Repair of Complex Mitral Valve Pathologies; Is It Worth to Cope With?

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ABSRACT

Introduction: Mitral valve (MV) repair is preferred over replacement for its benefits of the preservation of ventricular function, lower operative mortality, superior long-term survival and avoidance of anticoagulation. In this study, we aimed to review repair techniques of complex mitral valve pathologies and their outcomes.

Materials and Method: We retrospectively analyzed 56 patients (mean age 41.8±16.5years; 33 males) who underwent repair of complex mitral valve pathologies. 44 patients had pure mitral regurgitation (MR) and 12 (21.4%) had mixed mitral disease (mitral stenosis (MS) + MR). Preoperative and operative characteristics, postoperative MR severity, operative mortality, and midterm survival were examined for each patient.

Results: There was only 1 early death (30-day mortality: 1.8%) due to postoperative low cardiac output syndrome. The procedures were successful in all patients who underwent MV repair. Transthoracic echocardiography examinations revealed no/trivial MR in 74.6% and mild MR in 21.8% of patients at discharge . Late follow-up was obtained in 55 patients. The mean follow-up period of patients was 47,9 ±23,1 months. Mortality developed in one (1.8%) patient with Marfan syndrome who had acute aortic dissection three years after mitral valve surgery. During follow-up visits, mitral repair procedures were successful in 49 (90.7%) patients. Four (7.4%) patients presented with moderate MR. Only one (1.9%) patient needed re-operation because of severe mitral regurgitation.

Conclusion: This study showed that repair of complex mitral valve pathologies provides excellent surgical outcomes. Repair of complex mitral valve pathologies is safe and highly effective but operations require considerable surgical experience.

Keywords: Mitral valve repair; mitral regurgitation; mitral stenosis.

Kompleks Mitral Kapak Patolojilerin Onarımı; Uğraşmaya Değer Mi?

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ÖZET

Giriş: Ventrikül fonksiyonun korunması, daha az cerrahi mortaliteye sahip olması, üstün uzun dönem survey ve antikoagülan kullanımının önlenmesi gibi üstünlükleri nedeniyle mitral kapak onarımı replasmana daha çok tercih edilmektedir. Bu çalışmanın amacı, kompleks mitral kapak patolojilerin onarım teknikleri ve sonuçları sunmaktır.

Hastalar ve Metod: Retrospektif olarak kompleks mitral kapak patolojilerin onarımı geçiren 56 hasta incelendi (Ortalama yaş 41.8±16.5 yıl; 33 erkek). 44 hastada saf mitral yetmezliği varken, 12 (21.4%) hastada miks mitral kapak hastalığı (mitral darlığı + Mitral yetmezliği) vardı. Preoperatif ve operatif özellikleri, postoperatif mitral yetmezliği derecesi, cerrahi mortalite ve orta dönem sonuçları her hasta için araştırıldı.

Bulgular: Postoperatif düşük kardiyak debi sendromuna bağlı bir hastada erken mortalite (30-gün mortalite: 1.8%) görüldü. Mitral kapak onarımı ameliyatı olan bütün hastalarda mitral onarım prosedürleri başarılı olmuştur. Hastalar taburcu olduğunda yapılan ekokardiyografik değerlendirmede %74.6'sında hiç/eser yetersizlik ve %21.8'inde hafif yetersizlik saptandı. 55 hastada geç dönem takibi yapıldı. Hastalarımızın ortalama takip süresi 47,9 ±23,1 aydı. Geç mortalite mitral kapak onarımından 3 yıl sonra akut aort diseksiyonu nedeniyle ameliyata alınan marfan sendromlu bir hastada gözlendi. Takipler sırasında yapılan ekokardiyografik değerlendirmede hastaların %90.7'sinde (49 hasta) hiç ya da hafif yetersizlik gözlendi. Orta yetersizlik gözlenen dört (%7.4) hastada tıbbi tedavi uygulandı. İleri yetersizlik gözlenen bir (%1.9) hastada re-operasyon uygulandı.

Sonuç: Çalışmamız kompleks mitral kapak patolojilerin onarımının sonuçları mükemmel olduğunu gösterdi. Kompleks mitral kapak patolojilerin onarım teknikleri güvenli ve sonuçları son derece etkindir, fakat ameliyatlarda yeterli cerrahi tecrübe gereklidir

Anahtar Kelimeler: mitral kapak onarımı;mitral yetmezliği;mitral darlığı;

Geliş Tarihi: 17.05.2017 - **Kabul Tarihi:** 15.07.2017

INTRODUCTION

Mitral valve (MV) repair is preferred over replacement for its advantages of the preservation of ventricular function, lower operative mortality, better long-term survival and avoidance of anticoagulation (1-3). MV repair has been shown to have excellent durability in patients with mitral regurgitation (MR) caused by degenerative disease (4, 5, 6, 7) and is indeed the method of choice in the correction of MR whenever feasible. In contrast, valve reconstruction for rheumatic MR remains controversial as it is not only less feasible to repair (8) but also the repaired rheumatic valve has poorer durability when compared with a degenerative MV repair (9).

Most of the mitral valve pathology involves the posterior leaflet or annulus and usually can be repaired by using standard valve repair techniques. These procedures are feasible in almost 95% of patients with degenerative MR despite the presence of complex lesions (10). Difficulties may arise when trying to repair the less common anterior leaflet prolapse or calcified mitral annulus. While the repair for the prolapse of the posterior leaflet with valvular resection or artificial chordae is usually possible, correction of anterior or bileaflet prolapse may demand more complex repair procedures. Mitral valve repair in complex setting such as redo repair procedure, congenital anomalies and HOCM is often challenging because of a lack of leaflet mobility or adequate surface of coaptation. In this study, we aimed to review repair techniques of complex mitral valve pathologies and their outcomes.

MATERIALS AND METHODS

Study group and definitions

This is a retrospective study of 56 patients who underwent repair of complex mitral pathologies using multiple procedures for MR or MS at our hospital. Complex repair was defined as using multiple mitral valve repair techniques (three techniques or more) in the same patient. These more complex and challenging patients were selected as study group in order to assess more convincingly the efficacy of these techniques. The study was approved by the Institutional Ethics Committee of our hospital. All preoperative, intraoperative, and postoperative demographic, echocardiographic and clinical data were collected. Additionally, all surgical notes and discharge summaries were reviewed to collect supplementary information. The data collected was focused on preoperative ejection fraction, grade of MR or MS, valve pathology, repair techniques, intraoperative, postoperative early (<30 days) and late (>30 days) complications.

Surgical techniques

Operative data were retrospectively extracted from medical records, surgery notes and the computer-based databank from the Department of Cardiac Surgery. Surgical approach was via a mid-sternotomy in 52 patients and a right anterolateral thoracotomy in 4 patients for cosmetic reasons. Aorto-bicaval cannulation was used in all. Operations were performed under CPB at moderate hypothermia. Concomitant cardiac procedures were performed. After a right atriotomy was performed with an oblique incision, the mitral repair was completed through transseptal approach. In 14 patients, we used left atriotomy. Leaflet repair techniques were performed with principles originally reported by Carpentier et al. (11) and Duran et al. (12), but several modifications based on these principles were used. Our techniques of MV repair evolved over the years. In complex mitral pathologies, chordal replacement with Gore-tex cords, leaflet resection with

sliding or folding annuloplasty, or commissurotomy was performed considering the status of the mitral pathology. In rheumatic MV disease, leaflet augmentation with pericardium, commissurotomy, resection of primary or/and secondary chordae or chordal replacement were preferred. In MR due to hypertrophic obstructive cardiomyopathy (HOCM), we performed shortening of posterior leaflet, neochordae and ring annuloplasty in addition to septal myectomy to prevent systolic anterior motion (SAM). The left atrial appendage was routinely ligated in patients with atrial fibrillation (AF). Upon completion of repair, MV was tested by injecting cold saline into the left ventricular cavity to observe coaptation of leaflets. Intraoperative TEE was used routinely for intraoperative assessment of MV repair after CPB. When an unsatisfactory finding was observed during TEE examination, a second cross-clamp was placed for satisfactory repair, if possible.

Follow-up

Follow-up data were analyzed by using cardiology and cardiac surgery outpatient follow-up notes, primary care and institutional computer-based databanks and telephone interviews. All patients had a TTE before hospital discharge. Echocardiographic findings were recorded in computer database of the hospital. Clinical parameters recorded during follow-up period included early (<30 days) and late mortality after surgery. All patients were anticoagulated with warfarin sodium for 3 months after surgery and permanently if they had AF or another mechanical valves.

Statistical analysis

Data were presented as frequencies and percentages for categorical variables, and medians or means with standard deviations for continuous variables.

RESULTS

Patient characteristics

Demographic data and preoperative characteristics for all patients are presented in Table 1. Patients' age ranged from 5 to 77 years (mean age was 41.8±16.5 years) and female sex was less frequent than male sex (23 patients; 41.1%). Twenty-five patients (44.7%) were in New York Heart Association (NYHA) functional class III–IV. Mean preoperative LV ejection fraction was 62±5%. Concomitant cardiovascular pathologies included ischemic heart disease in 4 and tricuspid regurgitation in 18 cases (Fig. 1). Most patients had preoperative Grade 4 MR and underwent mitral repair according to our definition. Degenerative MV disease as the cause of MR was diagnosed in 38 patients. Distribution of MV pathologies during surgical exploration is presented in Table 2. 5 patients presented with the prolapse of the posterior leaflet, whereas 25 patients had an involvement of both mitral leaflets. Commissural fusion was diagnosed in 11 patients.

Operative data

Operative data are demonstrated in Table 3. Most of the procedures were performed through a median sternotomy. A minimally invasive approach through a right anterior mini-thoracotomy and trans-thoracic aortic clamping was used in 4 patients for cosmetic reasons.

Surgical procedures involving different techniques are listed in Table 4. Ring annuloplasty was performed in 54 patients. Technically, for example; quadrangular resection of the posterior leaflet, sliding annuloplasty, ring annuloplasty, Reed annuloplasty, and chordal replacement were performed. All patients undergoing chordal replacement and posterior leaflet resection had an annuloplasty procedure.

Table 1: Patient demographics and preoperative characteristics

Variables	
Sex (Male)	33(58.9%)
Age(years)	41.8±16.5
BMI (Kg/cm^2)	26±3
Hypertension	15(26.7%)
Diabetes mellitus	3(5.4%)
NYHA functional status, n	
Class II	31(55.3%)
Class III	23(41.1%)
Class IV	2(3.6%)
Euroscore	1(0-5)
LVEF,%	62±5
Mitral valve pathology, n	
Mitral regurgitation (MR)	44(78.6%)
Mixed lesion (MR + MS)	12(21.4%)
Mitral valve disease, n	
Degenerative	38(67.8%)
Rheumatic	13(23.2%)
Congenital	3(5.4%)
HOCM	2(3.6%)
Data are presented as mean value ± standard deviation,median value, or number of patients. BMI: Body Mass Index, NYHA: New York Heart Association, LVEF: Left ventricle ejection fraction, MR: Mitral regurgitation, MS: Mitral stenosis, HOCM: Hypertrophic Obstructive Cardiomyopathy	

Table 2: Distribution of mitral valve pathologies

Variables	**N**
Annular dilatation	34
Leaflet prolapse	
Anterior leaflet	2
Posterior leaflet	5
Both leaflet	25
Commissural	9
Chordal rupture	
Anterior leaflet	2
Posterior leaflet	3
Mitral cleft	
Anterior leaflet	4
Posterior leaflet	6
Commissural fusion	11
Leaflet retraction	
Anterior leaflet	1
Posterior leaflet	14
Chordal retraction	
Primary chordae	10
Secondary chordae	20
HOCM	2
Data are presented as number of patients. HOCM: Hypertrophic Obstructive Cardiomyopathy	

Table 3: Operative data

Variables	
Incision, n(%)	
Sternotomy	52(92.8%)
Right mini-thoracotomy (port access)	4(7.2%)
Surgical approach, n(%)	
Left atrium	14(25%)
Right atrium	42(75%)
Operation duration	
Cardiopulmonary bypass duration, min	144±35
Aortic cross-clamp duration, min	101±30
ICU stay, days	1.83±0.4
Hospital stay, days	7.12±1.86
Data are presented as mean±SD or number of patients. ICU: intensive care unit	

Table 4: Surgical repair techniques

Technique	**Patient (n)**
Resection of P2, Sliding Artificial chordae Commissuroplasty Ring annuloplasty	10
Resection of P2, Sliding Cleft repair Ring annuloplasty	1
Commissurotomy Resection of secondary chordae Resection of primary chordae Artificial chordae Ring annuloplasty	3
Commissurotomy Resection of secondary chordae Posterior leaflet augmentation Ring annuloplasty	6
Commissurotomy Posterior leaflet augmentation Ring annuloplasty	1
Commissurotomy Resection of secondary chordae Reed annuloplasty	1
Artificial chordae Posterior leaflet augmentation Ring annuloplasty	4
Artificial chordae Cleft repair Commissuroplasty Ring annuloplasty	6
Artificial chordae Shortening posterior leaflet	12

Ring annuloplasty	
Artificial chordae Cleft repair Shortening posterior leaflet Ring annuloplasty	1
Artificial chordae Resection of secondary chordae Resection of primary chordae Posterior leaflet augmentation Ring annuloplasty	6
Artificial chordae Resection of secondary chordae Ring annuloplasty	1
Artificial chordae Resection of secondary chordae Resection of primary chordae Cleft repair Reed annuloplasty	1
Anterior leaflet augmentation Shortening posterior leaflet Ring annuloplasty	1
Cleft repair Resection of secondary chordae Ring annuloplasty	2

Concomitant procedures are listed in Table 5. 4 coronary artery bypass grafting, 18 tricuspid repair, left atrial radiofrequency ablation in 12 patients with preoperative AF and left atrial appendix ligation in all patients with preoperative AF were performed. In patients presenting with MR, aortic aneurysm and aortic regurgitation, we preferred making valve sparing aortic repair (reimplantation procedure) if patients were below 70 years of age and had a favorable physical status.

Table 5: Concomitant surgical procedures

Concomitant surgical procedures	**n(%)**
CABG	4(7.1%)
TR	18(32.1%)
Kay annuloplasty	12(21.4%)
Ring annuloplasty	6(10.7%)
AVR	3(5.4%)
Aortic valve reconstruction	3(5.4%)
Valve-sparing aortic root replacement	2(3.6%)
Septal myectomy for HOCM	2(3.6%)
RF ablation	12(21.4%)
CABG: Coronary artery bypass grafting, TR: Tricuspid repair, AVR: Aortic valve replacement, HOCM: Hypertrophic Obstructive Cardiomyopathy, RF: Radiofrequency ablation.	

Clinical outcomes

Early and late complications after mitral repair are presented in Table 6. There was only 1 early death (30-day mortality: 1.8%) due to postoperative low cardiac output syndrome in patient with significant left ventricle dysfunction. The mean intensive care unit and hospital stay of patients were 1.83±0.4 and 7.12±1.86 days, respectively. New-onset AF developed in 4 patients and medically resolved in all. Inotropic support more than 24 hours was needed in four cases, and two of them needed intra-aortic balloon pump (IABP).

Late follow-up was obtained in 55 patients at an average of 47,9 ±23,1 months postoperatively. Mortality developed in one (1.8%) patient with Marfan syndrome who had acute aortic dissection three years after mitral valve surgery. Only one (1.9%) patient needed re-operation because of severe mitral regurgitation. This patient was treated with mechanical valve replacement after four years of initial repair.

Table 6: Early and late morbidity and mortality

Variables	n (%)
Early (<30 days)	
Mortality	1(1.8%)
New-onset atrial fibrillation	4(7.1%)
Pleural effusion requiring drainage	1(1.8%)
Low cardiac output syndrome	1(1.8%)
Inotropic support >24 hours	4 (7.1%)
Intra aortic balloon pump	2(3.6%)
Acute renal failure	1(1.8%)
Cerebrovascular accident	1(1.8%)
Late (47,9 ±23,1 monthes)	
Mortality	1(1.8%)
Re-operation	1(1.8%)
Data are presented as number of patients (percentage)	

Echocardiographic results

Echocardiographic data are given in Table 7. In all patients who underwent MV repair, the procedures were successful at discharge; transthoracic echocardiography examinations revealed no/trivial MR in 74.6% and mild MR in 21.8% of patients. During follow-up visits, mitral repair procedures were successful in 49 (90.7%). Only four (7.4%) patients presented with moderate MR, and they were asymptomatic under medical treatment. Unfortunately, severe MR developed in one patient. This patient was treated with mechanical valve replacement after four years of initial repair.

Table 7: Echocardiographic follow-up data of patients

Variables	Preoperative	Operative TEE	At discharge	At follow-up
MR grade, n (%)	56	56	55	54
None/Trivial	0	46(82.1%)	41(74.6%)	25(46.3%)
Mild	0	10(17.9%)	12(21.8%)	24(44.4%)
Moderate	4(7.1%)	0	2(3.6%)	4(7.4%)
Severe	52(92.9%)	0	0	1(1.9%)
Data are presented as number of patients (percentage), MR -Mitral Regurgitation				

DISCUSSION

Current consensus guidelines on MR recommend repair over replacement whenever possible and earlier surgical intervention if there is a high likelihood of repair (13, 14). Accordingly, repair feasibility is a key factor in the decision to operate, and is highly dependent on lesion complexity and surgeon experience (15). Repair of the mitral valve is well known for its efficacy, durability, and avoidance of many complications (16). As demonstrated in many studies (3,12,17), MV replacement is associated with (a) gradual decline in left ventricular function, (b) hazards of anticoagulation, (c) thromboembolism and (d) higher incidence of endocarditis. Results from a recent series (18) show a poor survival after valve replacement. Growth, marriage and pregnancy are important issues which are adversely affected by anticoagulation. During the last two decades, the number of MV repair procedures has increased across the world. As experience grows in this field, surgeons try to repair more valves in complex mitral valve disease patients. In our series consisting of 56 complex mitral valve cases that underwent MV repair, there was one early mortality after 5 days of surgery due to postoperative low cardiac output syndrome in a patient with significant left ventricle dysfunction. In the late follow-ups, there was one mortality due to acute aortic dissection after three years of surgery. This patient had Marfan syndrome and we repaired his mitral valve. At the time of operation, there was mild aortic regurgitation and the diameter of aortic root was 36mm. Echocardiographic assessment of patients at discharge revealed no/trivial regurgitation in 74.6% and mild MR in 21.8% of all patients. Echocardiographic examination during follow-up revealed that mitral insufficiency was none or mild in 90.7% of patients. Four (7.4%) patients had moderate MR and were treated medically. Mitral insufficiency recurrence with severe regurgitation occurred in one (1.9%) patient. This patient was treated with mechanical valve replacement after four years of initial repair. We prefer surgical repair of mitral valve in young patients (Mean age 41.8±16.5) and we think that it is not a good strategy for elderly patients.

The mitral apparatus includes the leaflets, annulus, chordae tendineae, papillary muscles and left ventricle. The goals of mitral repair are to maintain leaflet mobility, remodel the annulus, and allow normal coaptation of the anterior and posterior leaflets. In mitral valve prolapse or Barlow's syndrome, the leaflets and chordae become thickened and redundant, which results in leaflet prolapse beyond the plane of the annulus and MR. In our study, 38 patients had degenerative mitral valve. Upto 2011 we repaired degenerative mitral valve with leaflet resection, after that we switched to artificial chordae implantation as a routine technique. The most

simple and common MV lesion, the prolapse of posterior leaflet, can be treated with leaflet resection with excellent short-term and long-term results (19). However, the correction of anterior, bileaflet prolapse or even large areas of posterior prolapse is more complex (20,21). Particularly in patients with complex degenerative MV disease, we used three or more techniques together. For example, we used combination of artificial chordae, resection of secondary chordae, resection of primary chordae, posterior leaflet augmentation and ring annuloplasty in 6 patients. Our degenerative mitral valve repair was successful in all patients. Echocardiographic examination during follow-up revealed that mitral insufficiency was none or mild in 37 patients. One patient had moderate MR and treated medically.

MV repair has been shown to have excellent durability in patients with mitral regurgitation (MR) caused by degenerative disease (4, 5). In contrast, valve reconstruction for rheumatic MR remains controversial as it not only suffers from an inferior feasibility of repair (8), but also the repaired rheumatic valve is less stable with inferior durability when compared with a degenerative MV repair (9). The utilization of leaflet mobilization and extension with the pericardium to increase the leaflet area and the surface of coaptation may provide satisfactory results (22-24). Chauvaud et al. (22,23), on the other hand, had demonstrated good long-term results in repairing diseased rheumatic MVs using Carpentier's reconstruction techniques. Dillon J and his friends reported that after leaflet extension in rheumatic mitral valve reconstruction, MR grade was none/trivial in 64.5% of patients, mild in 22.6%, moderate in 6.5%, moderately severe in 4.8% and severe in 1.6%. Two patients had redo mitral surgery. At 5 years postoperatively, the estimated rates of freedom from reoperation was 96.8 % (25).

13 of our patients had diseased rheumatic mitral valve. We repaired their valves using commissurotomy, resection of primary or/and secondary chordae, artificial chordae, ring annuloplasty or posterior leaflet augmentation. Echocardiographic examination during follow-up revealed that mitral insufficiency was none or mild in 10 patients. Two patients had moderate MR and treated medically. One patient had redo mitral surgery after four years of surgery. In the follow-up, regurgitation was seen once often in rheumatic valves. Retraction of pericardial patch and the on-going process of rheumatic disease was considered to be the undergoing pathologies in these cases.

In contrast, in children with congenital mitral regurgitation, conventional repair of the valve is not always successful. In part, this reflects the complicated abnormalities of the valvular structures, and the associated cardiac malformations. When planning the optimal surgical repair of the mitral valve, attention must be directed at the annular attachment, the valvar leaflets and the tension apparatus of the valve. In patients with congenital mitral regurgitation, the annular attachment is commonly dilated, and the papillary muscles, as well as their attachments to the ventricular wall, are frequently abnormal (26,27). In some patients with prolapse of the leaflets of mitral valve, use of artificial chords have been suggested to provide efficient results in the short-term (28).

In our study, three patients underwent mitral reconstructive operations for congenital mitral diseases. The pathologic findings of the first patient's mitral valve were short and thickened chordae and annular dilatation. Her mitral valve was repaired using artificial chordae, resection of secondary chordae, resection of primary chordae, posterior leaflet augmentation and ring annuloplasty. The second's echocardiography showed severe mitral stenosis related to a hammock mitral valve and his valve was repaired using commissurotomy,

resection of secondary chordae and Reed annuloplasty. The third's mitral valve was repaired using artificial chordae, resection of secondary chordae, resection of primary chordae, cleft repair and Reed annuloplasty.

Kawahira Y. et al. used artificial cords in 11 children with congenital mitral regurgitation, and they reported that in two patients, regurgitation recurred within 1 year of the operation (29). Early and late results of reconstructive operation for congenital mitral regurgitation in 66 pediatric age group were reported by Okita Y. et al. Valvuloplasty failed in 19 of the long-term survivors and one of these patients underwent mitral valve replacement 11 years after initial operation(30). During follow-up there was no reoperation and one of the patients had moderate mitral regurgitation in echocardiographic examination. Valve repair was particularly prefered in this patient because he had mental retardation and warfarin use and regular INR follow-up was not feasible. The recurrence of mitral regurgitation in this patient, may be explained by the fact that mitral ring was not used in the repair surgery to avoid development of functional stenosis in the following years.

The mitral valve in HOCM usually has an increased length of the anterior and posterior mitral leaflet. The mitral valve, specifically the systolic anterior motion of the mitral valve leaflets, is an important component of the obstruction (31). In HOCM, abnormal anatomy and valve displacement induce drag forces that cause systolic anterior motion. This condition can be corrected by an autologous pericardial patch in the anterior mitral leaflet (32).

We routinely excise sufficient septal muscle to leave a residual septal thickness within the normal range. Patients with more severe forms of hypertrophic obstructive cardiomyopathy with mitral valve involvement may require a more complex reconstructive operation. The anterior leaflet is reconstructed using an ovoid patch of glutaraldehyde-treated autologous pericardium sutured to the edges of the leaflet incision. Whenever posterior leaflet was higher than 20mm, we reduced it to less than 20 mm by an ovoid resection. Finally, in severe forms with an excessively small annulus and a hyperkinetic ventricle, a rigid annuloplasty ring is implanted. There were two HOCM patients at this study. In the first case, we repaired the mitral valve using artificial chordae, shortening posterior leaflet, commissuroplasty and ring annuloplasty. The other's mitral valve was repaired using shortening posterior leaflet, anterior leaflet augmentation and ring annuloplasty. There is no mitral regurgitation in echocardiographic examination during follow-up.

Conclusion

Mitral valve repair for complex pathologies is a feasible and safe procedure with an excellent surgical outcomes in experienced hands. We demonstrated that mitral valve repair can be performed for mixed mitral valve disease patients with results similar to those in pure MR patients. Autologous pericardium is a useful leaflet substitute that facilitates mitral valve repair. Combining multiple techniques of mitral valve repair may extend valve repair into a wider spectrum of complex valve pathologies.

Limitations of the study

The major limitations of this study are the retrospective design, the small number of the patients and the short follow-up period in some patients.

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