Minimally invasive mitral valve repair for anterior leaflet prolapse

Bettina Pfannmüller, MD, Joerg Seeburger, MD, Martin Misfeld, MD, PhD,
Michael Andrew Borger, MD, PhD, Jens Garbade, MD, PhD, and Friedrich W. Mohr, MD, PhD

Objective: Mitral valve repair for anterior mitral leaflet prolapse is technically challenging. We report here our experience with minimally invasive anterior mitral leaflet repair.

Methods: Our institutional database for minimally invasive mitral valve surgery was screened for patients with mitral regurgitation caused by isolated prolapse of the anterior mitral leaflet. Patient characteristics, intraoperative data, and short- and long-term outcomes are analyzed and reported.

Results: A total of 180 patients presented with mitral regurgitation caused by isolated anterior mitral leaflet prolapse. All patients underwent minimally invasive surgery at our institution between 1999 and 2010. Mitral valve repair was performed in 170 cases (94.4%), and these patients form the focus of this study. The mean age of the patients was 59.7 ± 14.8 , and their mean log EuroSCORE was 4.9 ± 5.1 . Mean aortic crossclamp time (cardiopulmonary bypass time) was 82 ± 25 minutes (130 ± 40 minutes). Mitral valve repair techniques were neochordal replacement with the loop technique in 68.2% of patients, chordal transfer in 14.7%, anterior mitral leaflet resection in 7.1%, and edge-to-edge repair in 5.9%. Thirty-day mortality was 1.8%. Kaplan-Meier estimates showed $86.7\% \pm 3.2\%$ survival and $95.7\% \pm 1.6\%$ freedom from mitral valve reoperation at 5 years.

Conclusions: This large series demonstrates good results for anterior mitral leaflet repair with the minimally invasive approach. (*J Thorac Cardiovasc Surg* 2013;146:109-13)

Mitral valve (MV) repair for anterior mitral leaflet (AML) prolapse is technically challenging. Several repair strategies are available; however, leaflet resection and implantation of neochordae are reported to be of especial value.¹⁻⁵ Nevertheless, these repair techniques are not exclusive, and a large variety of repair techniques have proved to have acceptable long-term results.⁶⁻¹⁵

Our institutional policy for MV repair in cases of AML prolapse is to use chordal replacement by the loop technique through a minimally invasive approach.^{12,16} We report here on the repair strategies and long-term outcomes in patients with isolated AML prolapse undergoing minimally invasive MV surgery.

MATERIALS AND METHODS

Between September 1999 and May 2010, a total of 180 patients underwent surgery for isolated AML prolapse at our institution through a minimally invasive technique. Indication for MV surgery was moderate or severe mitral regurgitation (MR) as a result of AML prolapse, with either symptoms of heart failure, signs of left ventricular dysfunction, or dilation of the left ventricle. Patients with prolapse of the posterior mitral leaflet, those with previous cardiac surgery, and those undergoing concomitant tricuspid valve surgery were excluded from this study.

MV repair was successfully performed in 170 patients (94.4%), and these form the focus of this study. In the remaining 10 patients (5.9%), MV replacement was necessary, in 1 case after a failed repair with good postoperative outcome. Predominant MV pathologies according to MV repair versus replacement are depicted in Figure 1. MV replacement was indicated in patients with significant sclerosis of the MV annulus and leaflets, whereas annular dilatation was present in most patients who underwent MV repair.

The study was approved by the local ethics committee. Preoperative, intraoperative, and postoperative characteristics of patients were prospectively entered into our institutional database and retrospectively analyzed. In addition, preoperative and predischARGE echocardiographic reports were collected and analyzed. MR was calculated by measurement of vena contracta (VC) in a 4-chamber view.¹⁷ The MR grading was defined as follows: none (VC of 0), mild (VC <3 mm), moderate (VC of 3-6.9 mm), and severe (VC ≥ 7 mm).¹⁸

Surgical Technique

MV surgery was performed through a 5- to 8-cm right anterolateral minithoracotomy in the 4th or 5th intercostal space, as previously described elsewhere.^{12,14,19} The Chitwood clamp was used for aortic occlusion.²⁰ Transesophageal echocardiography was routinely performed for assessment of MV anatomy and function and for evaluation of left ventricular function before and after MV repair.

All but 2 patients (1.2%) received a MV ring annuloplasty with either a complete rigid ring (90.0%; n = 153) or an incomplete flexible band (8.8%; n = 15).

The technique chosen to correct the AML prolapse was at the surgeon's discretion. Most patients (n = 116; 68.2%) underwent implantation of neochordae by the loop technique, which has been well described elsewhere.^{15,16}

Follow-up

Individual patient contact after discharge was performed by sending questionnaires to all patients annually. Patients who did not respond were contacted by phone call. In case no further information was available, family physicians were contacted. Follow-up was 94% complete, with a mean follow-up time of 4.3 ± 2.9 years (range, 1 day-11.8 years).

From the Department of Cardiac Surgery, University of Leipzig Heart Center, Leipzig, Germany.

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Address for reprints: Bettina Pfannmüller, MD, University of Leipzig-Heart Center, Department of Cardiac Surgery, Strümpellstrasse 39, 04289, Leipzig, Germany (E-mail: pfab@med.uni-leipzig.de).

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Abbreviations and Acronyms

AML	= anterior mitral leaflet
CI	= confidence interval
MR	= mitral regurgitation
MV	= mitral valve
VC	= vena contracta

Statistical Analysis

Continuous variables are expressed as mean $\pm$ SD, and categorical data are expressed as proportions. Cumulative survival was calculated by Kaplan-Meier methods. All statistical analyses were performed with the SPSS statistical software package (version 17.0; IBM Corporation, Armonk, NY).

RESULTS

Average patient age was 69.7 ± 14.8 years for the entire patient cohort, and 57% of the patients were male. Average preoperative New York Heart Association functional class was 2.3 ± 0.9 . Mean preoperative left ventricular function was $61.2\% \pm 11.9\%$, with 34% of the patients presenting with atrial fibrillation and most having hypertension. Thirteen patients (7.7%) had previously undergone pacemaker or automatic implantable cardioverter/defibrillator implantation (Table 1).

Isolated MV repair was performed in 113 patients (66.5%). Concomitant procedures included ablation for atrial fibrillation in 27.1% of the cases and closure of an atrial septal defect or patent foramen ovale in 10.6%.

Operation time averaged 176 ± 50 minutes for all patients, with an aortic crossclamp time of 82 ± 25 min and a cardiopulmonary bypass time of 131 ± 41 minutes. In 1 case (0.6%), conversion to sternotomy was required for bleeding originating from the pulmonary artery caused by the transthoracic aortic crossclamp.

The average implanted ring size was 31.0 ± 5.3 mm for all patients. A variety of MV repair techniques were used, as shown in Figure 2. Chordal resuspension of the AML with the loop technique was performed in 68.5% of the cases (Table 2).

Three patients (1.8%) had postoperative stroke, and a total of 3 patients (1.8%) had low cardiac output syndrome develop. Postoperative bleeding necessitating rethoracotomy occurred in 10 patients (5.9%). The bleeding source was identified in 3 cases at a small-caliber blood vessel in the intercostal space and in 2 cases at the atriotomy site. In the remaining 5 cases, no identification of the origin of bleeding was achieved.

Preoperative echocardiography confirmed moderate MR (defined as VC >3 mm and <7 mm) in 77.3% of the patients (129/167) and severe MR (VC ≥ 7 mm) in the remaining patients. Postoperative predischage MR was graded as none in 65.7% of the cases (95/143), as trace in 31.2%

(44/143), and as moderate in 3.6% (5/143). In 141 patients (83%), preoperative and predischage echocardiographic imaging was available for a correlation, which is shown in Figure 3. There was no significant difference in predischage MR grading between patients undergoing repair with versus without the loop technique ($P = .5$).

Eleven patients required late reoperation, 8 for MV-related causes. Reason for MV-related reoperation was recurrent MR in 6 patients: in 4 of these patients as a result of ring dehiscence, in 1 patient because of occlusion of the circumflex artery, and in 1 patient because of injury of the aortic valve from MV suture placement. Reoperations for causes not related to the MV occurred in 3 cases: 2 patients underwent subsequent heart transplant, and 1 underwent isolated tricuspid valve repair. Freedom from MV-related reoperation at 5 years was $95.7\% \pm 1.9\%$ (95% confidence interval [CI] for mean survival time/mean time of freedom from reoperation, 126.9-138.7 months; Figure 4).

Overall 30-day mortality was 1.8% (3 patients). One patient died of acute aortic dissection 6 days after surgery and an initially uneventful postoperative course. One patient had acute lung failure develop, and the remaining patient died of low-output postcardiotomy syndrome (preoperative left ventricular ejection fraction, 15%).

There were 15 late deaths. Reasons for death were carcinoma in 2 patients (63 and 64 years old), gastrointestinal bleeding in 1 patient (79 years old), pneumonia with sepsis in 1 patient (41 years old), cardiac-related cause in 1 patient (preoperative left ventricular ejection fraction 15%, 49 years old), and unknown in 10 patients.

Overall 5-year survival was $88.2\% \pm 3.0\%$ (95% CI, 115.0-130.7 months). There was no survival difference at 5 years with respect to the use of the loop technique, with a survival of $88.8\% \pm 3.8\%$ (95% CI, 106.0-135.7 months) with the technique versus $83.8\% \pm 5.7\%$ (95% CI, 107.5-131.6 months) without it (Figure 5).

DISCUSSION

In this study, we have demonstrated the feasibility and safety of MV repair of AML prolapse through a minimally invasive technique. A high freedom from MV-related reoperation was achieved.

Several investigators have demonstrated the value of polytetrafluoroethylene sutures for chordal replacement in the treatment of AML prolapse, with promising long-term results. Frater and colleagues⁴ initiated the use of polytetrafluoroethylene sutures for chordal replacement in 1983. This approach was taken up and modified by David and colleagues,¹ who reported their initial experience with polytetrafluoroethylene chordal replacement in 1989. The latter group later demonstrated an excellent 10-year freedom from MV-related reoperation of $96\% \pm 1\%$ among patients with myxomatous disease with and without

FIGURE 1. Mitral valve pathology in patients undergoing mitral valve repair or replacement. AML, Anterior mitral leaflet; PML, posterior mitral leaflet.

polytetrafluoroethylene chordal replacement and concluded that polytetrafluoroethylene chordal replacement was associated with no observable adverse effects on the probability of MV repair success.²¹ In 2005, the same group reported a freedom from severe recurrent MR rate of 86% at 12 years after MV repair for AML prolapse and an 88% ± 4% freedom from MV-related reoperation.⁷ Approximately three quarters of these patients were treated with polytetrafluoroethylene chordal replacement, results that highlight the value of the chordal replacement concept.⁷

Kasegawa and associates¹¹ reported similar results, with a 12-year freedom from severe recurrent MR of 88% ± 3% and a 90% ± 3% freedom from MV-related reoperation after repair for AML prolapse. The vast majority of their

TABLE 1. Demographic data of all patients undergoing minimally invasive mitral valve repair for anterior leaflet prolapse (n = 170)

Age (y, mean ± SD)	59.7 ± 14.8
Male (no.)	97 (57.1%)
Preoperative NYHA functional class (mean ± SD)	2.3 ± 0.9
Logistic EuroSCORE (mean ± SD)	4.9% ± 5.1%
Left ventricular ejection fraction (% , mean ± SD)	61.2% ± 11.9%
Mean pulmonary arterial pressure (mm Hg, mean ± SD)	26.4 ± 19.5
Atrial fibrillation (no.)	57 (33.5%)
Hypertension (no.)	94 (55.3%)
Diabetes mellitus (no.)	16 (9.4%)
Permanent pacemaker or AICD (no.)	13 (7.7%)

AICD, Automatic implantable cardioverter/defibrillator; NYHA, New York Heart Association.

FIGURE 2. Methods of mitral valve repair. AML, Anterior mitral leaflet.

patients (93%) were treated with polytetrafluoroethylene sutures. Although these studies included patients undergoing MV repair through a median sternotomy, Rodriguez and coworkers¹³ showed a 91% 3-year freedom from MV-related reoperation after robotic MV repair for AML prolapse. This is of especial note because it proves the adaptability of chordal replacement to the use of an intraoperative telemanipulator.

Alternative concepts to chordal replacement, however, do exist. Long-term results after MV repair of AML prolapse with the edge-to-edge repair and chordal transfer are promising as well. De Bonis and colleagues⁸ reported a 96.6% ± 1.7% 5-year freedom from reoperation rate for patients treated with a surgical edge-to-edge repair technique for AML prolapse. This is similar to the experience of the Cleveland clinic with chordal transfer, reported in 2004 by Gillinov and colleagues¹⁰: they had a 5-year freedom from reoperation after MV repair for AML prolapse of 96%.

TABLE 2. Length and number of implanted polytetrafluoroethylene loops for chordal replacement

	No. of loops	P value	Loop length (mm)	P value
A1 segment				
All patients (n = 28)	1.9 ± 1.0		22.0 ± 3.0	
Sex		.04		.02
Male (n = 23)	2.0 ± 1.1		22.6 ± 2.5	
Female (n = 5)	1.0 ± 0.0		19.2 ± 3.6	
A2 segment				
All patients (n = 108)	3.0 ± 1.2		21.0 ± 3.3	
Sex		.6		<.01
Male (n = 60)	3.1 ± 1.3		22.0 ± 3.2	
Female (n = 48)	2.9 ± 1.0		20.3 ± 3.3	
A3 segment				
All patients (n = 51)	1.7 ± 0.9		21.6 ± 3.1	
Sex		.5		<.01
Male (n = 35)	1.8 ± 0.9		22.4 ± 2.9	
Female (n = 21)	1.6 ± 1.0		20.11 ± 2.9	

Data are mean ± SD.

FIGURE 3. Correlation between preoperative and predischarge echocardiographic studies. *MR*, Mitral regurgitation.

In contrast, chordal shortening is associated with worse long-term results than either chordal replacement or edge-to-edge repair. Phillips and coworkers²² published a 98.6% freedom from reoperation at 3.5 postoperative years after chordal replacement versus 85.2% after chordal shortening. Smedira and associates²³ reported a 5-year freedom from reoperation of 90% to 96% after chordal transfer, compared with only 74% after chordal shortening.

Although repair of AML prolapse is traditionally considered to be more technically complex than repair of isolated posterior mitral leaflet prolapse, our results confirm that patients with AML prolapse can be successfully treated with

FIGURE 4. Freedom from mitral valve-related reoperation (*MV-related Re-Op*) in patients undergoing mitral valve repair performed with or without the loop technique.

FIGURE 5. Postoperative survival of patients after mitral valve repair performed with or without the loop technique.

a minimally invasive approach and the use of neochordal implantation. As previously reported by our group,^{12,15,16} the premeasured loop technique is a highly reproducible and standardized method for MV repair. It was originally developed to facilitate AML prolapse repair through a minithoracotomy. Premeasured loops are available in 2-mm increments between 10 and 26 mm in length. When applying this technique, the precise measurement of the loop length is among the most challenging and most important steps of the procedure. The data presented in this article offer some guidance for surgeons adopting this technique. Especially, the mean lengths of loops used in our large series may help other groups in reaching an optimal postoperative result in these sometimes challenging AML repair operations.

Study Limitations

The main limitation of this study is its retrospective nature. It does, however, represent one of the largest series to date of patients with isolated AML prolapse. We therefore believe that it is worth presenting. Another significant limitation is the lack of long-term echocardiographic follow-up data. This lack is due mainly to the fact that well over a third of our patients undergoing MV repair are referred from distant regions.

CONCLUSIONS

AML prolapse can be safely and effectively treated with minimally invasive MV repair, with good long-term results.

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