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Midterm Results of Completely Beating Mitral Valve Plasty for Mitral Valve Prolapse

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ABSTRACT

Background: *The configuration of the mitral valve under cardiac arrest differs significantly from the configuration while the heart is beating, which often makes it difficult to reproduce the configuration including the region of prolapse, and mitral valve plasty (MVP) is difficult under these circumstances. We retrospectively investigated cases where more than 5 years has passed since the surgery to ascertain the midterm outcomes of MVP under beating heart (bMVP) and compared these outcomes of MVP under cardiac arrest (aMVP) around the same time.*

Methods: *43 patients, whom more than 5 years had passed since MVP alone for mitral valve prolapse implemented between July 2009 and September 2013, were divided into two groups, bMVP (n=17) and aMVP (n=26), and the outcomes were compared. There were no significant differences in preoperative factors.*

Results: *There were no patient deaths during the observation period. There were no significant differences in MR grade between two groups. There were also no significant differences in freedom from reoperation between two groups.*

Conclusion: *When it is difficult to reproduce the configuration of mitral valve and the region of regurgitation under cardiac arrest during the operation, bMVP may be a useful option.*

Keywords

Completely beating heart, Mitral valve plasty, Mitral valve prolapse.

Introduction

It is essential to accurately ascertain the configuration of the entire valve as well as the precise site and the cause of the prolapse to ensure appropriate valve plasty for mitral valve prolapse. Mitral valve plasty is usually performed under cardiac arrest, and the valve configuration is ascertained through a saline injection test under cardiac arrest. However, the configuration of the mitral valve under cardiac arrest differs significantly from the configuration while the heart is beating, which often makes it difficult to reproduce the configuration including the region of prolapse, and mitral valve plasty is difficult under these circumstances. There were some reports about saline injection test under beating heart, as well as methods to compensate for the shortcomings of this test [1,2].

In July 2009 in Tenri hospital, we introduced completely beating heart mitral valve plasty (bMVP) where the entire procedure was performed under beating heart, to further advance a saline injection test under beating heart for mitral valve prolapse. In the present study, we retrospectively investigated cases where more than 5 years has passed since the surgery to ascertain the midterm outcomes of bMVP and compared these outcomes with those of cases that underwent mitral valve plasty under cardiac arrest (aMVP) around the same time.

Methods

Indications for bMVP

Indications for bMVP were as follows: 1. cases where the prolapse was found in multiple regions in anterior and posterior valve cups.

2. cases where the plasty was expected to be difficult due to the complexity of the prolapse regions involving valve cusps, annulus and subvalvular tissues based on preoperative transthoracic, and/or transesophageal echocardiographic study.

Procedures of mitral valve plasty

bMVP was performed by using a normal median sternotomy and cardiopulmonary bypass (CPB) was initiated with arterial cannula into the ascending aorta and two venous cannulas in the superior and inferior vena cava (body temperature 34°C).

A coronary artery perfusion cannula and root pressure monitor line were inserted into the ascending aorta, and a left ventricular vent was inserted into the left ventricular apex. This left ventricular vent monitors the left ventricular pressure and is adjusted to ensure that the left ventricular pressure never exceeds the aorta root pressure to prevent air embolisms (Figure 1). Initially the aorta was not clamped, but we found that clamping the ascending aorta simplified control of the root pressure and was also used as a measure to prevent air embolisms, so the aorta was clamped from the middle stage of the study period. The trans-septal approach to the mitral valve was used basically. Similarly, aMVP was also performed with a median sternotomy, and CPB was established as mentioned above, and crystalloid cardioplegia was infused from the ascending aorta. The aorta was clamped and all patients underwent MVP from transseptal approach under cardiac arrest.

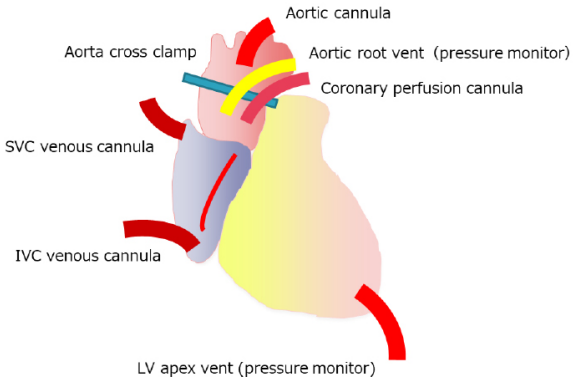

Figure 1: System of beating mitral valve plasty.
SVC: Superior Vena Cava; IVC: Inferior Vena Cava.

Patients

This single-center, retrospective study investigated 43 patients for whom more than 5 years had passed since MVP alone for mitral valve prolapse implemented between July 2009 and September 2013. However, patients who underwent MVP with tricuspid valve plasty and/or maze procedure were included in the study. Cases of emergency surgery and cases of infective endocarditis were excluded from the study. The Institutional Review Board approved this study and permission to collect data prospectively was obtained from the patients prior to entering the study.

These patients were divided into two groups, bMVP (n=17, Group B) and aMVP (n=26, Group A), and the outcomes were compared. The preoperative factors are shown in Table 1. The grades of mitral insufficiency were evaluated as none n=0, trivial n=1, mild n=2, moderate n=3, and severe n=4 on preoperative transthoracic echocardiography. There were no significant differences in any of the factors.

	Group B (n=17)	Group A8n=26)	p
Male/female	11/6	17/9	
Age at operation	58.7 ± 16.6	58.2 ± 10.5	0.90
BNP (pg/ml)	149.8 ± 50.2	166.2 ± 71.5	0.78
CTR (%)	53.4 ± 16.6	54.5 ± 5.8	0.62
LVDd (mm)	57.1 ± 6.0	58.3 ± 7.3	0.59
LVEF (%)	68.6 ± 10.7	69.7 ± 8.0	0.74
The degree of MR	3.29 ± 0.46	3.36 ± 0.48	0.66
The numbers of lesions prolapse (A3+B3=6)	1.76 ± 0.73	1.38 ± 0.49	0.052

Table 1: Preoperetive factors. BNP: Brain Natriuretic Peptide; CTR: Cardiothoracic Ratio; LVDd: Left Ventricular end-Diastolic diameter; LVEF: Left Ventricular Ejection Fraction; MR: Mitral Regurgitation.

The regions of prolapse are shown in Figure 2, with the lesions mainly on the anterior mitral leaflet in Group B and mainly on the posterior mitral leaflet in Group A. The intraoperative factors are shown in Table 2. Group A includes two patients who were switched from the scheduled bMVP, as it was not possible to attain a sufficient visual field to perform valve plasty adequately during the operation. The procedure involved implanting an annuloplasty ring in all patients. Artificial chordae reconstruction was mainly implemented for the anterior mitral leaflet, as commonly seen in Group B. Conversely, triangular-shaped wedge resection of the cusp was mainly indicated for the posterior mitral leaflet, as commonly seen in Group A. There were no significant differences between the groups for other techniques.

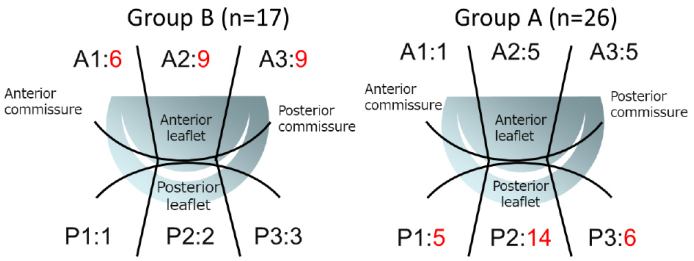

Figure 2: Regions of mitral valve prolapse.

		Group B (n=17)	Group A (n=26)	*p*
Duration of operation (min)		278.2 ± 71.1	289.2 ± 46.3	0.57
Duration of CPB (min)		174.7 ± 47.7	167.0 ± 47.7	0.62
Duration of ACC (min)		0	105.8 ± 32.0	<0.01
Shift			2 (B→A)	
Methods of plasty	Artificial chord	12	7	<0.01
	Edge-to edge	10	12	0.42
	Triangular-shaped wedge resection	1	18	<0.01
	Cleft closure	4	6	0.97
	Annuloplasty	17	26	0.99

Table 2: Perioperative factors. CPB: Cardiopulmonary Bypass; ACC: Aorta Cross Clamp.

The 43 patients were followed up in Tenri hospital, and an echocardiography was performed at least once per year to check the mitral valve.

Statistical analysis

Data are expressed as mean ± standard deviation and were analyzed using paired Student's t-test for continuous variables and a chi-test was use categorical variables. The Kaplan-Meier survival method was used to calculate estimates for mid-term survival. A p-value less than 0.05 was considered significant.

Results

The mean follow-up period was 6.8 years (max 8.9 years) and there were no patient deaths during this period. The early outcomes are shown in Table 3, and the short-term complications included one patient in Group B who developed cerebral infarction and hemiplegia thought to be caused by an air embolism. There were a few other complications, but there was no significant difference between the two groups. There was also no significant difference in the MR grade at the timing of discharge.

		Group B (n=17)	Group A (n=26)	*p*
Early death		0	0	0.99
Complications	Brain infarction	1	0	0.17
	Long respiratory support	0	1	0.16
	Arrhythmia (Paf)	3	4	0.43
	Effusion	2	2	0.34
	Duration of hospital stay(days)	15.8 ± 6.0	14.0 ± 3.7	0.27
	The degree of MR at discharge (0-4)	0.68 ± 0.68	0.68 ± 0.66	0.99

Table 3: Early outcomes. PAF: Paroxysmal Atrial Fibrillation.

The midterm outcomes are shown in Table 4. There were no significant differences in brain natriuretic polypeptides, cardiothoracic ratio, and left ventricular internal dimension in diastole. The MR grade increased slightly compared to immediately after surgery and at discharge, but both groups were grade 1 or less. There were 1 patient in Group B and 2 patients in Group A who required further surgical intervention for the mitral valve during the observation period.

	Group B (n=17)	Group A (n=26)	*p*
Late death	0	0	0.99
Re-opration of MV	1	2	0.41
BNP (pg/ml)	47.2 ± 56.2	42.8 ± 41.0	0.48
CTR (%)	51.4 ± 5.6	50.1 ± 4.5	0.53
LVDd (mm)	48.7 ± 7.1	49.0 ± 4.3	0.87
LVEF (%)	60.4 ± 9.4	62.8 ± 5.8	0.34
The degree of MR	0.97 ± 0.78	0.95 ± 0.75	0.95
MR>3	0	1	0.14

Table 4: Midterm outcomes. MV: Mitral Valve.

The reoperation free rate (5-year) was 94.1% in Group B and 91.7% in Group A, and there was no significant difference between the two groups (p=0.77) (overall reoperation free rate (5-year) was 92.9%) (Kaplan-Meier method). The patients who required further surgery are described in Table 5.

Discussion

It is important to reproduce the configuration of the mitral valve during surgery and perform valve plasty in line with the reproduced shape by ascertaining the shape of the mitral valve on preoperative echocardiography to enable an accurate and highly precise mitral valve plasty for mitral valve prolapse. Various methods have been reported to conduct these evaluations intraoperatively, but many of these methods are performed during cardiac arrest [3,4]. The configuration of the mitral valve observed under cardiac arrest differs to that of the valve while the heart is beating for the following reasons. 1. Difference in left ventricle pressure 2. Change in the configuration of the left ventricle (spherical or spindle-shaped) 3.Change in the distance between the papillary muscles (wider and longer under cardiac arrest) 4.Difference in the 3-dimensional structure of the mitral valve (distance between commissure and valve height).

The saline injection test under beating heart was proposed as a method to compensate for these shortcomings. There have been some reports indicating that unlike the regurgitation test under cardiac arrest, where the left ventricle is relaxed, under beating heart, the configuration resembles the physiological conditions associated with contraction of the left ventricle, papillary muscles, and mitral annulus, so it is expected to be easier to reproduce the configuration [1-2]. This method was introduced in Tenri hospital since 1980s [5], then we have introduced completely bMVP where the entire procedure is performed under beating heart since 2007. In the present study, we investigated the midterm outcomes of patients for whom more than 5 years had passed since the surgery, but the results were similar to the outcomes of aMVP cases conducted during the same period.

bMVP is a procedure with many manipulations required intraoperatively, including introduction of the left ventricle vent from the apex, and it also requires considerable care and attention. Therefore, bMVP was not indicated for all cases but was indicated for cases with more complex and varied lesions where valve plasty is considered to be possibly difficult. Considering the similar outcomes in the present study, bMVP may be effective for cases with such complicated mitral valve prolapse. On the other hand, there were 2 patients among the aMVP cases where bMVP was attempted initially, but precise plasty was deemed to be difficult due to the inability to attain a sufficient field of vision to complete the procedure, and it was switched to aMVP. However, even with these 2 patients' evaluation of the prolapse was effective under beating heart to ascertain the region of the prolapse and to decide the plasty method, which enabled effective subsequent mitral valve plasty under cardiac arrest.

Inducing cardiac arrest with infusion of cardioplegia is an

established method, and the standard duration of cardiac arrest has little effect on postoperative cardiac function. However, with mitral valve plasty, the duration of cardiac arrest can increase due to the difficulty of valve plasty and the need to stop the heart numerous times, which raises concerns about a decline in postoperative cardiac function. We introduced bMVP due to the advantage that the procedure can be performed without concerns about a decline in postoperative cardiac function, as well as alleviating concerns about complications including coronary reperfusion injury and aortic dissection associated with aortic clamping.

The reality is that the mitral valvuloplasty was a learning curve for both the surgeons and the team, but it has enabled simple treatment of cases previously considered to be difficult. There were some reports about new methods into intraoperative evaluation for mitral valve [6,7]. In addition, considering the aforementioned complications, the current indications for bMVP have narrowed compared to when it was initially introduced. However, we sometimes encounter the cases where mitral valve plasty is considered difficult, such as patients with Barlow's mitral valve disease, and we should have the option of bMVP or saline injection tests under beating heart. If additional mitral plasty is needed for residual MR from intraoperative transesophageal echocardiography after the valve plasty in aMVP cases, bMVP may be considered to be an effective method without re-inducing cardiac arrest.

This study only had a small number of patients, so further investigation is needed with more patients. Additionally, these results are the midterm outcome at the 5-year mark, so ongoing investigations of long-term outcomes is essential.

Conclusion

In the present study, we showed that there were no significant differences in MR grade and freedom from reoperation between bMVP and aMVP in the midterm phase. When it is difficult to reproduce the configuration of mitral valve and the region of regurgitation under cardiac arrest during the operation, bMVP may be a useful option for mitral valve plasty.

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