients, we performed resections of leaflets, being quadrangular in the posterior leaflet [2] in seven patients and triangular in anterior leaflet in one [1]. We avoid this last procedure in the anterior leaflet because it could lead to mitral stenosis by decreasing leaflet mobility. After quadrangular resection of the posterior leaflet and posterior leaflet prolapse correction, the two edges of the leaflet were approximated and sutured using 5-0 polypropylene sutures.

Leaflet enlargement - In one (4.5%) patient, we expanded the posterior leaflet of the mitral valve using a bovine pericardial patch to thereby facilitate better coaptation of the posterior leaflet to the anterior.

Other Associated Surgical Techniques

Four (18.2%) patients with functional tricuspid insufficiency underwent annuloplasty according to the technique described by DeVega [16], which consists in encircling the tricuspid annulus to flee the area corresponding to the passage of the conduction beam near the atrioventricular node. One (4.5%) patient had their interatrial communication closed and another (4.5%) underwent myocardial revascularization with internal thoracic artery to the anterior interventricular branch of the left coronary artery.

Postoperative Clinical Evaluation

Hospital and late mortality, the rate of reoperation due to failure of reconstructive surgery, and the postoperative morbidity were observed. The surviving patients (17) were clinically assessed at a median time after surgery of 47 months (range 4-70 months). As preoperatively, patients were classified according to the clinical status according to the NYHA classification of symptoms. On physical examination, during this same period, the auscultation of the mitral valve was assessed for the presence of murmurs.

EchoDopplercardiographic assessment

Seventeen patients underwent Doppler echocardiography to assess left ventricular function, left atrial diameter, mitral valve area, mean gradient, end-diastolic left ventricular volume and the degree of valvular regurgitation. The classification of Doppler echocardiographic mitral regurgitation was based on the extent and magnitude of the regurgitant jet in the left ventricular systole. We assessed the following indices: ejection fraction (EF) of the left ventricle, left atrium diameter (LA), mitral valve area (MVA), mitral mean gradient (GTVM) and left ventricular end-diastolic volume (LVEDV). The mean postoperative assessment of the 17 surviving patients was 47 months (range 4-70 months).

Statistical Analysis

Actuarial survival curve free of death and actuarial survival free of reoperation were obtained for total (22) of patients and for the 21 patients who were discharged from hospital and outpatients [17].

RESULTS

The postoperative clinical data are presented in Table 4. There was one death in the immediate postoperative period (4.5%) in low cardiac output syndrome in 70-year-old patients, diagnosed with mitral and associated tricuspid insufficiency and carrier of Barlow syndrome. The mitral annuloplasty ring consisted of using Gregori-Braile ring and tricuspid annuloplasty was performed using DeVega technique [6].

There were no thromboembolic events or hemolysis postoperatively. Four patients who had atrial fibrillation preoperatively continued with arrhythmia in the postoperative period. Two (9.1%) patients required reoperation at 35 and 46 months for mitral valve replacement, the latter died in low cardiac output syndrome in the first hours after arriving at the Intensive Care Unit. In both patients, the chordae shortening technique was associated and in none of them the bovine pericardium chordae were compromised implanted in the posterior leaflet. There was evolution of fibroelastic degeneration, especially involving the anterior leaflet of the mitral valve that received no artificial chordae.

Two patients died, one month and 12 months postoperatively, suddenly, being previously in functional class I, one without mitral regurgitation and one with slight reflux at Doppler echocardiography. In the first patient, ventricular fibrillation on mobile ICU's electrocardiogram was recorded. These patients had severe left ventricular dyskinesia on preoperative cineventriculography, and high left ventricular end-diastolic pressure. The total number of later deaths was 3 (13.6%) patients, if added these two deaths to those of reoperation after valve replacement. Eighteen (81.8%) patients are alive and 17 (77.3%) are alive

with native valves. Sixteen (94.1%) of 17 surviving patients are in functional class I and one (5.9%) in functional class II (NYHA). Fifteen (88.2%) patients had no murmurs in the mitral valve, and two (11.8%), there was presence of slight systolic murmur, one (5.9%) of them associated with a diastolic murmur at the apex. Actuarial survival free of death of 22 patients from cardiovascular causes demonstrated survival probability at 70 months of 78.3 ± 10.1% (Figure 1).

Table 4. Postoperative clinical data.

No.	Patients	Gender	Age (years)	Surg Date	Evol Date	Evol	FC	SMM	DMM
1	VG	M	61	05/31/06	12 M	LAT SUDDEN DEATH	-	-	-
2	CLSF	F	51	08/29/06	06/16/12	GOOD	I	0	0
3	JR	M	59	09/20/06	05/15/12	GOOD	I	0	0
4	AM	M	58	10/09/06	07/18/12	GOOD	I	0	0
5	AMB	M	53	10/16/06	06/19/12	GOOD	I	0	0
6	SFN	F	23	11/14/06	10/22/09	MVR REOP	-	0	0
7	ATF	F	68	12/04/06	04/20/12	GOOD	I	-	-
8	GMG	F	69	12/06/06	08/05/10	LAT DEAT TVM REOP	-	0	0
9	JAO	M	61	01/29/07	06/11/12	GOOD	I	0	0
10	PSM	M	19	02/12/07	06/11/12	GOOD	II	+	+
11	AC	M	72	02/27/07	07/20/12	GOOD	I	+	0
12	SM	M	76	05/30/08	07/20/12	GOOD	I	0	0
13	NAN	F	45	08/19/08	06/12/12	GOOD	I	0	0
14	GAL	M	55	12/15/08	03/13/12	GOOD	I	0	0
15	JC	M	66	08/19/09	07/05/12	GOOD	I	0	0
16	MAT	F	53	09/17/09	01/03/12	GOOD	I	0	0
17	MLPS	F	62	03/31/10	06/04/12	GOOD	I	0	0
18	AR	M	53	05/20/10	06/15/12	GOOD	I	0	0
19	HJA	M	55	10/06/10	07/11/12	GOOD	I	0	0
20	JAL	F	70	11/03/10	-	IMMED DEATH LOS	-	-	-
21	RF	M	62	03/16/11	1 M	LAT DEAT VF	-	-	-
22	ABR	M	58	03/05/12	07/04/12	GOOD	I	0	0

Evol = Evolution, Evol Date = Date of Evolution, FC = Functional Class, = SMM = Systolic mitral murmur, DMM = Diastolic mitral murmur, M = Male, F = Female, Lat Death = Late Deat, Immed Deat = Immediate Death, Reop = Reoperation, MVR = Mitral Valve Replacement, VF = Ventricular Fibrillation, LOS = Low output syndrome.

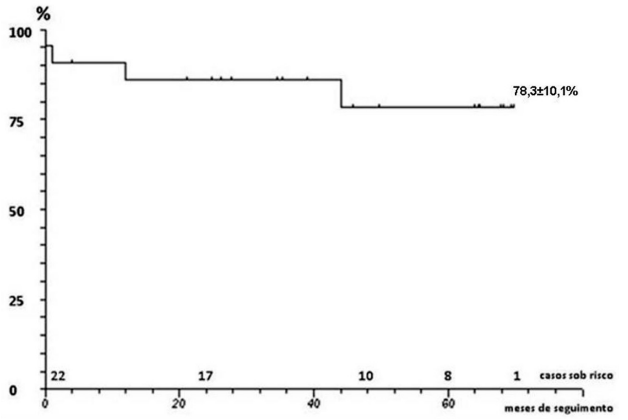

Fig. 1 - Actuarial survival curve of the patients (22). It is observed that 78.3 ± 10.1% of the patients are still alive after 70 months of follow-up

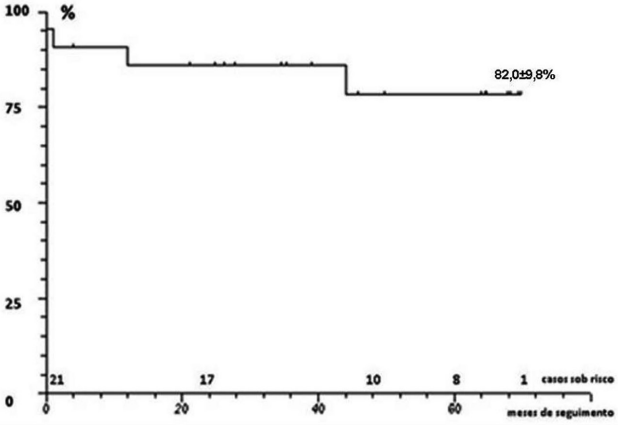

Fig. 2 - Actuarial survival curve of patients who were discharged from hospital and were followed-up as outpatients (21). It is observed that 82.0 ± 9.8% are alive at 70 months postoperatively

The actuarial survival of patients who left the hospital and remain under outpatient treatment (21) demonstrated survival probability at 70 months of 82.0 ± 9.8% (Figure 2).

The Doppler echocardiographic assessment was performed in the 17 surviving patients, between the months of January and July 2012, with a mean postoperative follow-up of 47 months (range 4-70 months). Left ventricular function measured by EF showed a mean of 0.59 (range 0.27 to 0.76). The average diameter of the left atrium was 4.5 cm (ranging from 3.0 to 6.9 cm). The mean MVS assessed was 2.9 cm^2 (range 1.6 to 4.5 cm^2), and satisfactory in all except one (1.6 cm^2) patient. The mean GTVM was 3.3 mmHg (range 1-9 mmHg), with negligible values in all patients except one. The average LVFDV was 141 ml (range 83-247 ml), which is normal in 12 (70.5%).

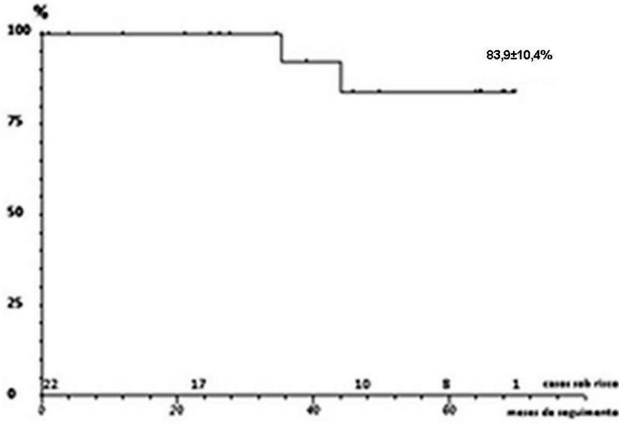

Fig. 3 - Actuarial survival curve of the surgical method, or that is, the implanted prosthesis in the mitral valve (22 patients). It is observed that 83.9 ± 10.4% of the prostheses are free from dysfunction at 70 months postoperatively

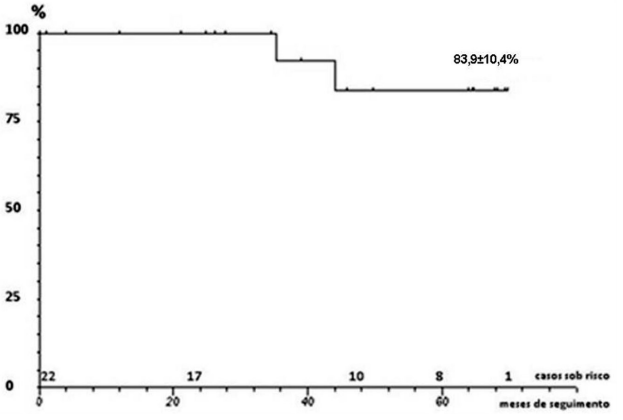

Fig. 4 - Actuarial curve free of reoperation for 21 patients who were discharged and were followed-up as outpatients at 70 months postoperatively (83.9 ± 10.4%)

The analysis of valve competence showed no mitral regurgitation in 11 (64.7%) of the 17 surviving patients assessed, slight regurgitation in five (29.4%) and mild/moderate in one (5.9%). Therefore, satisfactory competence of the mitral valve was observed in 94.1% of cases. Mild tricuspid regurgitation was observed in four (23.5%) patients and mild regurgitation of the aortic valve in four (23.5%). The actuarial reoperation-free after implantation of standardized bovine pericardium chordae treated with glutaraldehyde and non-calcifying agent for replacement of ruptured chordae tendineae of the mitral valve was at 70 months postoperatively, 83.9 ± 10.4% (Figure 3).

The actuarial reoperation-free for the 21 patients who were discharged and followed as outpatients at 70 months postoperatively showed rate of 83.9 ± 10.4% (Figure 4).

DISCUSSION

Several techniques have been described over the years aiming at mitral valve reconstruction. Therefore, a thorough knowledge of anatomical pathology is necessary. The mitral valve is composed by an incomplete fibrous ring that goes from the right fibrous trigone to the left fibrous trigone - its anterior portion is occupied by the ring of the aortic valve and it was previously thought that it did not dilate until Hueb et al. [18] showed pathological changes of this portion of the mitral valve in hearts with ischemic and degenerative disease. Anyway, changing that part or not, the annular dilatation should be corrected - and this is the last step of the reconstruction, restoring the original shape of the ring which is of a vat, culminating with a perfect approximation of the anterior and posterior leaflets and commissures.

There are six valves composing the mitral valve, one anterior and three posterior (posterolateral, posteromedial and posterior itself), besides the two commissures containing leaflets and chordae attached to the papillary muscles and/or the free wall the left ventricle. During left ventricular systole, the mitral valve contracts, similarly to a sphincter - takes the form of a kidney while relieving the outflow of the left ventricle. In the dilated left ventricle (either in volume overload or cardiomyopathy), the ring expands subsequently acquiring the ovoid form, but more intensely at right next to the posteromedial commissure.

Hence the reason we have used the ring developed by us [12] that with the shape of a hemi-ellipse approximates the posterior leaflets to the anterior leaflet, and because it has correction on its right side, approximates this part of the mitral annulus, more often dilated. Even being open, in its anterior portion, the upper ends of the prosthesis, fixed

along the trigone, prevent annular dilatation on that site, occupied by the fibrous ring of the aortic valve. Stretching and rupture of chordae are the most common complications in degenerative mitral valve. Changes in the leaflets also occurs, with sagging and proliferation of connective tissue and may be exaggerated, as in Barlow syndrome (six patients in this study), much harder to be treated than in fibroelastic degeneration, when there is plenty of tissue.

Faced with cases of chordae rupture, surgeons commonly have different behavior if it is located in the anterior leaflet of the mitral valve. The chordae rupture of the anterior leaflet is a major challenge, since in these cases the valve failure is usually significant. The anterior leaflet has basically function of excursion and the posterior leaflets have function of containing and support to the anterior leaflet. Valve prolapse by chordae rupture are easier to be treated when present in the posterior leaflet.

The repair by Merendino et al. [2], have been used successfully for a long time, often solving the problem often in such cases. Contrary to what the literature shows, in our cases, correction of chordae rupture of the anterior leaflet was more frequent than in the posterior leaflet. The surgical technique to be used depends on the level of commitment and the location of the damaged chordae. There are several procedures that can be adopted in chordal rupture. Transfering chordae from the posterior leaflet to the anterior leaflet of the mitral valve proposed by Carpentier et al. [4] has been used, including in our department.

Constructing a neocord through the removal of a flap of the anterior leaflet of the mitral valve when lowered on top of the papillary muscle, replacing ruptured chordae tendineae is an alternative technique [5], but its use is restricted to patients with the anterior leaflet well developed, which does not occur in rheumatic, ischemic or even in endocarditis diseases. It is therefore almost exclusively of degenerative disease. Partial transfer of the tricuspid valve (posterior leaflet in most cases) to the mitral valve, providing chordae to the anterior leaflet, was proposed by Gregori et al. in 1992 [6], with very satisfactory results.

These techniques require handling of leaflets and chordae with normal anatomy and, in general, are feared by surgeons that initiate in reconstructive surgery of the mitral valve. Synthetic and biological materials have been used for the replacement of chordae. The PTFE threads, proposed by David et al. [8] have been shown to be more frequently used in the world. A recent study using PTFE showed excellent results at five and 10 years postoperatively, with no reoperation in 93.3% and 81.7%, respectively [19]. However, the use of these techniques requires enormous degree of subjectivity, requiring a high degree of individual skill. Dang et al. [20] described a simplified method for using PTFE, slightly easing its implementation.

With biological materials, Frater et al. [7] were the first to employ the bovine pericardium for chordal replacement with satisfactory initial results. Their study was interrupted due to fear of calcification over the years. However, in their original study, two groups of patients undergoing implant of PTFE and bovine pericardium chordae were compared. It should be emphasized that a pericardial measured 4 mm wide, with not being premolded chordae, nor standardized by instruments (meters). In addition, follow-up time was longer in the group which used bovine pericardium than in the group that used PTFE.

Even so, there was no significant difference in long-term evolution of the two groups, nor calcification of bovine pericardium implanted. Calcification is really a problem and should be matter of concern. Many efforts have been made to improve the durability of the bovine pericardium with the introduction of new chemical reagents as used in our case, the glutamic acid. It has been very frequent the use of bovine pericardium in cardiovascular surgery. Its use is common in the manufacture of prostheses, in orifice occlusions in congenital heart defects, reconstructions of the ventricular outflow tract, in ventricular repair after repair of left ventricular aneurysms, among other procedures. In mitral valve surgery, the pericardium has been used as a rope to maintain the tension between the top of the papillary muscles and the mitral valve in valve replacement, with significant improvement in ventricular function [21].

The use of standardized bovine pericardium prosthesis makes the procedure easier and therefore fast, objective and reproducible. Laboratory tests of the artificial chordae showed a rupture level in 15 kg/cm^2. It must be remembered that in a patient with high blood pressure of 140 mmHg in systole of his left ventricle, the tension to which the chordae are subjected is approximately 0.5 kg/cm^2, therefore thirty times smaller. The chordae implantation technique is similar to that described by us in case of partial transfer of the tricuspid valve (posterior leaflet, usually) to the mitral valve [6]. In this study, in all patients was performed annuloplasty using rigid open Gregori-Braile ring [12], preceeded in both cases, of Wooler annuloplasty [13], along the posteromedial commissure. Clinical improvement was observed in surviving patients, both with respect to functional class (16 of them in functional class I and one in functional class II) and the excellent auscultation of mitral valve (15 with no murmurs and two with discrete systolic murmur in the mitral focus, one of them associated with a diastolic murmur at the apex).

Aiming standardization of laboratory data, we assessed hemodynamically patients preoperatively, since echocardiograms were performed by different clinicians, which has not happened postoperatively. It is noted that, in the two patients with sudden death in the late postoperative period, the preoperative ventriculography showed severe left

ventricular hypokinesis, in addition to high left ventricular end diastolic pressure. The Doppler echocardiography has been the best method for postoperative assessment of mitral valve and, in the patients of this study, implantation of standard bovine pericardial chordae associated with open rigid annuloplasty and other techniques presented postoperative quite satisfactory. We attribute these results to a significantly greater coaptation line between the leaflets, since extensive resections are avoided.

The postoperative data of this prospective study confirmed the clinical findings observed. Except in one case, the mean transvalvular gradients were normal, in over 70% of cases, left ventricular end-diastolic volume was normal and the mitral valve area was satisfactory. Satisfactory results were also observed in the analysis of mitral valve competence in view of the absence of regurgitation or only mild mitral regurgitation in 16 of 17 patients. The benefit of the artificial chordae implantation is more evident in cases of ruptured chordae of the anterior leaflet, in which resection should be avoided because it may damage its main function, which is excursion. However, it is still interesting its application in the posterior leaflet. Falk et al. [22] corroborated this statement in a prospective randomized study comparing the use of PTFE chordae with resection of the posterior leaflet prolapse.

Thus, the good late results are technique-dependent. A prospective analysis of our cases is valid because the series is consecutive, the patients had mitral valve lesions of the same etiology (degenerative) and underwent surgery by the same surgeon. The actuarial survival curves free of death and reoperation showed probability of survival at 70 months postoperatively for more than 80%, confirming our previous publications [9,10]. Over 90% of the 17 surviving patients showed competent mitral valve postoperatively, and none showed signs of calcification of the implanted prosthesis. Furthermore, in no patient with events of death or reoperation was confirmed dysfunction of the bovine pericardium prosthesis preserved in glutaraldehyde for the replacement of ruptured chordae tendineae.

The early death in the first surgery and early death in a patient who had undergone surgery for mitral valve replacement were due to low cardiac output syndrome, with prostheses functioning normally. In the two patients who died suddenly in the late postoperative period, the most likely cause would have been ventricular fibrillation - documented in a mobile ICU. In the rupture of mitral valve chordae, patients have usually in severe cases, acute pulmonary edema. With good postoperative follow-up, with respect to the patient who had undergone surgery for mitral valve replacement, during surgery was observed that the mitral valve showed severe degeneration of the anterior leaflet, being with good aspect the implant of bovine pericardium chordae in the posterior leaflet.

CONCLUSION

Despite a follow-up not extensive, the outcomes obtained, both clinical and Doppler echocardiographic, allow us to affirm that clinical outcome after use of the technique of chordae replacement by premolded chordae of bovine pericardium preserved in glutaraldehyde are satisfactory in patients with impaired mitral degenerative etiology.

REFERENCES

1. McGoon DC. Repair of mitral insufficiency due to ruptured chordae tendineae. J Thorac Cardiovasc Surg. 1960;39:357-62.

2. Merendino KA, Thomas GI, Jesseph JE, Herron PW, Winterscheid LC, Vetto RR. The open correction of rheumatic mitral regurgitation and/or stenosis; with special reference to regurgitation treated by posterormedial annuloplasty utilizing a pump-oxygenator. Ann Surg. 1959;150(1):5-22.

3. Pomerantzeff PAM, Brandão CMA, Rossi EG, Cardoso LF, Tarasoutchi F, Grimberg M, et al. Quadrangular resection without ring annuloplasty in mitral valve repair. Eur Cardiovasc Surg. 1997;2:271-3.

4. Carpentier A, Relland J, Deloche A, Fabiani JN, D'Allaines C, Blondeau P, et al. Conservative management of the prolapsed mitral valve. Ann Thorac Surg, 1978;26(4):294-302.

5. Gregori F Jr, Takeda R, Silva S, Façanha L, Meier MA. A new technique for mitral insufficiency caused by ruptured chordae of the anterior leaflet. J Thorac Cardiovasc Surg, 1988;96(5):765-8.

6. Gregori F Jr, Cordeiro C, Croti UA, Hayashi SS, Silva SS, Gregori TE. Partial tricuspid valve transfer for repair of mitral insufficiency due to ruptured chordae tendineae. Ann Thorac Surg, 1999;68(5):1686-91.

7. Frater RW, Gabbay S, Shore D, Factor S, Strom J. Reproducible replacement of elongated or ruptured mitral valve chordae. Ann Thorac Surg. 1983;35(1):14-28.

8. David TE, Bos J, Rakowski H. Mitral valve repair by replacement of chordae tendineae with polytetrafluorethylene sutures. J Thorac Cardiovasc Surg. 1991;101(3):495-501.

9. Leal JCF, Gregori Jr. F, Galina LE, Thevenard RS, Braile DM. Avaliação ecocardiográfica em pacientes submetidos à substituição de cordas tendíneas rotas. Rev Bras Cir Cardiovasc. 2007;22(2):184-91.

10. Gregori F Jr, Leal JC, Braile DM. Premolded bovine pericardial chords for replacement of ruptured or elongated chordae tendineae. Heart Surg Forum. 2010;13(1):E17-20.

11. Braile DM, Ardito RV, Pinto GH, Santos JLV, Zaiantchik M, Souza DRS, et al.. Plástica mitral. Rev Bras Cir Cardiovasc. 1990;5(2):86-98.

12. Gregori F, Silva SS, Hayashi SS, Aquino W, Cordeiro C, Silva LR. Mitral valvuloplasty with a new prosthetic ring. Analysis of the first 105 cases. Eur J Cardiothorac Surg. 1994;8(4):168-72.

13. Wooler GH, Nixon PG, Grimshaw VA, Watson DA. Experience with the repair of the mitral valve in mitral in competence. Thorax. 1962;17:49-57.

14. Carpentier A, Deloche A, Dauptain J, Soyer R, Blondeau PH, Piwinica A, et al. A new reconstructive operation for correction of mitral and tricuspid insufficiency. J Thorac Cardiovasc Surg. 1971;61(1):1-13.

15. Gregori Júnior F, Silva S, Façanha L, Cordeiro C, Aquino W, Moure O. Preliminary results with a new technique for repairing elongated chordae tendineae of the anterior mitral valve leaflet. J Thorac Cardiovasc Surg. 1994;107(1):321-3.

16. DeVega NF. La anuloplastia selectiva, regulable y permanente. Rev Esp Cardiol. 1972;25:555-6.

17. Kaplan EL, Meier P. Non-parametric estimation from incomplete observations. J Am Statist Assoc. 1958;53:457-8.

18. Hueb AC, Jatene FB, Moreira LF, Pomerantzeff PM, Kallás E, Oliveira SA. Ventricular remodeling and mitral valve modifications in dilated cardiomyopathy: new insights from anatomic study. J Thorac Cardiovasc Surg. 2002;124(6):1216-24.

19. Kobayashi J, Sasako Y, Bando K, Minatoya K, Niwaya K, Kitamura S. Ten-year experience of chordal replacement with expanded polytetrafluoroethylene in mitral valve repair. Circulation. 2000;102(19 Suppl 3):III30-4.

20. Dang NC, Stewart AS, Kay J, Mercando ML, Kruger KH, Topkara VK, et al. Simplified placement of multiple artificial mitral valve chords. Heart Surg Forum. 2005;8(3):E129-31.

21. Gomes OM, Pitchon M, Barros MVL. Utilização de cordas tendíneas de pericárdio bovino em cirurgia da valva mitral. Coração. 1990;2:20-2.

22. Falk V, Seeburger J, Czesla M, Borger MA, Willige J, Kuntze T, et al. How does the use of polytetrafluoroethylene neochordae for posterior mitral valve prolapse (loop technique) compare with leaflet resection? A prospective randomized trial. J Thorac Cardiovasc Surg. 2008;136(5):1205.

23. Gregori Junior F. Conservative surgical management of mitral insufficiency: an alternative approach. Rev Bras Cir Cardiovasc. 2012;27(2):312-7.