Volume 1 • Issue 2 • 2019

Research Article

Journal of Medicine and Surgical Sciences

Comparison of the Mortality Rates of Surgical Techniques for Correcting Atrioventricular Disjunction

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Received: October 28, 2019; **Published:** November 08, 2019

Abstract

Objective: A left ventricular rupture is a rare but lethal complication of surgical mitral valve replacement. We compared the mortality rates of two different surgical techniques for the correction of atrioventricular disjunction.

Methods: From January 2005 to January 2012, 720 patients underwent mitral valve replacement at our institution. Two different surgical techniques were used for the correction of atrioventricular disjunction. The techniques were: in group I, the mitral annulus was fixed with bovine pericardial strips; in group II, a 'patch' of bovine pericardium was sutured; the patch extended from the base of the lateral and medial papillary muscle, covered the posterior wall of the left ventricle, went through the posterior mitral annulus, and ended in the posterior wall of the left atrium adjacent to the mitral ring.

Results: Atrioventricular disjunction occurred in 10 (1.39%) of 720 patients, out of which the group I technique was used in 6 (60%) patients, and the group II technique in 4 (40%) patients. The mortality rate for the group I technique was 100% (6 patients) with 5 deaths in the operating room and 1 death from postoperative cardiogenic shock. For the group II technique, the mortality rate was 25% (1 patient) and the death was associated with late pulmonary sepsis.

Conclusion: The group II technique showed a lower mortality, and was more efficient than the group I technique.

Keywords: *Mitral valve; Heart rupture; Mitral valve insufficiency; Mitral valve stenosis*

Introduction

Atrioventricular disjunction associated with left ventricular rupture (LVR) is a rare and serious complication following mitral valve replacement [1]. It was initially described by Roberts and Morrow in 1967 from autopsy findings in 2 patients [2].

The etiology of LVR includes the replacement of a previously implanted prosthesis, selecting a larger prosthesis than the mitral annulus and the left ventricle, weakness of the left ventricular wall due to cardiomyopathy, mechanical traction injuries of the mitral annulus, and excessive papillary resection, while the key factors are mitral stenosis and calcification of the mitral annulus [3]. However, in most patients, the specific cause cannot be determined [4].

Consequently, a safe and reproducible surgical technique is necessary for dealing with this complication. In this study, we compared the mortality rates of two surgical techniques for the correction of LVR.

Methods

A retrospective study was carried out using data collected from January 2005 to January 2012, during which 720 surgeries involving mitral valve replacement were performed. Valve prostheses (biological or mechanical) were used for mitral valve replacement as the primary surgery, mitral valve replacement associated with other procedures (myocardial revascularization, multiple valve replacement, aortic surgery, etc.), and mitral valve replacement during re-operation.

All procedures were performed under extracorporeal circulation, with arterial cannulation in the ascending aorta and bicaval venous cannulation with moderate hypothermia (28°C), antegrade myocardial protection, and cold blood cardioplegia (4:1 dilution) every 20 minutes. The mitral valve was accessed by left atriotomy.

Following these surgeries, left ventricular rupture was observed in 10 patients who were further divided into the following 2 groups according to the type of corrective technique adopted: group I (n= 6), which involved the establishment and strengthening of the posterior mitral ring with two strips of bovine pericardium and separate polypropylene 3-0 "U" sutures in the ruptured region, using the same sutures to implant the prosthesis, securing the location of the lesion, and using biological adhesive and bovine pericardium to correct external hemorrhages (Figure 1); and group II (n= 4), which involved placement of a bovine pericardium patch, fixed with continuous polypropylene 4-0 sutures and extending from the base of the medial and lateral papillary muscles, covering the posterior wall of the left ventricle through the posterior portion of the mitral valve annulus and ending in the posterior wall of the left atrium adjacent to the mitral annulus. The prosthesis was placed on this patch and separate "U" sutures supported the bovine pericardium allowing the correction of external hemorrhages (Figure 2).

There was no need for replacement of the prosthesis in any of the groups, and all prostheses were biological and manufactured from bovine pericardium. The project was approved by the Scientific Ethics Committee of the Real e Benémerita Associação Portuguesa de Beneficência de São Paulo (opinion 209.339).

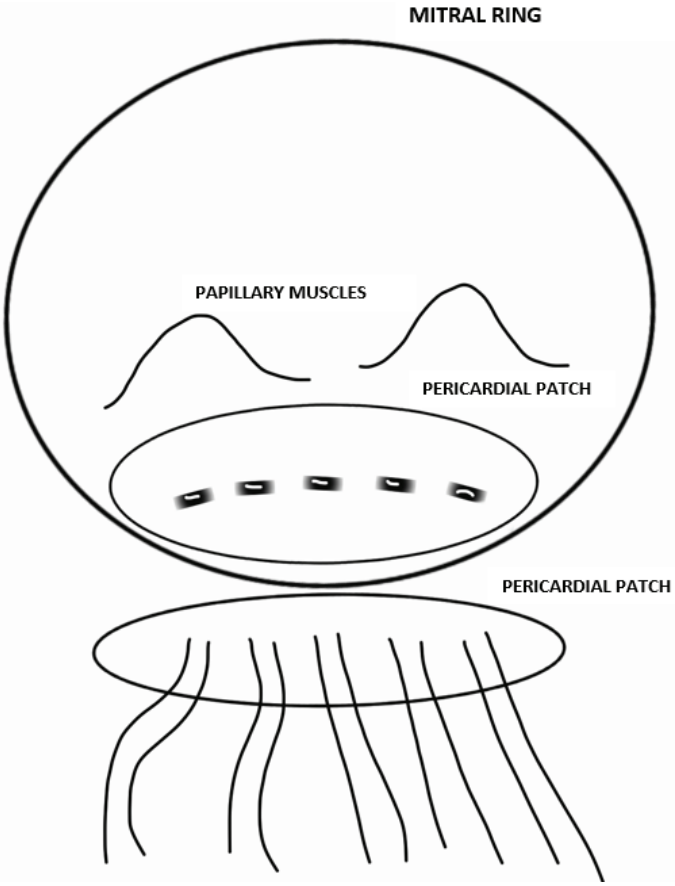

Figure 1: *Schematic drawing of the surgical technique performed in group I.*

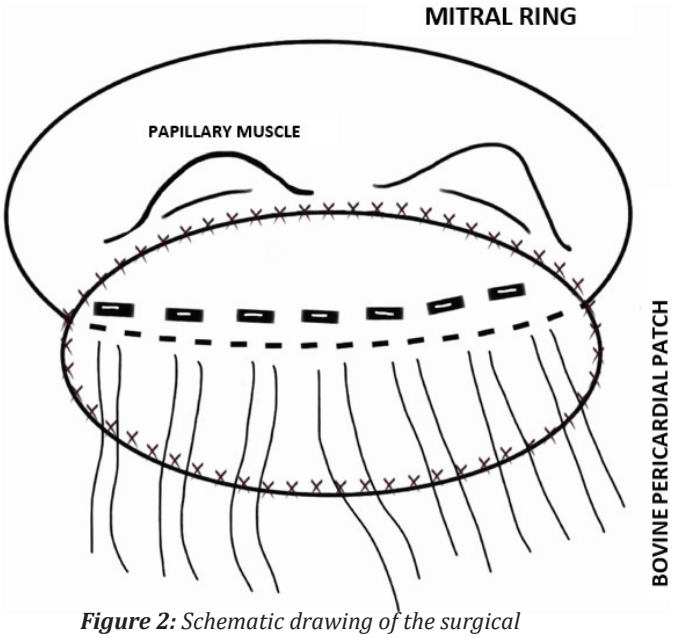

Figure 2: *Schematic drawing of the surgical technique performed in group II.*

Statistical Analysis

The statistical analysis of all the data collected from this survey initially included descriptive means. For quantitative (numerical) variables, some summary measures, such as mean, median, minimum and maximum values, and standard deviation were calculated, and one-dimensional scatterplots were drawn. Qualitative (categorical) variables were analyzed through the calculation of absolute and relative frequencies (percentage) in addition to the construction of bar graphs.

Inferential analyses were employed in order to confirm or refute evidence found in the descriptive analysis as follows: Fisher's Exact Test or its extension for the comparison of groups I and II according to sex, mitral valve disease, calcification of mitral annulus, LVR, and death [5]; Student's t-Test for independent samples for the comparison of groups I and II according to the mean age, left atrium size, and ejection fraction before surgery [6]; Mann-Whitney Test (SIEGEL, 2006) for the comparison of groups I and II according to hospitalization time [7].

A significance level (α) of 5% was used in all the inferential analyses. The data were entered in a Windows Excel 2010 spreadsheet for proper storage of information. Statistical analyses were performed with the Statistical Package software for the Social Sciences (SPSS), version 19.0, for Windows and R, version 2.11.1.

Results

The sample for this study consisted of 10 patients with LVR after mitral valve replacement. In 6 patients, LVR was corrected by fixing the mitral annulus with strips of bovine pericardium (group I) and in the remainder, the suture technique for an extra-annular bovine pericardium patch was used (group II). Details of the group profiles are presented in Tables 1 and 2.

	Group I		Group II		Total		P
Sex							
Female	5	83.3%	1	25.0%	6	60.0%	0.190[a]
Male	1	16.7%	3t	75.0%	4	40.0%	
Total	6	100.0%	4	100.0%	10	100.0%	
Age (years)							
N	6		4		10		0.486b
Mean	59.8		53.8		57.4		
Median	61.0		51.5		59.5		
Minimum-maximum	53.0-66.0		40.0-72.0		40.0-72.0		
Standard deviation	5.4		15.0		10.1		
Mitral valve disease							
Mitral insufficiency and stenosis (stenosis > insufficiency)	4	66.7%	1	25.0%	5	50.0%	0.190[a]
Mitral stenosis	2	33.3%	1	25.0%	3	30.0%	
Mitral insufficiency	-	-	2	50.0%	2	20.0%	
Total	6	100.0%	4	100.0%	10	100.0%	
Calcification of mitral annulus							
No	-	-	3	75.0%	3	30.0%	0.033[a]
Yes	6	100.0%	1	25.0%	7	70.0%	
Total	6	100.0%	4	100.0%	10	100.0%	
Left ventricular rupture							

I	6	100.0%	2	50.0%	8	80.0%	0.133[a]
III	-	-	2	50.0%	2	20.0%	
Total	6	100.0%	4	100.0%	10	100.0%	
Death							
Death in the operation theater	5	83.3%	-	-	5	50.0%	0.010[a]
Late death	1	16.7%	1	25.0%	2	20.0%	
No death	-	-	3	75.0%	3	30.0%	
Total	6	100.0%	4	100.0%	10	100.0%	
Hospitalization time (days)							
N	6		4		10		0.114[c]
Mean	11.3		26.3		17.3		
Median	1.0		21.0		5.0		
Minimum-maximum	1.0-63.0		9.0-54.0		1.0-63.0		
Standard deviation	25.3		20.4		23.5		

[a]Fisher exact test or its extension, [b]Student's t-test for independent samples, [c]Mann-Whitney

Table 1: *Distribution of the groups I and II profiles according to sex, age, mitral valve disease, calcification of mitral annulus, left ventricular rupture, death, and hospitalization time.*

	Group I	Group II	Total	P
Left atrium (mm) before surgery				0.307[b]
N	6	4	10	
Mean	57.8	51.5	55.3	
Median	59.5	53.0	55.0	
Minimum-maximum	46.0-74.0	44.0-56.0	44.0-74.0	
Standard deviation	10.6	5.3	9.1	
Left atrium (mm) after surgery				
N	1	4	5	
Mean	62.0	55.0	56.4	
Median	62.0	56.0	58.0	
Minimum-maximum	62.0-62.0	49.0-59.0	49.0-62.0	
Standard deviation	-	4.5	5.0	
Ejection fraction (%) before surgery				
N	6	4	10	0.835[b]
Mean	69.0	67.8	68.5	
Median	68.5	70.5	70.0	
Minimum-maximum	63.0-79.0	50.0 -80.0	50.0 -80.0	
Standard deviation	5.8	12.7	8.5	
Ejection fraction (%) after surgery				
N	1	4	5	
Mean	48.0	57.8	55.8	

Median	48.0	57.5	48.0	
Minimum-maximum	48.0-48.0	45.0-71.0	45.0-71.0	
Standard deviation	-	14.2	13.0	

[b]Student's-test for independent samples

Table 2: *Distribution of the profile of groups I and II according to the left atrium size and ejection fraction before and after surgery.*

Group I included 5 (83.3%) women and only 1 (16.7%) man. The average age of the patients in this group was 59.8 years (range 53 to 66 years) with a standard deviation of 5.4 years. Group II included 1 (25.0%) woman and 3 (75.0%) men. The average age of the patients in this group was 53.8 years (range 40 to 72 years) with a standard deviation of 15.0 years. Among the mitral valve disease patients in group I, 4 (66.7%) patients had mitral insufficiency and stenosis (stenosis >insufficiency) and 2 (33.3%) presented with pure mitral stenosis. In group II, 1 (25.0%) patient had mitral insufficiency and stenosis (stenosis >insufficiency), 1 (25.0%) had mitral stenosis, and 2 (50.0%) patients had mitral insufficiency.

Before surgery, in group I, the average size of the left atrium was 57.8 mm (range from 46 to 74 mm) with a standard deviation of 10.6 mm. After surgery, the size of the left atrium in the only survivor was 62 mm. The mean ejection fraction before surgery was 69.0% (range from 63 to 79%) with a standard deviation of 5.8%, and after surgery, the ejection fraction was 48.0%. In group II, before surgery, the average size of the left atrium was 51.5 mm (range 44 to 56 mm) with a standard deviation of 5.3 mm, and after surgery, the average size of the left atrium was 55 mm (range 49 to 59 mm) with a standard deviation of 4.5 mm. The mean ejection fraction before surgery was 67.8% (range 50 to 80%) with a standard deviation of 12.7%, and after surgery, the mean ejection fraction was 57.8% (range 45 to 71%) with a standard deviation of 14.2%.

All 6 (100%) patients from group I presented with calcification of the mitral annulus and on average, the patients in this group were in hospital for 11.3 days (range 1 to 63 days) with a standard deviation of 25.3 days. In group II, only 1 (25.0%) patient showed calcification of the mitral annulus and on average, the patients in this group were in hospital for 26.3 days (range 9 to 54 days) with a standard deviation of 20.4 days. In group I, all patients had type I LVR and died (5 in the surgical center and 1 late death). In turn, in group II, type I LVR was observed in 2 (50.0%) patients and type III LVR in 2 (50.0%) patients. In this group, only 1 patient had a late death.

The inferential results from the comparison of groups I and II showed that these profiles are statistically similar for sex (p=0.190), age (p=0.486), mitral valve disease (p=0.190), LVR (p=0.133), hospitalization time (p=0.114), left atrium size (p=0.307), and ejection fraction (p=0.835) before the surgery. Group I had a higher frequency of calcification of the mitral annulus (p=0.033) and death (p=0.010) compared to group II. The comparison of the left atrium size and ejection fraction before and after surgery can only be carried out in a descriptive manner due to the small number of patients who did not die during surgery in both the groups.

The only patient in group I that did not die in surgery showed a decrease in both the size of the left atrium (74 mm to 62 mm) and the ejection fraction (63% to 48%). In group II, the 4 patients who did not die in the operation theater showed an increase in the size of the left atrium and a decrease in the ejection fraction. Considering only the deaths (both in the operation theater and the late deaths), group I had 6 deaths, and group II only 1.

In group I, the 5 deaths were of 4 women and 1 man. The average age of the individuals who died was 59.8 years and ranged from 53 to 66 years with a standard deviation of 5.4 years. In terms of mitral valve diseases, 4 deaths were because of mitral insufficiency and stenosis (stenosis >insufficiency) and 2 were caused by mitral stenosis. All 6 patients from group I who died, showed calcification of the mitral annulus and type I LVR. On average, the patients in this group were in hospital for 11.3 days (range 1 to 63 days) with a standard deviation of 25.3 days. The only death in group II was of a 72-year-old woman with mitral insufficiency and type III LVR, but without calcification of the mitral annulus; she remained in the hospital for 9 days.

There was a predominance of women (60%); they had a mean age of 57 years and mitral stenosis in 80% of the population, together with calcification of the mitral annulus in 70% of patients. In 7 cases (70%), the posterior leaflet and its subvalvular apparatus were preserved. From group I, 6 patients (100%) died, with 5

deaths (83.3%) in the operation theater and 1 late death (16.6%) from pulmonary sepsis. In group II, there was 1 late death (25%), which was associated with pulmonary sepsis in the late postoperative period.

When we analyzed the postoperative period, the mean length of hospital stay was 39 days and there was a 7% decrease in the ejection fraction on average, similar to that found in presurgical transthoracic echocardiography. There was no evidence of myocardial infarction; electrocardiograms showed no ischemic changes and cardiac enzymes remained within the standards expected for surgical cardiac procedures.

Discussion

The surgical treatment of LVR presents a series of difficulties, such as weakness in the structures causing difficulty in anchoring sutures, poor exposure and problematic visualization of lesions, proximity of lesions to the circumflex coronary artery, and perforation of the left ventricle wall further from the initial lesion [8]. In both groups, the patients progressed to a cardiogenic shock with great difficulty in completion of the repair, regardless of the technique used. In all cases, successful or otherwise, the LVR was evidenced by hemorrhage in the free left ventricular wall.

LVR is classified into 3 types ranging from its position in relation to the mitral annulus and papillary muscles [9,10]. Type I LVR is located in the mitral annulus and adjacencies; in type II, the rupture occurs at the base of papillary muscles; and in type III, the tear is mid-ventricular, located in the region between the mitral annulus and the papillary muscles [10,11]. In the cases examined, a greater occurrence of type I LVR was observed indicating that the probable excessive manipulation of the mitral annulus and calcification were responsible for LVR.

LVR can be avoided with the maintenance of the posterior apparatus of the partial or complete mitral valve. In cases where there is extensive valve calcification, removal of calcium should be sufficient only for the passage of the sutures through the ring and fixation of the prosthesis, avoiding hypertension in the postoperative period [4,11]. Although the literature shows a reduction in the occurrence of LVR during the preservation of the posterior apparatus of the mitral valve, in our sample, the posterior apparatus was maintained in most cases.

A high mortality rate is reported in the literature and ranges from 65% to 100%, while survival is associated with its intraoperative identification [9,12]. Of the patients included in this study, 10 occurrences of LVR were observed, with a frequency of 1.39%. An overall mortality rate of 60% was observed; this was 100% in group I and 25% in group II. Deaths could be late and without direct correlation with the pathology.

Surgical techniques have been described to correct LVR, based on the healing and strengthening of the tear region, and intraventricular with the use of extracorporeal circulation [3,9,10,12]. The patients in group I underwent the type of correction typically used by our service, with interposition of strips of bovine pericardium in the mitral annulus. The technique used in group II began with the extensive suturing of a pericardial patch covering the torn area and the mitral annulus in a random manner, and because of the results, this was retained as the default technique.

There are descriptions of the use of epicardial repair, at the torn ventricular face, without the use of extracorporeal circulation, which is based on the use of biological adhesives to seal the tear [13]. No repair was carried out with the use of biological adhesives in the cases described, but their use may be useful to minimize the use of sutures that can generate larger lesions in very damaged and fragile tissues. Observing the literature, we found a higher incidence in patients above 60 years of age, and the calcification of the mitral annulus was considered the main risk factor [1], which was consistent with the one found in the sample studied, with a mean age of 57 years and a predominant pathology of mitral stenosis.

Limitations of the Study

This study has some limitations because it is a retrospective analysis of low incidence pathology, thereby including a low number of study individuals. There was no randomization of surgical techniques analyzed. The procedures were selected according to the experience of the surgeon at the time of surgery.

Conclusion

In the cases analyzed, better results were obtained in terms of mortality in group II, with correction using an extra-ring bovine pericardium patch, which had a mortality rate of 25%.

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