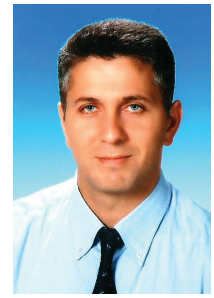
The Heart Surgery Forum #2009-1006
12 (5), 2009 [Epub October 2009]
doi: 10.1532/HSF98.20091006

Online address: http://cardenjennings.metapress.com

Posterior Pericardial Annuloplasty in Ischemic Mitral Regurgitation



Dr. Omay

Oguz Omay, MD,[1] Emre Ozker, MD,[2] Cenk Indelen, MD,[3] Murat Baskurt, MD,[4] Kaya Suzer, MD,[5] Ilhan Gunay, MD[1]

[1]Baskent University, Department of Cardiovascular Surgery, Istanbul, Turkey; [2]Ordu State Hospital, Department of Cardiovascular Surgery, Ordu, Turkey; [3]Isvicre Hospital, Department of Cardiovascular Surgery, Istanbul, Turkey; [4]Istanbul University, Institute of Cardiology, Department of Cardiology, Istanbul, Turkey; [5]Hizmet Hospital, Department of Cardiovascular Surgery, Istanbul, Turkey

ABSTRACT

Background: Ischemic mitral regurgitation (IMR) is an important risk factor in coronary artery bypass grafting (CABG) operations. The decision to perform concomitant mitral annuloplasty along with the CABG depends on the surgeon's choice. The aim of this study was to evaluate the results of posterior annuloplasty procedures with autologous pericardium performed in patients with midadvanced and advanced functional ischemic mitral regurgitation.

Methods: Study participants were 36 patients with IMR (mean age 59 ± 10 years) who underwent posterior pericardial annuloplasty and CABG operations between 2002 and 2007. Preoperative and postoperative (mean follow-up 18 ± 1 months) MR grade, left atrium diameter, left ventricle end systolic diameter, left ventricle end diastolic diameter, left ventricle ejection fraction, and mitral valve gradients were measured with transthoracic echocardiography.

Results: There was one late mortality (2, 8%) but none of the patients required reoperation for residual MR. We did not observe thromboembolism, bleeding, or infective endocarditis. The mean MR grade decreased from 3.4 ± 0.5 to 0.5 ± 0.6 ($P < .01$), left atrium diameter decreased from 45.3 ± 5.5 mm to 43.2 ± 3.8 mm ($P < .01$), left ventricle end diastolic diameter decreased from 53.2 ± 5.6 mm to 50.9 ± 5.5 mm ($P < .01$), and left ventricle end systolic diameter decreased from 39.7 ± 5.8 mm to 34.6 ± 6.5 mm ($P < .01$), whereas mean left ventricle ejection fraction increased from 37.9% ± 6.1% to 43.7% ± 7.3% ($P < .01$). In the late postoperative term, the functional capacity of the patients increased from mean New York Heart Association class 2.6 ± 0.9 to 1.1 ± 0.5. We did not observe any gradient in the mitral valve preoperatively in any patient, but in the follow-up, the mean gradient increased to 1.3 ± 2.1 mmHg ($P < .01$).

Conclusion: Posterior pericardial annuloplasty with CABG in the treatment of IMR provides efficient mitral repair and significant decrease in the left atrium and left ventricle diameters, and provides a significant increase in left ventricular function. These results show IMR to be as effective as the other annuloplasty techniques. IMR is performed with autologuous material and therefore does not entail any risk of complications from prosthetic material and is highly cost-effective.

INTRODUCTION

The surgical treatment of ischemic mitral regurgitation (IMR) has 2-fold the operative mortality of coronary revascularization, but untreated MR deteriorates quality of life and decreases long-term survival; therefore the decision to perform concomitant mitral valve surgery remains challenging for cardiac surgeons.

With increasing experience, annuloplasty applications have become popular in ischemic midadvanced MR. Reports of successful mid- and long-term outcomes have led surgeons to reevaluate their decisions on the choice of treatment [Prifti 2001; Bax 2004; Braun 2005; Geidel 2005; Geidel 2007; Braun 2008].

Herein we do not discuss the treatment modalities in IMR. We planned a prospective study in which we tried to demonstrate that autologous pericardium is as acceptable and effective a material as the others used in annuloplasty procedures in highly advanced IMR patients. We evaluated the

Table 1. Preoperative Clinical Data*

Age, y	58.8 ± 10.5
Male/Female	20/16
Diabetes mellitus	8 (22.2%)
Hypertension	13 (36.1%)
Smoking	21 (58.3%)
Family history of coronary artery disease	11 (30.5%)
Hyperlipidemia	7 (19.4%)
Previous percutaneous transluminal coronary angioplasty	4 (11.1%)
Chronic obstructive pulmonary disease	5 (13.5%)

*The values are reported as n, mean ± SD, or n (%).

Received January 17, 2009; received in revised form March 26, 2009; accepted April 13, 2009.

Correspondence: Emre Ozker, Osmanyilmaz Mh. Ataturk CD. NO:42/9 Gebze, Kocaeli, Turkey PK: 41100; 00-90-532-515-42-25; fax: 00-90-262-641-45-69 (e-mail: dremreozker@yahoo.com).

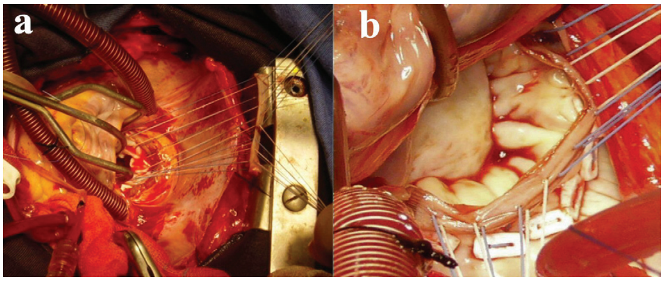


Figure 1. A, Operative view showing the pericardial patch and suturing of the stitches. B, Operative view showing the pericardial patch in place and the normal functioning mitral leaflets after saline injection.

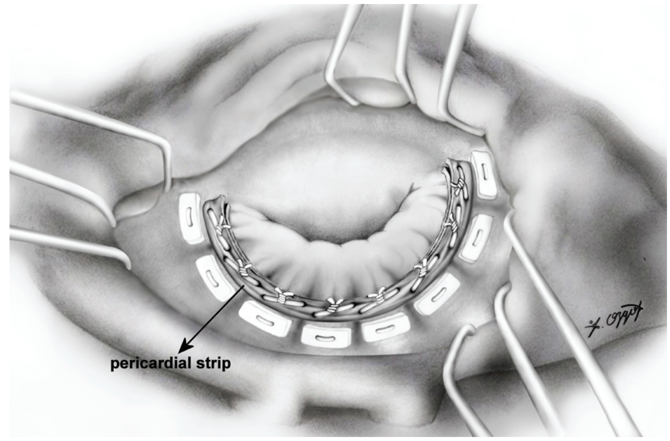


Figure 2. Drawing showing the pericardial patch and Teflon-reinforced stitches.

preoperative and postoperative clinical status and the echocardiographic findings of the patients with IMR in whom we used autologous pericardium as the annuloplasty material.

MATERIALS AND METHODS

Patient Population

The study group consisted of 36 patients who had chronic IMR and underwent coronary artery bypass graft (CABG) along with posterior pericardial annuloplasty (PPA) surgery during the period between 2002 and 2007. Table 1 tabulates the preoperative patient data. Mean age was 58.8 ± 10.5 years (range 31-76 years); 20 patients were male (55.5%). All of the patients were coronary artery patients who had had a previous myocardial infarction. MR greater than grade 3 and critical coronary artery stenosis with left ventricular (LV) contraction disturbances were detected both angiographically and echocardiographically. New York Heart Association functional capacity was class 4 in 7 patients (19.4%) and class 3 in 9 patients (25%); 4 patients (11.1%) had undergone previous percutaneous transluminal coronary angioplasty previously. MR preoperatively was grade 4 in 15 patients (42%) and grade 3 in 21 patients (58%).

Study Protocol

Patients who had MR related solely to coronary artery ischemia, Carpentier type I-IIIb, were included in the study. Patients who had MR grade 1-2 were excluded from the study. Patients with rheumatoid, degenerative, and other mitral valve pathologies that accompanied ischemia were also excluded from the study. Patients who had papillary muscle rupture caused by infarction were not included in the study, nor were patients who had any other concomitant surgical procedures except for the tricuspid valve plasties. Informed consent was obtained from each patient.

Patients' functional capacities were evaluated according to New York Heart Association criteria. Left atrium and LV diameters were measured with parasternal M mode echocardiography. Mitral regurgitation grades were measured with parasternal long axis and apical 4-chamber view. MR grades were classified from mild to severe and expressed as 1 to 5. Transmitral diastolic gradient was calculated with continuous-wave Doppler. Preoperative LV ejection fraction was determined from echocardiographic measurements. Cardiopulmonary bypasss time, aortic cross-clamping time, bypass number per patient, use of left internal mammarian artery, postoperative complications, and duration of intensive care unit stay were documented, in the study protocol.

Echocardiography and functional capacity evaluations were performed preoperatively, on postoperative day 7, and every 6 months after surgery. Because the latest results are considered more valuable, the results obtained on postoperative month 18 were taken into consideration and statistically evaluated.

Surgical Procedure

All operations were performed via midline sternotomy, through aorta-bicaval cannulation, and with the patient under moderate hypothermia. Cardiac arrest was maintained by cross-clamping of the aorta and with intermittent isothermic blood cardioplegia. All coronary arteries except for the left anterior descending artery were bypassed by sapheneous vein grafts. Mean number of grafts used was 3.4 ± 0.8. Mitral valves were explored through standard left atriotomy in all patients, except for 5 patients in whom a transseptal approach was preferred because of preoperatively planned concomitant tricuspid valveplasty procedures.

During surgery, the presence of chronic ischemic mitral insufficiency with annular dilatation (Carpentier type I-IIIb) was examined. Mitral valve and valve apparatus were checked, and preoperative diagnoses were confirmed. The patients with displacement of papillary muscles and any additional organic cardiac diseases were noted and excluded from the study.

For all patients, pericardial strips of 4 to 5 cm length and 1 cm width were soaked in 0.65% gluteraldehyde solution for 10 minutes and then washed in 3 saline baths for at least 5 minutes in each bath.

Eight to ten 2.0 Ethibond sutures (Ethicon, Somerville, NJ, USA) reinforced with Teflon pledget stitches were sutured to the posterior mitral annulus starting from the middle point of the posteromedial commissure and ending at the middle point of the anterolateral commissure, each stitch sutured in

Table 2. Surgical Data*

Aortic cross-clamping time, min	70.0 ± 12.0
Cardiopulmonary bypass time, min	94.6 ± 12.1
Grafts per patient	3.4 ± 0.8
Use of left internal mammary artery	33 (91.6%)
Associated procedure: tricuspid valve annuloplasty	5 (13.8%)

*The values are reported as mean ± SD or n (%).

equal distance from each other. The pericardial strip was prepared to be 1 cm wide and 4 cm long in the early operations of the study, until we detected a gradient across the mitral valve in the control echocardiographies. We then started to prepare the strips in 4 to 5 cm lengths according to the body surface area and the annulus size of each patient. The pericardial strip was folded inside out, so the epicardial side of the pericardium faced outside. The stitches were passed through the open end of the pericardial strip and then placed into the posterior annulus (Figure 1a and Figure 2). The efficiency of the posterior annuloplasty and the valve competence were tested by filling of the LV with saline (Figure 1b). Due to the circumstances of the clinic, transesophageal echocardiography could not be performed. In 5 patients (13.8%) in whom mitralplasties were performed through a transseptal approach, Kay annuloplasties were also performed following the atrial septotomy closure. In 33 patients (91.6%), the left anterior descending artery was revascularized with the left internal mammarian artery. In the remaining 3 patients, sapheneous vein grafts were used instead. All of the proximal anastomoses were performed under partial aortic clamp in all patients. The mean cardiopulmonary bypass time was 94.6 ± 12.1 minutes, and the mean aortic cross-clamping time was 70.0 ± 12.0 minutes. The procedural data are shown in Table 2.

Statistical Analysis

The SPSS (10.0) statistical analysis program for Windows (Chicago, IL, USA) was implemented for the analysis. After testing the normality of data distribution, we performed a paired-sample *t*-test to compare the pre- and postoperative measurements. Qualitative data between groups were compared with the χ^2 test. Data were expressed as the mean ± SD. Statistical significance was assumed at a probability level of less than 0.05.

Table 3. Postoperative Data*

Atrial fibrillation	5 (13.8%)
Ventricular arrhythmia	1 (2.8%)
Pericardial effusion	1 (2.8%)
Wound infection	2 (5.5%)
Prolonged ıntubation (>48 h)	3 (8.3%)
Neurologic complication	1 (2.8%)
Respiratory complication	1 (2.8%)

*The values are reported n (%).

RESULTS

No perioperative complication related to mitralplasty was observed in any patient. Mean follow-up duration was 17.9 ± 1 (16-20) months. In the early postoperative period, in 1 patient (2.8%), pericardial effusion was detected in routine investigations of the postoperative arrhythmia. Pericardial tube drainage was applied. Postoperative atrial fibrillation was seen in 5 patients (13.9%) and was treated with amiodarone. In 3 (8.3%) patients extubation time was prolonged, and in 1 (2.8%) of these patients sternal wound infection was seen. This patient then underwent reoperation for sternal dehiscence. These 3 patients had chronic obstructive pulmonary disease or were heavy smokers preoperatively. In 1 patient (2.8%) postoperative pneumonia was seen and was treated with antibiotherapy. One patient (2.8%) had left hemiparesia in the third postoperative month. No cardiac or carotid artery disease was found. There was significant improvement in the postoperative functional capacity of the patients, whereas in 7 patients (19.4%) functional status remained class II (Table 3).

During the 18-month follow-up, 1 patient (2.78%) died of sudden cardiac death. Mitral regurgitation decreased to mild or grade 1 MR in 33 patients (91.67%). In 3 patients (8.3%), grade 2 MR was detected, but none of the patients needed reoperation related to the insufficient mitral annuloplasty. The mean left ventricle ejection fraction increased from 37.9 ± 6.1 to 43.7 ± 7.3 ($P < .01$). The mean left atrium diameter decreased from 45.3 ± 5.5 mm to 43.2 ± 3.8 mm ($P < .01$). Left ventricle end diastolic diameter decreased from 53.2 ± 5.6 mm to 50.9 ± 5.5 mm ($P < .01$), whereas the fall in left ventricle end systolic diameter was 39.7 ± 5.8 mm to 34.6 ± 6.5 mm ($P < .01$). Table 4 shows the pre- and postoperative comparisons of cardiac measurements. There was no transmitral gradient in the preoperative echocardiographic measurements in any patient, but in 12 patients (33.3%) there was a 1.3 ± 2.1 mmHg ($P < .01$) mean gradient in the postoperative 18th month echocardiography follow-up. None of these patients showed a significant increase in the mean gradient or a gradient increase with a negative effect on the functional capacity. During the follow-up, no

Table 4. Echocardiography and Clinical Data before Surgery and at Late Follow-Up*

	Before Surgery	Late Follow-Up	*P*
Ejection fraction, %	37.9 ± 6.1	43.7 ± 7.3	< .01
LA, mm	45.3 ± 5.5	43.2 ± 3.8	< .01
LVEDD, mm	53.2 ± 5.6	50.9 ± 5.5	< .01
LVESD, mm	39.7 ± 5.8	34.6 ± 6.5	< .01
MR grade	3.4 ± 0.5	0.5 ± 0.6	< .01
Transmitral gradient	0.0	1.3 ± 2.1	< .01
NYHA class	2.6 ± 0.9	1.1 ± 0.5	< .01

*The values are reported as mean ± SD. LA indicates left atrium; LVEDD, left ventricular end diastolic dimension; LVESD, left ventricular end systolic dimension; MR, mitral regurgitation; NYHA, New York Heart Association.

Table 5. Reported Data on Posterior Pericardial Annuloplasty*

Author	No. of Patients	Follow-up Time, mo	Mean Bypass Time, min	Preoperative LAD, mm	Postoperative LAD, mm	Preoperative LVEDD, mm	Postoperative LVEDD, mm	Preoperative LVESD, mm	Postoperative LVESD, mm	Preoperative MRG	Postoperative MRG
Omay (2009)	36	18	3.4	45	43	53	51	39	35	3.4	0.5
Geidel (2005)	38	13	2.3	51	45	60	57	47	42	3.6	0.5
Bax (2004)	51	18	3.3	53	47	64	58	51	43	3.4	0.8
Braun (2005)	87	18	3.0	54	48	64	58	52	44	3.1	0.6
Geidel (2007)	63	24	3.4	52	45	62	56	49	41	3.6	0.6
Braun (2008)	100	46	2.9	45	43	60	54	46	39	3.1	0.8

*LAD indicates left atrium diameter; LVEDD, left ventricle end diastolic diameter; LVESD, left ventricle end systolic diameter; MRG, mitral regurgitation grade.

pericardial degeneration or calcification or overgrowth in the fibrous tissue in the annuloplasty region was detected.

DISCUSSION

IMR is defined as MR caused by coronary artery disease, with the exclusion of patients with mitral valve disease due to rheumatic, myxomatous, infectious, congenital, or connective tissue diseases. We excluded patients with the aforementioned pathologies from our study in order to evaluate the efficacy of our technique on IMR.

IMR is not a benign condition; on the contrary, it carries a 2-fold excess mortality of 62% at 5 years in postinfarction patients irrespective of other risk factors [Grigioni 2001]. In addition, IMR is a progressive disorder in which MR-related LV volume overload promotes further LV remodeling, leading to worsening of MR. Therefore it is crucial to assess the late-term results of the procedure. Follow-up time longer than 1 year was accepted as appropriate unless a new ischemic event occurred in the interim.

The severity of chronic IMR is possibly related to the processes of myocardial remodelling that occur in the individual patient after myocardial infarction. Myocardial remodeling itself is defined as localized or global structural changes that can be either reversible (short-/midterm stunning or hibernation) or irreversible (long-term fibrosis, cell apoptosis, myocardial scar) and must be understood as an adaptive response to the underlying cardiac pathology and/or an additional stressor (eg, volume/pressure overload) [Geidel 2007].

The management of IMR remains controversial. Surgical treatment options include CABG alone or with concomitant mitral valve annuloplasty or valve replacement.

Reece and colleagues reported that revascularization alone was ineffective because of irreversible anatomic distortions from ventricular scarring, ventricular dilatation, or annular dilatation [Reece 2004]. Therefore mitralplasty must be added to the revascularization procedure.

Prifti and colleagues mentioned that LV dimension and function improved significantly in patients undergoing combined surgery as a result of reperfusion of ischemic myocardial areas, stabilization of the mitral annulus and unloading, and decreased volume overload secondary to MR correction [Prifti 2001].

Even though mitral replacement has beneficial results in selected patients, patients who undergo mitral valve replacement and coronary artery revascularization have high early and late mortality and low long-term survival.

Compared with mitral valve replacement, mitral valve repair has been associated with a low rate of complications, especially thromboembolism and warfarin-related hemorrhage. Previous studies have shown that in IMR patients mitral valve repair (especially mitral annuloplasty) can decrease or eliminate MR in most cases [Prifti 2001; Bax 2004; Reece 2004; Braun 2005; Geidel 2005; Kim 2005; Geidel 2007; Braun 2008]. Although mitral annuloplasty is an important aspect of mitral valve repair, the preferred technique remains controversial.

Borghetti and colleagues compared the use of rigid rings and the pericardium in mitral annuloplasties in patients with advanced MR due to isolated posterior leaflet prolapse. They concluded that as well as LV systolic and diastolic functions, annular dynamics showed better results in pericardium group [Borghetti 2000]. They also reported that the mitral valve annulus had a dynamic structure that supported the motion of the mitral valve apparatus. They suggested that the basoconstrictor muscles in the posterior annulus worked as a sphincter during the contraction and relaxation of the myocardium. They postulated that rigid rings diminished this dynamic motion of the annulus and deteriorated the ventricle/valve relationship and altered the left ventricle function [Borghetti 2000].

PPA was first reported by Salati and colleagues in 1991, who suggested that pericardium provided better physiological mitral annulus dynamics and better ventricle performance than rigid rings under stress in cases with posterior annular dilatation [Salati 1991].

Scrofani and colleagues used autologous pericardial strips in their mitralplasty procedures and found pericardium as effective as rigid materials. They suggested that pericardial strips, like rigid rings, protect cardiac motion and left ventricle functions during the cardiac cycle [Reece 2004].

Another prospective study on PPA revealed low early postoperative mortality, better functional capacity, and fewer complications such as thromboembolic events and bleeding. These authors found their results encouraging but suggested that the technique should be reevaluated with late-term results [Chotivatanapong 2001].

In the studies with PPA, the major postoperative problem has been shown to be the residual MR. This condition is more often encountered in annuloplasty procedures performed in non-IMR [Gillinov 2001; Bevilacqua 2003; Matsukuma 2005]. In this latter group of patients, structural disorder in the valve leaflet accompanies the pathology. On the other hand, in IMR, the leaflet structure is normal and the main etiology is the LV dilatation caused by the LV remodeling and the deterioration of valve coaptation due to posterior annulus dilatation following ischemia. In posterior annuloplasty, the coaptations of the leaflets are maintained through gathering of the dilated annulus. At the same time, the coronary bypasses perfuse the ischemic myocardium and heals the dysfunctioning LV that causes myocardial regurgitation. We believe LV myocardial dysfunction caused by ischemia is mainly responsible for the MR in our patients, because the left ventricle diameters are close to the normal range (mean left ventricle end diastolic diameter 53.2 ± 5.6 mm) (Table 5). The mean number of grafts used was 3.4 ± 0.8 per patient. We believe optimum reperfusion of the ischemic areas and the annuloplasty will avoid the volume overload of the LV and help LV contraction and recovery of function.

In the preoperative echocardiographic evaluation, the surgeon can figure out the relationship between the amount of MR and the coaptation defect, which is expected to heal after the recovery of the ischemic myocardium. It is at this point that the surgeon should foresee how much of the regurgitation will recover after revascularization and will not create any mitral stenosis. Gradients less than 2 mmHg can easily be tolerated. In the postoperative term, one should check for the presence of any gradient. In 12 patients, we detected mean gradient of 1.3 ± 2.1 mmHg without any deterioration in the functional capacity. Calafiore and colleagues used pericardial strips of 4 cm length in their annuloplasty practices and measured 3.6 mmHg mean gradient in the postoperative term. The calculated gradient increased up to 5.2 mmHg during stress. However, these investigators claimed that the mitral valve area did not alter patient exercise tolerance [Calafiore 2003]. We also prepared the pericardial strips in 4-cm lengths at the beginning of our own practice, until we measured the paravalvular gradient in the early postoperative term. We then started to adjust the length of the strip to between 4 and 5 cm according to the body surface and the mitral valve area of the individual patient and detected gradient only in very few patients.

When we planned this study, we could not find any report concerning solely the PPA technique in IMR, or any study on PPA patients that also reported results on ischemic mitral disease.

Kim and colleagues reported 26 PPA patients in their study, in which they compared patients who had only a CABG operation with patients who had CABG and concomitant mitral valve plasty. The authors did not report the results of PPA operations performed with pericardium [Kim 2005]. In our study, when we evaluated the midterm results of our patients who underwent CABG and PPA operations for IMR patients, we only observed one mortality and detected residual MR in 3 patients without any change in their functional status. We observed statistically significant recovery in the left atrium and ventricle diameters and function, as well as the functional capacity.

Study Limitations

We believe an 18-month follow-up time is not sufficient to determine fibrosis and calcification that occur in pericardial mitral annuloplasties. We are continuing our study and patient follow-ups to identify the long-term results of this technique. In the beginning of the study we speculated that the mitral annulus motions would be protected with this technique, but thus far our postoperative evaluation data do not demonstrate this result.

Conclusion

In posterior mitral annuloplasty and concomitant CABG operation with autologous pericardium, no synthetic material except for the sutures is used; therefore complications such as endocarditis, hemolysis, and thromboembolism that are related to the prosthetic material are highly diminished. The use of anticoagulant therapy in the postoperative term and resulting complications are also avoided. Because autologous pericardium can easily be maintained with no additional cost and has proven to have acceptable midterm results, we believe use of this material will provide successful surgical outcome.

REFERENCES

Bax JJ, Braun J, Somer ST, et al. 2004. Restrictive annuloplasty and coronary revascularization in ischemic mitral regurgitation results in reverse left ventricular remodeling. Circulation 110:II103-8.

Bevilacqua S, Cerillo AG, Gianetti J, et al. 2003. Mitral valve repair for degenerative disease: is pericardial posterior annuloplasty a durable option? Eur J Cardiothorac Surg 23:552-9.

Borghetti V, Campana M, Scotti C, et al. 2000. Biological versus prosthetic ring in mitral-valve repair: enhancement of mitral annulus dynamics and left-ventricular function with pericardial annuloplasty at long term. Eur J Cardiothorac Surg 17:431-9.

Braun J, Bax JJ, Versteegh MI, et al. 2005. Preoperative left ventricular dimensions predict reverse remodeling following restrictive mitral annuloplasty in ischemic mitral regurgitation. Eur J Cardiothorac Surg 27:847-53.

Braun J, Van de Veire NR, Klautz R, et al. 2008. Restrictive mitral annuloplasty cures ischemic mitral regurgitation and heart failure. Ann Thorac Surg 85:430-7.

Chotivatanapong T, Kasemsarn C, Sungkahapong V, Chaisei P, Yosthasurodom C, Cholitkui S. 2001. Mitral valve repair with autologous pericardial ring. Asian Cardiovasc Thorac Ann 9:10-3.

Calafiore AM, D. Mauro MD, Gallina S, Canusa C, Iacò AL. 2003. Optimal length of pericardial strip for posterior mitral overreductive annuloplasty. Ann Thorac Surg 75:1982-4.

Geidel S, Lass M, Schneider C, et al. 2005. Downsizing of the mitral valve and coronary revascularization in severe ischemic mitral regurgitation results in reverse left ventricular and left atrial remodeling. Eur J Cardiothorac Surg 27:1011-6.

Geidel S, Schneider C, Lass M, et al. 2007. Changes of myocardial function after combined coronary revascularization and mitral valve downsizing in patients with ischemic mitral regurgitation and advanced cardiomyopathy. Thorac Cardiovasc Surg 55:1-6.

Gillinov AM, Wierup PN, Blackstone EH, et al. 2001. Is repair preferable to replacement for ischemic mitral regurgitation? J Thorac Cardiovasc Surg 122:1125-41.

Grigioni F, Enriquez-Sarano M, Zehr KJ, Bailey KR, Tajik AJ. 2001. Ischemic mitral regurgitation: long-term outcome and prognostic implications with quantitative doppler assessment. Circulation 103:1759-64.

KimYH, Czer LSC, Soukiasian HJ, et al. 2005. Ischemic mitral regurgitation: revascularization alone versus revascularization and mitral valve repair. Ann Thorac Surg 79:1895-901.

Matsukuma S, Eishi K, Yamachika S, et al. 2005. Risk factors of posterior pericardial annuloplasty for isolated posterior leaflet prolapse. Ann Thorac Surg 80:820-4.

Prifti E, Bonacchi M, Frati G, et al. 2001. Should mild-to-moderate and moderate ischemic mitral regurgitation be corrected in patients with impaired left ventricular function undergoing simultaneous coronary revascularization? J Card Surg 16:473-83.

Reece TB, Tribble CG, Ellman PI, et al. 2004. Mitral repair is superior to replacement when associated with coronary artery disease. Ann Surg 239:671-7.

Salati M, Scrofani R, Santoli C. 1991. Posterior pericardial annuloplasty: a physicological correction? Eur J Cardiothorac Surg 5:226-9.

Scrofani R, Moriggia S, Salati M, Fundaro P, Danna P, Santoli C. 1996. Mitral valve remodeling: long-term results with posterior pericardial annuloplasty. Ann Thorac Surg 61:895-9.