Turkish Journal of Thoracic and Cardiovascular Surgery 2019;27(4):459-468
http://dx.doi.org/doi: 10.5606/tgkdc.dergisi.2019.18165

Original Article / Özgün Makale

Durability of mitral valve repair: A single center experience

Mitral kapak onarımın dayanıklığı: Tek merkez deneyimi

Salih Salihi[1], Mustafa Güden[2]

Institution where the research was done:
Sakarya University Training and Research Hospital, Sakarya, Turkey

Author Affiliations:
[1]Department of Cardiovascular Surgery, Sakarya University Training and Research Hospital, Sakarya, Turkey
[2]Department of Cardiovascular Surgery, Mega Medipol Hospital, Istanbul, Turkey

ABSTRACT

Background: This study aims to present clinical outcomes of mitral valve repair in patients with different etiologies.

Methods: Between June 2006 and August 2017, a total of 421 consecutive patients (266 males, 155 females; mean age 53.1±15.6 years; range, 5 to 89 years) who underwent mitral valve repair with or without concomitant cardiac procedures were retrospectively analyzed. All pre-, intra-, and postoperative data were collected. Echocardiographic examinations were performed at discharge and during follow-up. Kaplan-Meier analysis was used to estimate overall survival and from residual severe mitral regurgitation, endocarditis and reoperation-free survival rates.

Results: The mean follow-up was 58.9±35.1 months. Of the patients, 12 (2.8%) had previous cardiac operations. The most predominant pathology was degenerative disease in 265 patients (62.9%). Repair techniques included ring annuloplasty (n=366, 86.9%), artificial chordae implantation (n=185, 44%), and commissurotomy (n=38, 9%). Overall in-hospital mortality rate was 1.2% (n=5). Echocardiography before discharge showed no/trivial mitral regurgitation in 64.9% (n=270) and mild mitral regurgitation in 34.85% (n=145) of the patients. At the late postoperative period, transthoracic echocardiography revealed moderate mitral regurgitation in 23 patients (5.7%) and severe in 11 patients (2.7%). The mean late survival and freedom from endocarditis, reoperation, and recurrent severe mitral regurgitation rates were 92±0.03%, 98.5±0.07%, 98.1±0.01%, and 94.7±0.02%, respectively.

Conclusion: Our study results suggest that mitral valve repair is a safe and effective procedure associated with favorable long-term outcomes in experienced centers.

Keywords: Mitral regurgitation, mitral stenosis, mitral valve annuloplasty.

ÖZ

Amaç: Bu çalışmada farklı etiyolojileri olan hastalarda mitral kapak onarımının klinik sonuçları sunuldu.

Çalışma planı: Haziran 2006 - Ağustos 2017 tarihleri arasında eş zamanlı kardiyak ameliyat ile birlikte veya tek başına mitral kapak onarımı yapılan toplam 421 ardışık hasta (266 erkek, 155 kadın; ort. yaş 53.1±15.6 yıl; dağılım, 5-89 yıl) retrospektif olarak incelendi. Tüm ameliyat öncesi, sırası ve sonrası veriler toplandı. Ekokardiyografik incelemeler taburculukta ve takip sırasında yapıldı. Kaplan-Meier analizi genel sağkalım ve rezidüel ciddi mitral yetmezlik, endokardit ve tekrar ameliyatsız sağkalım oranlarının tahmininde kullanıldı.

Bulgular: Ortalama takip süresi 58.9±35.1 ay idi. Hastaların 12'si (%2.8) daha önce kalp ameliyatı geçirmişti. En yaygın patoloji 265 hastada (%62.9) dejeneratif hastalık idi. Onarım teknikleri ring anüloplasti (n=366, %86.9), yapay korda implantasyonu (n=185, %44) ve komissürotomi (n=38, %9) idi. Genel olarak hastane mortalitesi %1.2 (n=5) idi. Taburculuk öncesinde ekokardiyografide hastaların %64.9'unda (n=270) mitral yetmezlik izlenmedi veya önemsiz mitral yetmezlik izlendi ve hastaların %34.85'inde (n=145) hafif mitral yetmezlik izlendi. Ameliyat sonrası geç dönemde, transtorasik ekokardiyografide 23 hastada (%5.7) orta dereceli ve 11 hastada (%2.7) ciddi mitral yetmezlik izlendi. Ortalama geç sağkalım, endokardit, yeniden ameliyat ve tekrarlayan ciddi mitral yetmezlikten bağımsızlık oranı sırasıyla %92±0.03, %98.5±0.07, %98.1±0.01 ve %94.7±0.02 idi.

Sonuç: Çalışma sonuçlarımız mitral kapak onarımının deneyimli merkezlerde uzun dönem olumlu sonuçlar ile ilişkili olarak, güvenli ve etkin bir yöntem olduğunu göstermektedir.

Anahtar sözcükler: Mitral yetmezlik, mitral darlık, mitral kapak anüloplastisi.

Received: May 15, 2019 *Accepted:* July 14, 2019 *Published online:* October 23, 2019

Correspondence: Salih Salihi, MD. Sakarya Üniversitesi Eğitim ve Araştırma Hastanesi Kalp ve Damar Cerrahisi Kliniği, 54100 Sakarya, Turkey.
Tel: +90 505 - 876 30 59 e-mail: drssalihi@yahoo.com

Cite this article as:
Salihi S, Güden M. Durability of mitral valve repair: a single center experience. Turk Gogus Kalp Dama 2019;27(4):459-468

Mitral regurgitation (MR) is a commonly encountered valvular pathology in daily practice. It can arise from pathologies of any part of the mitral valve apparatus including valve leaflets, annulus, chordae tendinea, and papillary muscles. Currently, two main surgical mitral valve procedures are available for the treatment of chronic MR, namely valve repair and valve replacement.[1] Mitral valve repair (MVr) has been widely used as the optimal surgical procedure to treat mitral valve dysfunction of all etiologies and is, today, the most commonly performed surgical procedure for MR.[2]

The major advantages of MVr over mitral valve replacement (MVR) are complete preservation of the subvalvular apparatus which protect the left ventricular (LV) function and avoidance of prosthetic heart valves and its potential complications. In addition, MVr does not require lifelong anticoagulation, compared to mechanical prosthesis.[3,4] Current MVr techniques with the use of artificial chordae replacement and ring annuloplasty have significantly expanded the scope and durability of repair, particularly in patients with bileaflet and anterior leaflet prolapse.[5,6] These procedures are feasible in almost 95% of the patients with degenerative MR, despite the presence of complex lesions.[7] The MVr has been shown to have excellent durability in patients with MR caused by degenerative disease and is, indeed, the method of choice in the correction of MR, whenever feasible.[8,9]

In this study, we aimed to present clinical and echocardiographic outcomes of MVr in patients with different etiologies in an experienced center.

PATIENTS AND METHODS

Between June 2006 and August 2017, all patients who underwent MVr by a single surgeon with or without concomitant cardiac procedures were retrospectively analyzed. Patients with infective endocarditis (n=6), and dilated cardiomyopathy (n=7) were excluded from this study. Five patients died in hospital. We were unable to reach 31 patients due to changed telephone numbers and addresses. Finally, a total of 421 consecutive patients (266 males, 155 females; mean age 53.1±15.6 years; range, 5 to 89 years) were included in the study. All pre-, intra-, and postoperative data were collected. Additionally, all surgical and discharge notes were reviewed. Data including preoperative ejection fraction, severity of MR, valve pathology, repair techniques, and intra- and early postoperative (<30 days) and late complications were noted. Institutional approval was obtained for the study.

Surgical techniques

Surgical approach was mid-sternotomy (n=403) or a right anterolateral thoracotomy in young patients (n=18) for cosmetic reasons. Aortobicaval cannulation was used in all patients. Operations were performed under cardiopulmonary bypass (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 109 patients (25.9%), we used left atriotomy. After a careful analysis of the mitral valve leaflets and subvalvular apparatus, the reconstruction procedure was planned. Depending on the valve morphology, different combinations of techniques were used including annuloplasty, commissurotomy, leaflet resection, cleft suturing, pericardial augmentation, and artificial chordae implantation. Our MVr techniques evolved over the years. Mitral annuloplasty techniques consisted of prosthetic ring annuloplasty and modified posterior suture annuloplasty similar to DeVega tricuspid annuloplasty (Wooler-Reed annuloplasty). In degenerative MR, leaflet prolapse was repaired by triangular or quadrangular resection of mitral leaflet with or without concomitant sliding plasty in the earlier part of our experience. Recently, we have favored the leaflet preservation strategy including the use of either 2-0 or 3-0 polytetrafluoroethylene sutures placed on the head of the anterolateral or posteromedial papillary muscle. The level of the zone of opposition was adjusted according to the level of the annulus. In rheumatic mitral valve disease, augmentation of the posterior leaflet by the extension with autologous pericardium, release of the retracted subvalvular apparatus, and commissurotomy were preferred. In certain cases, even restricted primary chords were resected, and they were substituted with artificial chordae. We selected mitral ring according to mitral valve pathology. We adopted different annuloplasty strategies for degenerative MR over the past years, ranging from flexible rings (Medtronic-Duran AnCore annuloplasty system Duran AnCore Ring [Medtronic, Minneapolis, MN, USA], St. Jude flexible ring [St. Jude Medical, St. Paul, Minn, USA]) to the current practice of using a complete saddle-shaped ring (Profile 3D annuloplasty system, Memo 3D Semi-Rigid annuloplasty ring [Sorin SpA, Milan, Italy]). In functional MR, we preferred completely semi-rigid, saddle-shaped ring (Profile 3D annuloplasty system, Memo 3D Semi-Rigid annuloplasty ring). We did not use rigid rings (except for rheumatic patients) due to the risk of systolic anterior motion (SAM) which can obstruct the outflow tract of the LV. Although there

is no consensus on which type of annuloplasty ring (flexible, semi-rigid or rigid) is a better choice for the different mitral pathologies, our experience shows that saddle-shaped rings are effective for patients with rheumatic, degenerative, and functional valve diseases. In MR due to hypertrophic obstructive cardiomyopathy (HOCM), we performed shortening of posterior leaflet, artificial chordae implantation and ring annuloplasty in addition to septal myectomy to prevent SAM.

The left atrial appendage was routinely closed from the left atrium with the double running suture technique in patients with atrial fibrillation (AF). Upon completion of repair, the mitral valve was examined by injecting cold saline with a bulb syringe into the LV cavity to observe coaptation of the leaflets. Intraoperative transesophageal echocardiography (TEE) was routinely used for intraoperative assessment of the MVr after CPB. When an unsatisfactory finding was observed on TEE, a second cross-clamp was placed to achieve a satisfactory repair, if possible.

Follow-up

Follow-up data were analyzed using cardiology and cardiac surgery outpatient follow-up records, primary care and institutional computer-based databases, and telephone interviews. Prior to discharge, transthoracic echocardiography (TTE) was carried out in all patients and were repeated at one, three, and six months postoperatively and every year, thereafter. Echocardiographic findings were recorded in the computer database of the hospital. Clinical parameters recorded during follow-up included early (<30 days) and late mortality after surgery. A total of 56 patients completed the 10-year follow-up. All patients were anticoagulated with warfarin for three months after surgery and permanently, if they had AF or another mechanical valve.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max), or number and frequency. Actuarial estimates for the cumulative survival and freedom from adverse events including MR recurrence, reoperation and endocarditis were calculated using the Kaplan-Meier method.

RESULTS

Baseline characteristics of all patients are listed in Table 1. Of the patients, 12 (2.9%) had previous cardiac operations. A total of 255 patients (60.6%) were in the New York Heart Association (NYHA) Functional Class III-IV. Most of the patients had degenerative disease

Table 1. Clinical characteristics of patients (n=421)

Variables	n	%	Mean±SD
Age (year)			53.1±15.7
Gender			
Female	155	36.8	
Associated diseases			
Hypertension	189	44.9	
Diabetes mellitus	39	9.3	
Chronic obstructive pulmonary disease	12	2.9	
Peripheral vascular disease	4	1	
Cerebrovascular disease	7	1.7	
Previous cardiac operations			
Coronary artery bypass grafting	3	0.7	
Aortic valve surgery	2	0.5	
Mitral valve repair	1	0.2	
Congenital heart surgery	5	1.2	
Resection of cardiac myxoma	1	0.2	
Preoperative atrial fibrillation	60	14.3	
NYHA III-IV	255	60.6	
Preopeorative LVEF (%)			58.2±8.9

SD: Standard deviation; NYHA: New York Heart Association, LVEF: Left ventricular ejection fraction

(n=265, 62.9%), followed by functional MR (n=108, 25.7%). Valve etiology and lesions were identified by the surgeon with the inspection of the valve during the operation. While 97 patients (23%) had Carpentier type 1, 274 (65.1%) had type 2. Mitral valve anatomy and Carpentier classification of mitral valve pathologies are given in Table 2. Forty-two patients (5.7%) presented with the prolapse of the anterior leaflet, whereas 67 patients (15.9%) had an involvement of both mitral leaflets. Commissural fusion was diagnosed in 38 patients (9%). Most of the operations (n=403, 95.7%) were performed through a median sternotomy. Concomitant surgical procedures and repair techniques are presented in Table 3. Left atrial radiofrequency ablation was performed in 51 patients (12.1%) with preoperative AF and left atrial appendix ligation was done in all patients with preoperative AF (Table 3). Repair techniques included ring annuloplasty (n=366, 86.9%), either alone (n=106) or with another repair techniques (n=260), including leaflet resection (n=41, 9.8%), artificial chordae implantation (n=185, 44%), and commissurotomy in 38 patients (9%). Posterior leaflet extension with a pericardial patch was used in 13 patients (3.1%) with rheumatic disease. Shortening posterior leaflet and anterior leaflet augmentation was performed in a hypertrophic cardiomyopathy patient.

Early and late outcomes

The early and late postoperative outcomes of all patients are presented in Table 4. Overall in-hospital mortality rate was 1.2% (n=5). Four patients (1%) had low cardiac output (on postoperative Days 4, 4, 5, and 12) and one (0.2%) died of acute renal failure on postoperative Day 20. Eight patients (1.9%) had re-sternotomy due to bleeding on the first day postoperatively, and nine (2.1%) required intra-aortic balloon pump support. Three patients (0.7%) had cerebrovascular events, and 24 (5.7%) had

Table 2. Clinical characteristics of patients (n=421)

Variables	n	%	Mean±SD
Mitral valve disease			
Mitral regurgitation (MR)	384	91.2	
Mixed lesion (MR + MS)	37	8.8	
Mitral valve pathology			
Degenerative	265	62.9	
Functional	108	25.7	
Ischemic	77	18.3	
Moderate	24	5.7	
Severe MR	53	12.6	
Others	31	7.4	
Moderate MR	5	1.2	
Severe MR	26	6.2	
Rheumatic	39	9.3	
Congenital	6	1.4	
Hypertrophic obstructive cardiomyopathy	3	0.7	
Carpentier classification			
Type 1	97	23	
Type 2	274	65.1	
Type 3			
Type 3a	39	9.3	
Type 3b	11	2.6	
MR severity			
Mild	9	2.1	
Moderate	29	6.9	
Severe	383	91	

SD: Standard deviation; MR: Mitral regurgitation, MS: Mitral stenosis.

renal failure in the postoperative period. Twenty-nine patients (6.9%) had pulmonary complications and two (0.5%) required permanent pacemaker implantation. The mean intensive care unit stay was 2.25±1.54 (range, 1 to 20) days and the mean ward stay was 7.81±2.51 (range, 4 to 30) days.

The mean follow-up was 58.9±35.1 (range, 0 to 136) months. During follow-up, 14 patients (3.3%) died. Six of them (1.4%) died from cardiac causes, six (1.4%) from other causes, and two (0.5%) from unknown causes. The causes of late cardiac deaths were congestive heart failure in two, sudden death in two, acute aortic dissection in one, and myocardial infarction in one patient.

Table 3. Operative data (n=421)

Variables	n	%
Incision		
Sternotomy	403	95.7
Right mini-thoracotomy (port access)	18	4.3
Surgical approach		
Transseptal	294	69.8
Left atriotomy	109	25.9
Superior septal	18	4.3
Concomitant surgical procedures		
Coronary artery bypass grafting	130	30.9
Tricuspid repair	142	33.7
Kay annuloplasty	87	20.7
Ring annuloplasty	53	12.6
Others	2	0.5
Aortic valve replacement	35	8.3
Aortic valve reconstruction	1	0.2
Ascending aortic replacement	2	0.5
Bentall procedure	13	3.1
Valve-sparing aortic root replacement	4	1
Septal myectomy for HOCM	3	0.7
Left atrial radiofrequency ablation	51	12.1
Congenital heart surgery	9	2.1
Surgical repair techniques		
Ring annuloplasty	366	86.9
Reed annuloplasty	48	11.4
Artificial chordae	185	44
Resection of P2, sliding	7	1.7
Quadrangular resection	34	8.1
Commissurotomy	38	9
Shortening posterior leaflet	6	1.4
Posterior leaflet augmentation	13	3.1
Cleft repair	9	2.1
Commissuroplasty	18	4.3
Resection of secondary chordae	19	4.5
Resection of primary chordae	3	0.7

HOCM: Hypertrophic obstructive cardiomyopathy.

Cumulative survival analysis of the patients as assessed by the Kaplan-Meier method revealed an overall survival rate of 92.1% at 10 years (Figure 1a).

Recurrent MR

Only one patient was discharged from hospital with moderate MR, while the remaining patients had none, trivial, or mild MR. At the final follow-up visit, the MR grade was moderate in 23 patients and severe in 11 patients (Table 5). The valve pathologies in moderate MR were functional in 11, rheumatic in six, degenerative in five, and congenital in one patient (Figure 2). Among 11 patients with severe MR, six had reoperations and five were alive (two asymptomatic with normal ventricular function and three in Class NYHA III with poor ventricular functions). The rate of freedom from recurrent severe MR was 94.7% at 10 years (Figure 1b).

Infective endocarditis

There were five cases (1.18%) of infective endocarditis. Two patients were treated with antibiotics alone and three required surgery. All patients survived. The rate of freedom from endocarditis was 98.5% at 10 years (Figure 1c).

Reoperation

Six patients (1.4%) had redo mitral valve surgery during follow-up. At redo surgery, MVR was performed in all patients. The reasons for redo surgery were recurrent MR from progression of rheumatic disease in two patients and inadequate initial repair in one patient with ischemic MR. Three patients underwent MVR due to infective endocarditis. Overall rate of freedom from reoperation was 98.1% at 10 years (Figure 1d).

DISCUSSION

In this study, we report clinical outcomes of 421 patients who underwent MVr for MR due to different etiologies over a 10-year period. Our study results demonstrated that MVr was a safe procedure associated with good postoperative outcomes and long-term results. The overall early mortality rate was 1.2%. The discharge echocardiography showed no/trivial MR in 64.9% and mild MR in 34.85% patients. According to the Kaplan-Meier survival estimations, the mean late survival and freedom from endocarditis, reoperation,

Table 4. Early and late morbidity and mortality

Variables	n	%	Mean±SD
Early (<30 days)			
In-hospital mortality	5	1.2	
Cardiac	4	1	
Non-cardiac	1	0.2	
Low cardiac output syndrome	12	2.9	
Inotropic support >24 hours	37	8.8	
Intra-aortic balloon pump	9	2.1	
Extracorporeal membrane oxygenation	1	0.2	
New-onset postoperative atrial fibrillation	69	16.4	
Pleural effusion requiring drainage	17	4	
Reoperation for bleeding	8	1.9	
Postoperative renal failure*	24	5.7	
Hemodialysis	4	1	
Stroke	3	0.7	
Superficial wound infection	7	1.7	
Permanent pacemaker implantation	2	0.5	
Pulmonary complications	29	6.9	
Prolonged mechanical ventilation	13	3.1	
Late (month)			59.0±35.1
Mortality	14	3.3	
Cardiac	6	1.4	
Non-cardiac	8	2	
Mitral regurgitation recurrence			
Moderate	23	5.5	
Severe	11	2.74	
Reoperation	6	1.4	
Endocarditis	3	0.7	

SD: Standard deviation; * Creatinine level of >1.5 mg/dL.

and recurrent severe mitral regurgitation rates were 92±0.03%, 98.5±0.07%, 98.1±0.01%, and 94.7±0.02%, respectively.

In recent years, the MVr has become the preferred method for the treatment of MR, with favorable results, compared to MVR.[6,9] The main advantages of MVr over MVR are lower operative mortality, improved preservation of the LV function, and avoidance of prosthetic valve-related complications such as thromboembolism, anticoagulant-induced hemorrhage, and endocarditis.[1] Additionally, MVr is cost-effective with reduced short-and long-term medical expenses.[10] Using MVr, the expense of prosthetic valve is avoided and is free from lifelong anticoagulation treatment.

According to the current guidelines, MVr is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR involving the anterior leaflet or both leaflets when a successful and durable repair can be accomplished.[1] The MVr without delay is recommended in experienced centers for asymptomatic patients with chronic severe primary MR and preserved LV function (LV ejection fraction >60% and LV end-systolic diameter <40 mm) in whom the likelihood of successful and durable repair without residual MR exceeds 95% and with an operative mortality risk of <1% (Class IIa). Rather than waiting for symptoms or objective clinical endpoints of LV dysfunction, pulmonary hypertension, or AF, which was the standard in the past, the current trend favors early intervention

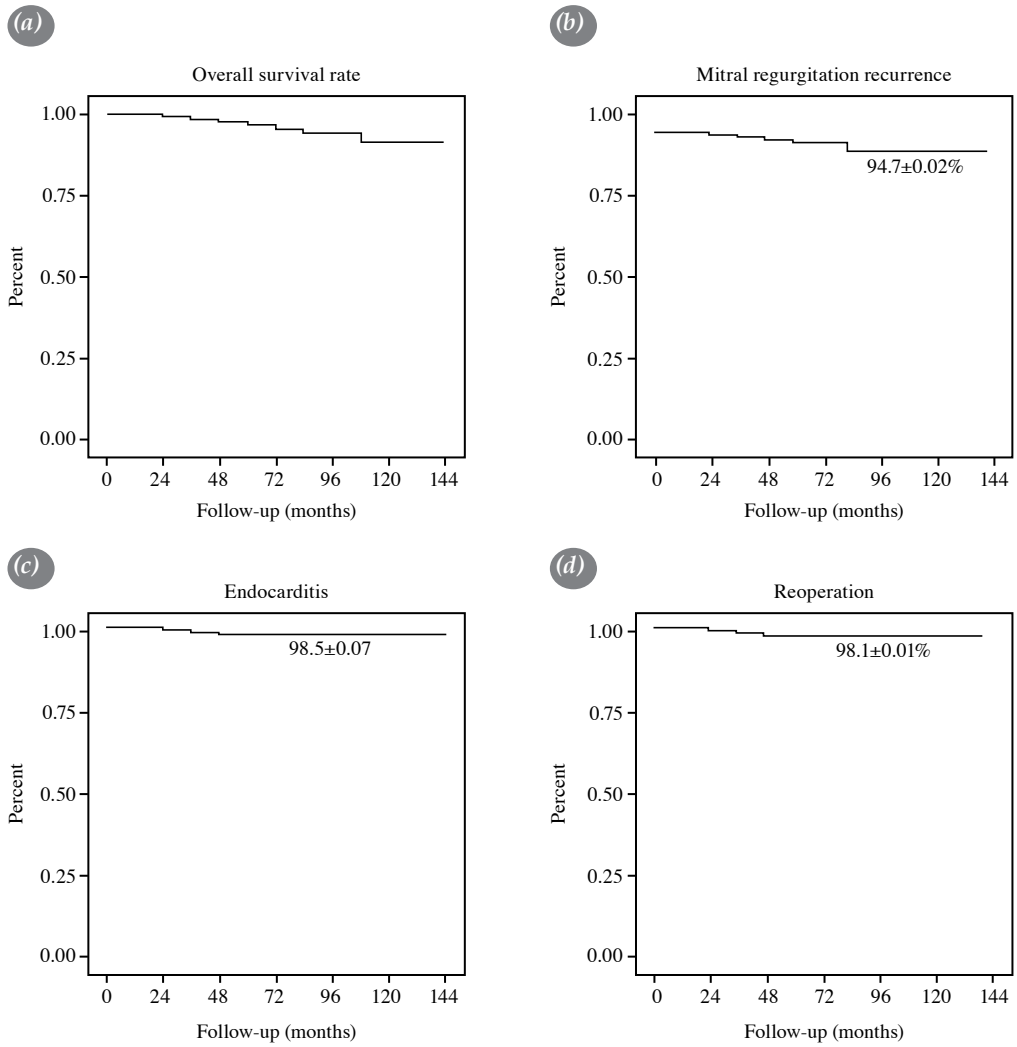

Figure 1. (a) Survival estimates; **(b)** Kaplan-Meier analysis of overall freedom from recurrent severe mitral regurgitation; **(c)** Kaplan-Meier analysis of overall freedom from endocarditis, **(d)** Kaplan-Meier analysis of overall freedom from reoperation on the mitral valve.

in asymptomatic patients, when MR is severe and the valve can be repaired by an experienced surgical team. That is why Bonow and Adams[11] claimed that the time had come to define centers of excellence in MVr. The criteria of these centers include: *(i)* mitral valve surgery volume requirement, *(ii)* expert periprocedural imaging capabilities, and *(iii)* transparency regarding outcomes, including rates of repair, mortality and stroke and the durability of repair.[11] Fortunately, in our center, close cooperation between the cardiac surgery team

Table 5. Echocardiographic results of the patients after mitral valve repair

	Preoperative (n=421)		At discharge (n=416)		At follow-up (n=402)	
Mitral regurgitation grade	n	%	n	%	n	%
None/trivial	0	0	270	64.9	224	55.72
Mild	9	2.1	145	34.85	144	35.82
Moderate	29	6.9	1	0.25	23	5.72
Severe	383	91	0	0	11	2.74

MR: Mitral regurgitation.

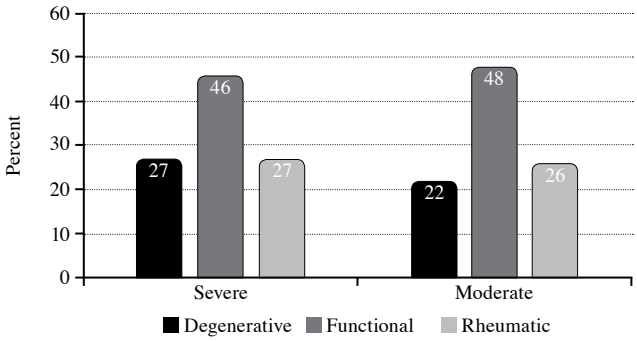

Figure 2. Presentation of echocardiographic grading of mitral regurgitation recurrence in degenerative, rheumatic, and functional patients.

and cardiologists helps to determine the timing of operations. We negotiate the pre- and intraoperative assessment of the valves via echocardiography and the feasibility of repair before tailoring the management strategy for each individual patient. Adams and Anyanwu[12] reported that cardiologists should be aware of specific mitral lesions favoring the rate of mitral repair so that the patient could be referred to a mitral subspecialist. Onan et al.[13] also found that both symptomatic and asymptomatic patients could be operated with a favorable surgical outcome before the development of LV dysfunction.

In our center, intraoperative TEE is performed routinely for all MVr operations. The 2014 American Heart Association valvular guideline gives a Class I recommendation for performing intraoperative TEE which is indicated to establish the anatomic basis for MR and to guide repair.[1,14] The TEE can provide the surgeon a better understanding of the valve anatomy and type of repair which would likely be performed, although the ultimate decision is made only, when the valve is inspected visually. Intraoperative TEE is also helpful in evaluating the adequacy of repair. We are aware that even mild residual MR after repair increases the likelihood of long-term repair failure necessitating reoperation, and we target near-perfect surgical repair. If moderate or more severe MR is detected in the operating room, the repair is revised. The TEE is also useful for the diagnosis of SAM with outflow obstruction, mitral inflow obstruction or LV outflow obstruction as a result of MVr.[14] When SAM is observed, we ensure that there is no low preload with underfilling of LV.

Successful repair is based on a proper understanding of the anatomic and functional alterations (Carpentier classification) of the diseased valve. The MVr techniques may vary according to echocardiographic and direct visual intraoperative findings. More than 90% of degenerative mitral valves are suitable for valve repair rather than replacement with superior short and long-term clinical outcomes.[15] Valve morphology, particularly lesion site and extent, defines the choice of MVr technique in degenerative mitral disease. Currently, different types of surgical repair procedures have been performed to correct leaflet pathologies. Quadrangular resection with or without sliding annuloplasty is an accepted procedure of choice for posterior leaflet prolapse. On the other hand, anterior leaflet prolapse (Carpentier type 2) can be repaired with triangular resection, artificial chordae replacement, edge-to-edge technique, chordal transfer, chordal shortening, and papillary muscle repositioning.[15,16] Specifically, artificial chordae replacement with no leaflet resection has been reported to be successful in cases of degenerative prolapse or chordal rupture.[16] In our clinical practice, prior to 2010, leaflet prolapse (Carpentier type 2) was repaired by triangular or quadrangular resection of the mitral valve leaflet. Recently, however, we favored the use of artificial chordae replacement owing to its simplicity and favorable long-term outcomes.[16] For prolapse of medial (A3/P3) and lateral (A1/P1) scallops of anterior, posterior or both leaflets, we use commissuroplasty (edge-to-edge repair). The free edge of the anterior leaflet is attached to the free edge of the posterior leaflet to reduce the circumference of the mitral orifice. Long-term outcomes of MVr in degenerative disease was successful in all patients, except for three who had severe MR during follow-up. Only one of them needed reoperation and was treated with mechanical valve replacement after 20 months of the initial repair. Echocardiographic examination during follow-up revealed that MR was none or mild in 257 patients (97%). In addition, five patients had moderate MR and were treated medically.

Functional MR may result from annular enlargement (Carpentier type 1) secondary to LV dilatation and/or papillary muscle displacement (Carpentier type 3b) due to LV remodeling, resulting in tethering and excess tenting of the leaflets.[17] Ischemic MR is difficult to repair due to several mechanisms involved, and only ring annuloplasty can solve the problem at the annular level. The issue of leaflet tethering by displacement of the papillary muscles, which results from progressive LV dilatation, cannot be solved by surgery and may lead to late recurrence of regurgitation. The decision to perform surgery on the mitral valve for ischemic MR is based upon the severity of the MR and upon whether CABG would be performed. Mitral valve surgery is recommended in patients with moderate-to-severe

ischemic MR undergoing CABG. Mitral annuloplasty at the time of CABG obviously reduce the severity of MR, compared to CABG alone.[18] In our hospital, in moderate and severe cases of ischemic MR, we performed MVr with coronary artery revascularization, as there is still no consensus on the surgical treatment procedures. In the beginning of our experience, Reed annuloplasty was commonly used to reduce the anterior-posterior annular dimension; however, when we found that suture annuloplasty was not effective enough, we started using ring annuloplasty with semi-rigid rings in addition to coronary revascularization, to prevent further annular dilatation. Our series included a total of 108 patients of functional MR and 14.8% of these patients (n=16) had recurrent MR (n=5 severe MR and n=11 moderate MR), while two of them were operated again. Thus, in the last four years, we have attempted to evaluate the pathophysiology of functional MR with TEE before taking a decision. We preferred valve-sparing MVR techniques, leaving the leaflets and subvalvular apparatus intact, preserving LV function in patients which the most severe degrees of tethering, as assessed by a tenting height of >11 mm, a posterior leaflet angle of >45°, or a basal aneurysm or dyskinesis.[19,20]

Although the mitral repair was successful for most of the patients in this study, 5.7% presented with moderate MR during follow-up. In those cases, the preoperative pathologies were mostly rheumatic and functional. The MVr is the procedure of choice for degenerative MR,[9] but is technically more difficult in rheumatic valve disease with conflicting results. The using of leaflet mobilization and augmentation with the pericardium to increase the leaflet area and the surface of coaptation may provide satisfactory results.[21] Decalcification of the leaflets or annulus and removal of thickened areas allowed for an increased mobility and provided a coaptation area for the leaflets. Chauvaud et al.[21] reported good long-term results of repair of rheumatic mitral valve using the Carpentier reconstruction techniques. Dillon et al.[22] also reported that, after leaflet extension in rheumatic MVr, MR grade was none/trivial in 64.5%, mild in 22.6%, moderate in 6.5%, moderately severe in 4.8%, and severe in 1.6% of the patients. Two patients had also redo mitral surgery. At five years postoperatively, the estimated rates of freedom from reoperation was 96.8%. In this series, 39 patients were operated due to rheumatic mitral valve. Echocardiographic examination during follow-up revealed that MR was none or mild in 30 patients. Six patients had moderate MR and treated medically. Three patients had redo mitral surgery after three years of the first operation. David et al.[7] reported approximately 95% freedom from reoperation after MVr.[7] In this study, the rate of freedom from reoperation was found to be 98.1%. The patients with functional and rheumatic disease might have developed residual MR more than other patients. Retraction of the pericardial patch and on-going process of rheumatic disease were considered underlying pathologies in rheumatic cases.

The operative mortality and morbidity for isolated MVr are low, and early failures are uncommon in experienced hands.[6,7,9] Sousa et al.[23] reported that the overall operative mortality rate in patients who underwent MVr for severe MR was 1.7%. In our series, the overall in-hospital mortality rate was 1.2% (n=5), and cardiac mortality occurred in four patients. Three patients had functional MR and poor LV pump function. Many retrospective studies demonstrated improved LV function and survival benefits in patients undergoing MVr, compared to MVR with or without subvalvular preservation.[15,24] In a study of Medicare database including 47,279 patients who underwent primary isolated mitral valve surgery between 2000 and 2009 with a median follow-up of five years, Vassileva et al.[24] reported that the operative mortality rate was 3.9% for patients who had MVr, compared to 8.9% in those who had MVR. One, five and 10-year Kaplan-Meier survival estimates were higher among those who underwent MVr, compared to MVR (91%, 77%, and 54% vs. 83%, 65%, and 37%, respectively).[24] In our study, the overall survival rate was 100% at one year, 95% at five years, and 92% at 10 years.

Nonetheless, the present study is limited to its retrospective design and inclusion of patients treated over a 10-year period. Furthermore, our patients had a variety of valvular pathologies and some of them were only followed for a short period of time. Further large-scale studies are needed to confirm these findings.

In conclusion, our study results suggest that mitral valve repair is a safe and effective procedure associated with favorable long-term outcomes in experienced centers in patients with mitral valve diseases of different etiologies.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Nishimura RA, Otto CM, Bonow RO, Carabello BA, Erwin JP, Guyton RA, et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. J Thorac Cardiovasc Surg 2014;148:1-132.
2. Gammie JS, Sheng S, Griffith BP, Peterson ED, Rankin JS, O'Brien SM, et al. Trends in mitral valve surgery in the United States: results from the Society of Thoracic Surgeons Adult Cardiac Surgery Database. Ann Thorac Surg 2009;87:1431-7
3. Akins CW, Hilgenberg AD, Buckley MJ, Vlahakes GJ, Torchiana DF, Daggett WM, et al. Mitral valve reconstruction versus replacement for degenerative or ischemic mitral regurgitation. Ann Thorac Surg 1994;58:668-75.
4. Galloway AC, Colvin SB, Baumann FG, Grossi EA, Ribakove GH, Harty S, et al. A comparison of mitral valve reconstruction with mitral valve replacement: intermediate-term results. Ann Thorac Surg 1989;47:655-62.
5. Carabello BA. Is it ever too late to operate on the patient with valvular heart disease? J Am Coll Cardiol 2004;44:376-83.
6. Suri RM, Schaff HV, Dearani JA, Sundt TM, Daly RC, Mullany CJ, et al. Survival advantage and improved durability of mitral repair for leaflet prolapse subsets in the current era. Ann Thorac Surg 2006;82:819-26.
7. David TE, Ivanov J, Armstrong S, Christie D, Rakowski H. A comparison of outcomes of mitral valve repair for degenerative disease with posterior, anterior, and bileaflet prolapse. J Thorac Cardiovasc Surg 2005;130:1242-9.
8. David TE, Armstrong S, Sun Z, Daniel L. Late results of mitral valve repair for mitral regurgitation due to degenerative disease. Ann Thorac Surg 1993;56:7-12.
9. Gillinov AM, Cosgrove DM, Blackstone EH, Diaz R, Arnold JH, Lytle BW, et al. Durability of mitral valve repair for degenerative disease. J Thorac Cardiovasc Surg 1998;116:734-43.
10. Beresniak A, Sabatier B, Achouh P, Menasché P, Fabiani JN. Cost-effectiveness of mitral valve repair versus replacement by biologic or mechanical prosthesis. Ann Thorac Surg 2013;95:98-104.
11. Bonow RO, Adams DH. The time has come to define centers of excellence in mitral valve repair. J Am Coll Cardiol 2016;67:499-501.
12. Adams DH, Anyanwu AC. Seeking a higher standard for degenerative mitral valve repair: begin with etiology. J Thorac Cardiovasc Surg 2008;136:551-6.
13. Onan B, Erkanlı K, Onan IS, Ersoy B, Aktürk IF, Bakır I. Clinical outcomes of mitral valve repair: a single-center experience in 100 patients. Turk Gogus Kalp Dama 2014;22:19-28.
14. Saiki Y, Kasegawa H, Kawase M, Osada H, Ootaki E. Intraoperative TEE during mitral valve repair: does it predict early and late postoperative mitral valve dysfunction? Ann Thorac Surg 1998;66:1277-81.
15. Enriquez-Sarano M, Schaff HV, Orszulak TA, Tajik AJ, Bailey KR, Frye RL. Valve repair improves the outcome of surgery for mitral regurgitation. A multivariate analysis. Circulation 1995;91:1022-8.
16. David TE, Armstrong S, McCrindle BW, Manlhiot C. Late outcomes of mitral valve repair for mitral regurgitation due to degenerative disease. Circulation 2013;127:1485-92.
17. Trichon BH, O'Connor CM. Secondary mitral and tricuspid regurgitation accompanying left ventricular systolic dysfunction: is it important, and how is it treated? Am Heart J 2002;144:373-6.
18. Fattouch K, Guccione F, Sampognaro R, Panzarella G, Corrado E, Navarra E, et al. POINT: Efficacy of adding mitral valve restrictive annuloplasty to coronary artery bypass grafting in patients with moderate ischemic mitral valve regurgitation: a randomized trial. J Thorac Cardiovasc Surg 2009;138:278-85.
19. De Bonis M, Ferrara D, Taramasso M, Calabrese MC, Verzini A, Buzzatti N, et al. Mitral replacement or repair for functional mitral regurgitation in dilated and ischemic cardiomyopathy: is it really the same? Ann Thorac Surg 2012;94:44-51.
20. Maltais S, Schaff HV, Daly RC, Suri RM, Dearani JA, Sundt TM, et al. Mitral regurgitation surgery in patients with ischemic cardiomyopathy and ischemic mitral regurgitation: factors that influence survival. J Thorac Cardiovasc Surg 2011;142:995-1001.
21. Chauvaud S, Fuzellier JF, Berrebi A, Deloche A, Fabiani JN, Carpentier A. Long-term (29 years) results of reconstructive surgery in rheumatic mitral valve insufficiency. Circulation 2001;104:12-5.
22. Dillon J, Yakub MA, Nordin MN, Pau KK, Krishna Moorthy PS. Leaflet extension in rheumatic mitral valve reconstruction. Eur J Cardiothorac Surg 2013;44:682-9.
23. Sousa Uva M, Dreyfus G, Rescigno G, al Aile N, Mascagni R, La Marra M, et al. Surgical treatment of asymptomatic and mildly symptomatic mitral regurgitation. J Thorac Cardiovasc Surg 1996;112:1240-8.
24. Vassileva CM, Mishkel G, McNeely C, Boley T, Markwell S, Scaife S, et al. Long-term survival of patients undergoing mitral valve repair and replacement: a longitudinal analysis of Medicare fee-for-service beneficiaries. Circulation 2013;127:1870-6.