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Comparison of outcomes of minimally invasive mitral valve surgery for posterior, anterior and bileaflet prolapse[☆]

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Abstract

Objective: We sought to compare the outcomes of minimally invasive mitral valve (MV) surgery for anterior (anterior mitral leaflet, AML), posterior (posterior mitral leaflet, PML) or bileaflet (BL) MV prolapse. **Methods:** Between August 1999 and December 2007, 1230 patients who presented with isolated AML (*n* = 156, 12.7%), isolated PML (*n* = 672, 54.6%) or BL (*n* = 402, 32.7%) MV prolapse underwent minimally invasive MV surgery. The preoperative mitral regurgitation (MR) grade was 3.3 ± 0.8, left ventricular ejection fraction (LVEF) was $62 \pm 12\%$ and mean age was 58.9 ± 13.0 years; 836 patients (68.0%) were male. Mean follow-up time was 2.7 ± 2.1 years, and the follow-up was 100% complete. **Results:** Overall, the MV repair rate was 94.0% (1156 patients). Seventy-four patients (6.0%) received MV replacement. MV repair for PML prolapse was accomplished in 651 patients (96.9%), for AML in 142 patients (91%) and for BL in 363 patients (90.3%). Repair techniques consisted predominantly of leaflet resection and/or implantation of neochordae, combined with ring annuloplasty. Concomitant procedures were tricuspid valve surgery (*n* = 56), atrial fibrillation ablation (*n* = 286) and closure of an atrial septal defect or patent foramen ovale (PFO) (*n* = 89). The overall duration of cardiopulmonary bypass was 127 ± 40 min and aortic cross-clamp time was 78 ± 33 min. The mean postoperative hospital stay was 11.6 ± 9.7 days for the overall group. Early echocardiographic follow-up revealed excellent valve function in the vast majority of patients, regardless of the repair technique, with a mean MR grade of 0.3 ± 0.5. For the overall group, 5-year survival rate was 87.3% (95% CI: 83.9—90.1) and 5-year freedom from cardiac reoperation rate was 95.6% (95% CI: 94.1—96.7). The log-rank test revealed no significant difference between the three groups regarding long-term survival or freedom from reoperation. **Conclusions:** Minimally invasive MV repair can be achieved with excellent results. Long-term outcomes and reoperation rates for AML prolapse are not significantly different from PML or BL prolapse.

Keywords: Mitral valve repair; Prolapse; Minimally invasive

1. Introduction

The predominant lesion for degenerative mitral valve (MV) disease is the prolapse of the posterior mitral leaflet (PML), which can be reproducibly repaired in the majority of patients using either quadrangular/triangular leaflet resection or chordae replacement [1,2]. In contrast, anterior mitral leaflet (AML) prolapse repair is more technically challenging and involves a larger variety of repair techniques such as chordae replacement, chordae transposition, chordae shortening or papillary muscle repositioning. Bileaflet (BL) prolapse is considered the most technically challenging pathology to repair. Relatively few studies have thus far investigated the outcomes of minimally invasive MV surgery based on the underlying MV pathology and type of prolapse [3—6]. We therefore sought to compare the outcomes of minimally invasive MV surgery for isolated AML, isolated PML and BL prolapse with a particular focus on operative strategies and long-term outcomes for these three groups of patients.

2. Material and methods

2.1. Patients

Amongst the patients who received minimally invasive MV surgery at our institution between August 1999 and December 2007, a total of 1708 patients underwent minimally invasive MV repair. Amongst those patients, 1230 patients (72%) were diagnosed with mitral regurgitation (MR) owing to either predominant prolapse of the AML (156), prolapse of the PML (672) or BL prolapse (402). This cohort of patients forms the focus of the current study and is reported herein. Minimal invasive MV repair patients who were operated on during the same time period but were excluded from the current study

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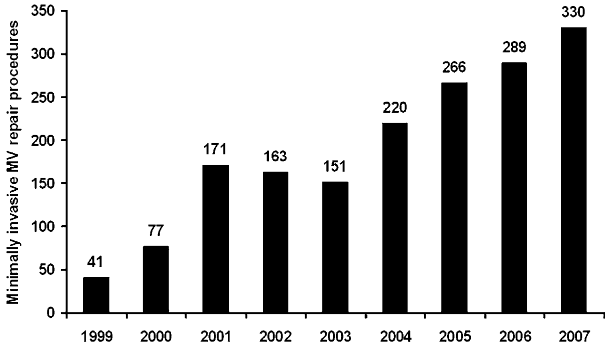

Fig. 1. Number of minimal invasive mitral valve repair procedures performed per year at Leipzig Heart Center over the study period.

included those with isolated annular dilation (n = 436), ischaemic MR (n = 84), endocarditis without mitral prolapse (n = 10) and mixed mitral stenosis and regurgitation (n = 24).

Fig. 1 demonstrates the number of minimal invasive MV repair procedures that have been performed at our institution over the years of the current study. Mean preoperative MR grade in the overall group was 3.3 ± 0.8, wherein 0 = no MR, 1+ = trivial or mild MR, 2+ = moderate MR, 3+ = moderate-to-severe MR and 4+ = severe MR. All surviving patients underwent transthoracic echocardiography prior to discharge.

The mean preoperative left ventricular ejection fraction (LVEF) was $62 \pm 12\%$ for the entire cohort. The mean age of patients in the overall group was 58.9 ± 13.0 years, and 836 of them (68.0%) were male. Thirty-six patients (2.9%) had previously undergone cardiac surgery: coronary artery bypass grafting (CABG) in 20 patients, valve surgery in 14 patients, CABG and valve procedures in three and congenital surgery in two patients. Details on baseline characteristics and MV pathology are depicted in Tables 1 and 2.

2.2. Surgical technique

All patients underwent minimally invasive MV surgery using a right-lateral mini-thoracotomy and femoral cannulation for cardiopulmonary bypass (CPB) with mild-to-moderate hypothermia. In the vast majority of patients, a transthoracic aortic clamp introduced by Chitwood was used [7]. Details on the minimally invasive operative approach are described elsewhere [8,9]. In this study, a variety of different MV repair techniques were applied including leaflet resection and implantation of Gore-Tex neochordae (most commonly) and chordal transfer, commissural plication and Alfieri edge-to-edge repair in a minority of patients (see Table 3). The decision regarding which technique to use was solely taken according to the preference of the operating surgeon. An annuloplasty ring was implanted in the vast majority of cases, with a complete rigid ring being the most commonly implanted type (Table 3). The size of the implanted ring was determined by assessing the intertrigonal distance and the size of the anterior MV leaflet with a standard sizer.

Table 1
Demographic data of all 1230 patients undergoing minimally invasive mitral valve repair for mitral valve prolapse between 1999 and 2007.

	PML			AML			BL		
	[n]		%	[n]		%	[n]		%
Number of patients	672			156			402		
Age, y*		60.1 ± 12.2			60.7 ± 13.5			56.1 ± 13.5	
Male sex, n (%)*	462		68.8	86		55.1	288		71.6
LVEF (%)*		61.9 ± 11.7			60.9 ± 11.9			62.6 ± 11.4	
MR grade*		3.26 ± 0.03			3.14 ± 0.05			3.34 ± 0.03	
Previous operation*	19		2.8	10		6.4	7		1.7
Preop EuroSCORE*		3.8 ± 4.2			4.6 ± 4.7			3.0 ± 3.1	

PML: posterior mitral leaflet, AML: anterior mitral leaflet, LVEF: left ventricular ejection fraction, MR: mitral regurgitation, BM; bileaflet.
* $p < 0.05$.

Table 2
Mitral valve pathology as recorded by intraoperative findings. Mitral valve prolapse was the predominant pathology in all patients. (Note that details on mitral valve pathology are not mutually exclusive and therefore can add up to more than 100%.).

	PML (n = 672)		AML (n = 156)		BL (n = 402)	
	[n]	%	[n]	%	[n]	%
Annulus dilatation	565	84.1	125	80.1	344	85.6
Chordae elongation*	435	64.7	103	66	322	80.1
Chordae rupture*	264	39.3	60	38.5	219	54.5
Calcification PML*	21	3.1	4	2.6	25	6.2
Calcification AML*	9	1.3	9	5.8	11	2.7
Calcification annulus	27	4	3	1.9	22	5.5
Cleft	0	0	1	0.6	3	0.7
Rupture papillary muscle	10	1.5	3	1.9	25	6.2
Additional restriction*	15	0.2	16	10.3	12	3
Commissural closure	3	0.4	2	1.3	4	1
Endocarditis*	17	2.5	11	7.1	12	3

PML: posterior mitral leaflet, AML: anterior mitral leaflet and BL: bileaflet.
* $p < 0.05$.

Table 3
Intraoperative data, surgical techniques, and concomitant procedures in patients with isolated anterior, posterior, or bileaflet mitral valve prolapse.

	PML (n = 672)		AML (n = 156)		BL (n = 402)	
	[n]	%	[n]	%	[n]	%
Operative data						
Operation time*	163 ± 42		170 ± 45		185 ± 51	
CPB duration*	119 ± 36		126 ± 34		142 ± 46	
Aortic clamp time*	72 ± 29		75 ± 30		91 ± 35	
Surgical techniques						
Mitral valve repair*	651	96.9	142	91	363	90.3
Mitral valve replacement*	21	3.1	14	9.0	39	9.7
AML resection*	1	0.1	14	9.0	25	6.2
PML resection*	309	46	5	3.2	131	32.6
Sliding plasty PML*	38	5.7	0	0	25	6.2
Loops AML*	16	2.4	88	56.4	223	55.5
Loops PML*	311	46.3	4	2.6	221	55
Chordal transfer*	14	2.1	28	17.9	80	19.9
Plication anterolateral commissure*	7	1.0	7	4.5	14	3.5
Plication posteromedial commissure	13	1.9	2	1.3	12	3.0
Cleft closure	11	1.6	5	3.2	13	3.2
Edge-to-edge (Alfieri)*	6	0.9	7	4.5	37	9.2
Ring annuloplasty	645	96	139	89.1	358	89.1
Complete rigid	460	71.3	123	88.5	294	82.1
Incomplete flexible	185	28.7	16	11.5	64	17.9
Annuloplasty ring size*	31.8 ± 2.9		31.2 ± 3.1		33.6 ± 3.1	
Concomitant procedures						
AF ablation therapy*	135	20.1	51	32.7	100	24.9
Tricuspid valve surgery*	17	2.5	13	8.3	26	6.5
Atrial septum defect	43	6.4	12	7.7	34	8.5
Atrial reduction plasty	6	0.6	2	1.3	12	3

PML: posterior mitral leaflet, AML: anterior mitral leaflet, BL: bileaflet, CPB: cardiopulmonary bypass and AF: atrial fibrillation.
* $p < 0.05$.

Patients in whom the above two methods resulted in a discrepancy, the size of the anterior leaflet was considered the most important measurement.

Ablation for atrial fibrillation was performed using either cryo- or radio frequency techniques as described elsewhere. Concomitant atrial fibrillation ablation was performed with a flexible argon-based cryoablation probe, as described previously [10].

2.3. Follow-up

Follow-up information on all patients was collected either through outpatient visit; telephone contact with the patients or the referring physician, respectively; or by a questionnaire. Follow-up was 100% complete with a mean length of 2.7 ± 2.1 years.

2.4. Statistical analysis

Categorical variables are expressed as proportions and continuous variables as mean ± standard deviations throughout this study. The baseline characteristics and outcomes were compared using the chi-square analysis (Pearson) for categorical data and the analysis of variance (ANOVA) for continuous variables. Survival and freedom from reoperation were analysed with Kaplan–Meier actuarial methods and compared using the log-rank test. Statistical significance was considered at the $p < 0.05$ level. All analyses were performed using the SAS JMP7.0 (SAS Institute, Cary, NC, USA). The guidelines for reporting morbidity and mortality after cardiac valvular operations followed [11].

3. Results

Table 1 displays the preoperative characteristics for the three groups of leaflet pathology patients. BL patients were significantly younger, had more preoperative MR and had a slightly better LVEF than the other patients. AML patients were more likely to be female and to have undergone previous cardiac surgery, and had a slightly higher European system for cardiac operative risk evaluation (EuroSCORE)-predicted risk of mortality.

Detailed information on MV pathology is displayed in Table 2. Chordae elongation was more frequently observed in BL patients, but chordal rupture was more likely in PML patients. Calcification of the posterior leaflet was more likely to be observed in BL patients, whereas that of the anterior leaflet was more likely in AML patients. Additional leaflet restriction (in addition to the primary leaflet prolapse) and endocarditis were also more frequently found in AML patients.

The overall MV repair rate in this study was 94% (1156 out of 1230 patients), with MV replacement being performed in 6% of patients (n = 74). A significantly different MV repair rate of 90.3% (363 out of 402) for BL prolapse, 91% (142 out of 156) for isolated AML prolapse and 96.9% for isolated PML prolapse (651 out of 672; $p < 0.05$) was observed. Table 3 displays other intraoperative data for the three groups of patients.

Table 4
Postoperative outcomes after mitral valve surgery for isolated anterior, posterior, or bileaflet prolapse.

	PML (*n* = 672)		AML (*n* = 156)		BL (*n* = 402)	
	[*n*]	%	[*n*]	%	[*n*]	%
Postop LVEF	57.8 ± 9.9		56.6 ± 11.4		58.3 ± 10.3	
Postop MR	0.28 ± 0.54		0.31 ± 0.57		0.35 ± 0.58	
Hospital stay	11.3 ± 6.4		12.9 ± 9.2		11.4 ± 13.6	
Stroke	18	2.7	4	2.6	8	2.0
Low cardiac output syndrome	20	3.0	5	3.2	13	3.2
Reoperation for bleeding	38	5.7	8	5.1	18	4.5
30-day mortality	10	1.5	4	2.6	9	2.2

PML: posterior mitral leaflet, AML: anterior mitral leaflet, BL: bileaflet, LVEF: left ventricular ejection fraction and MR: mitral regurgitation.

Operation times, duration of CPB and aortic cross-clamp times were significantly longer in the BL group compared to the PML and AML groups. As expected, leaflet-specific procedures were more commonly performed in the corresponding leaflet pathology subgroups (see Table 3). In addition, chordal transfer, plication of the anterolateral commissure and an edge-to-edge (Alfieri) repair were less frequently performed in the PML group. Concomitant tricuspid valve repair and atrial fibrillation ablation were performed more frequently in the AML group.

The intraoperative course was uneventful in all but seven patients (0.6%) who required conversion to sternotomy owing to aortic dissection (one patient), atrio-ventricular disruption (one patient), bleeding from the atrial appendage (two patients), bleeding from the left ventricular apex (two patients) and extensive adhesions to the chest wall (one patient). The conversion to sternotomy rates was not significantly different between groups and the duration of hospital stay was similar in all three groups.

The mean postoperative MR prior to discharge was 0.3 ± 0.5 for the overall group (Table 4) and was not different between groups. Early postoperative LVEF was also not different between groups.

Other early postoperative outcomes are displayed in Table 4. The 30-day mortality was 1.8% for the overall group (*n* = 23), and was not different for the three leaflet pathology subgroups. Stroke occurred in 2.4% of all patients (*n* = 30) and this was not different between groups. We also failed to demonstrate any significant differences between groups with regard to low cardiac output syndrome, reoperation for bleeding or the length of hospital stay.

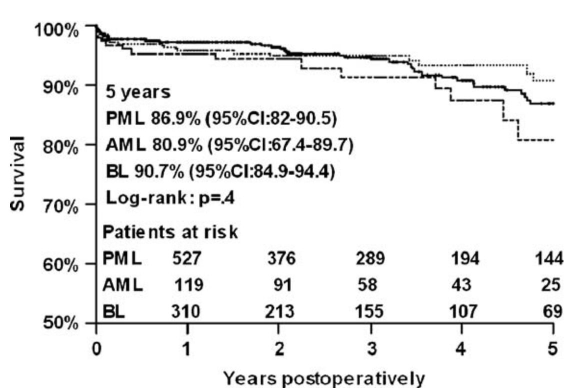

Fig. 2. Kaplan–Meier curve for survival following minimally invasive MV surgery for isolated posterior (PML), anterior (AML), and bileaflet (BL) prolapse.

The Kaplan–Meier estimate for cumulative survival at 5 years for the overall group was 87.3% (95% CI: 83.9–90.1). The 5-year survival was 86.9% (95% CI: 82.0–90.5) for patients with isolated PML prolapse, 80.9% (95% CI: 67.4–89.7) for patients with isolated AML prolapse and 90.7% (95% CI: 84.9–94.4; Fig. 2) for patients with BL prolapse. The log-rank test detected no significant difference between the groups regarding survival ($p = 0.4$).

During the 8-year study period, a total of 51 patients (4.1%) had to undergo cardiac reoperation (Fig. 3). Reasons for reoperation were CABG in two patients, MV re-repair in 15, MV replacement in 26, aortic valve surgery in six and cardiac transplantation in two patients. Freedom from reoperation at 5 years for the overall group was 95.6% (95% CI: 94.1–96.7). With regard to the different patient groups, 5-year freedom from reoperation rate was 96.1% (95% CI: 94.3–97.4) for patients with isolated PML prolapse, 92.4% (95% CI: 84–96.6) for patients with isolated AML prolapse and 95.9% (95% CI: 93.2–97.5) for patients with BL prolapse. We failed to detect a significant difference between groups regarding freedom from reoperation ($p = 0.5$).

4. Discussion

The current study shows that a very high rate of MV repair can be achieved in patients with mitral prolapse, with excellent survival and freedom from reoperation rates. MV repair was achieved in 94% of patients, even though many patients had complex MV pathology (Table 2). Reoperation

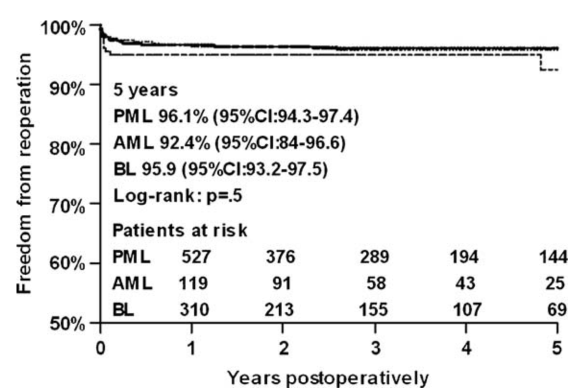

Fig. 3. Kaplan–Meier curve for freedom from reoperation following minimally invasive MV surgery for isolated posterior (PML), anterior (AML), and bileaflet (BL) prolapse. A total of 51 patients required reoperation during the 8-year study period, of which 41 patients received repeat mitral valve surgery.

was required in only 51 of 1230 patients during an 8-year follow-up period, of which 10 required cardiac surgery for non-MV related reasons. Although the mean duration of follow-up was only 2.7 years – as a result of the increasing number of patients that are being referred to our centre for this procedure over the last few years (see Fig. 1) – the number of patients that is available for follow-up 5 years postoperatively ($n = 238$) is enough to draw meaningful conclusions about the efficacy of this procedure.

As previous studies have shown, patients with isolated PML prolapse had the best results in the current study with a MV repair rate of almost 97% and a 5-year freedom from reoperation rate of over 95%. Although the MV repair rate was significantly higher for isolated PML prolapse than for AML or BL prolapse, we failed to detect a significant difference in reoperation rates during follow-up between patient groups.

It is noteworthy that patients with AML prolapse had a higher preoperative EuroSCORE, a higher rate of previous cardiac operations and the highest proportion of concomitant tricuspid valve surgery. Furthermore, there was a non-significant trend towards worse postoperative outcomes in the AML group with a freedom from reoperation rate of 92.4% and a 5-year survival rate of 80.9%. These findings compare favourably with previously reported data by other groups [3–6].

Braunberger et al. reported a significantly lower long-term freedom from valve-related reoperation rate for patients with AML prolapse when compared to other types of mitral prolapse [5]. This group exclusively applied the classical Carpentier-type MV repair techniques including leaflet resection and sliding annuloplasty [1]. A study published by Mohty et al. showed a higher reoperation rate of $28 \pm 7\%$ for AML prolapse, compared to $11 \pm 3\%$ for PML prolapse [6]. These findings were further supported by those of David et al., who reported a 12-year freedom from moderate or severe MR of $65 \pm 8\%$ for isolated AML, $67 \pm 6\%$ for BL prolapse and $80 \pm 4\%$ for isolated PML prolapse [3]. Freedom from reoperation rates were also less in the AML group ($88 \pm 4\%$ vs $94 \pm 2\%$ and $96 \pm 2\%$ for BL and PML prolapse, respectively), with AML prolapse being the only independent predictor of reoperation. This group performed the implantation of polytetrafluoroethylene (PTFE) neochordae for anterior and BL prolapse. Although each of these studies showed significantly poorer outcomes for patients with AML prolapse, De Bonis et al. reported a similar long-term outcome of up to 14 years for patients with AML and PML repair [4]. This group used the edge-to-edge repair technique for patients with AML prolapse, and quadrangular resection for PML prolapse.

In the present study, many different MV repair techniques were utilised. Carpentier-type leaflet resection and the implantation of neochordae using premeasured loops (the so-called 'loop technique') were used in the vast majority of patients (see Table 3), but the frequency of premeasured loop implantation has steadily increased over time at our institution [12,13]. For AML repair, loops were used in 56.4% of patients, whereas resection was used in only 9%. For PML repair, the numbers were nearly equal with 46.3% receiving loops and 46% undergoing leaflet resection. Since the decision on the repair strategy was at the discretion of the operating surgeon, this distribution of repair techniques underlines the value of the loop technique for the repair of AML prolapse.

Despite the fact that patients with BL prolapse underwent more complex repairs, with significantly longer operation, CPB and aortic cross-clamp times, very acceptable 5-year freedom from reoperation (95.6%) and 5-year survival (87.3%) rates were demonstrated in this group. We believe this finding underscores the philosophy that patients with complex mitral prolapse should also undergo MV repair, although referral of such patients to surgeons and centres with higher MV surgery volumes may be more appropriate [14].

Interestingly, although details on MV pathology were collected intraoperatively in a prospective manner, five patients of the AML group required additional PML repair and one patient in the PML group required additional AML repair. In addition, premeasured Gore-Tex loops were occasionally required for the opposite leaflet in patients with predominant AML and PML prolapse (Table 3). We assume that these 'crossovers' were caused by the morphological changes of the valvular structures induced by the already-finished steps of repair. It is conceivable that this leads to a significant alteration of the valve structure and function with need for subsequent additional correction.

Concomitant repair strategies like chordal transfer were frequently necessary in the AML (17.9% of patients) and BL (19.9%) groups, but were infrequently required in the PML group (2.1%). Our increasing use of premeasured loop implantation over time, however, has resulted in a concomitant steady decrease in the number of patients undergoing chordal transfer. The edge-to-edge Alfieri repair technique with concomitant insertion of an annuloplasty ring was required for more BL prolapse patients (9.2%) than the other two groups (4.5% and 0.9% for AML and PML prolapse, respectively). Despite the fact that the Alfieri procedure was usually performed as a 'bail-out' manoeuvre in patients with residual prolapse or regurgitation after the initial repair attempt, freedom from reoperation rates remained very good in the BL group. We can therefore conclude that the edge-to-edge repair is a worthy and, sometimes, valuable technique for cardiac surgeons to have available when performing more complex MV repairs.

All repair techniques used in the current study were found to be durable with an overall low rate of reoperation of 95.6% at 5 years. Over the complete 8-year study period, the results for AML prolapse were equal to those for BL and isolated PML prolapse. When compared to previous studies [3,5,6], however, our results for AML prolapse were better than those reported by other centres. We firmly believe that our excellent freedom from reoperation rate for AML prolapse is owing to the extensive use of neochordae construction with premeasured loops in such patients [12,13]. Further studies will be required to determine if our results for the 'loop technique' continue to be durable in the very long term.

4.1. Study limitations

The current study is retrospective in nature and is therefore subject to the inherent weaknesses of a retrospective analysis. Another limitation is the lack of long-term echocardiographic follow-up data that are currently available for our patient population. We therefore used reoperation as the primary indicator for MV repair durability. Although freedom from reoperation is a relatively 'hard' outcome, it may underestimate the actual rate of MV repair failure if patients are turned down for subsequent re-do surgery. It is our firm belief that this is a very infrequent event, however, particularly when considering the young age of our patient cohort (mean 58.9 years). Further studies will focus on the long-term echocardiographic outcomes of our patient population.

5. Conclusion

Minimally invasive MV surgery for mitral prolapse can be performed with very good perioperative and long-term results. Survival and freedom from reoperation rates for patients with isolated AML prolapse are equal to those with PML or BL prolapse in our patient cohort. The extensive use of neochordae (loop technique) for repair of AML prolapse may have been responsible for the excellent outcomes observed in this patient group.

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Appendix A. Conference discussion

Dr W.R. Chitwood (*Greenville, NC, USA*): Formerly it has been said by many what I call 'classic surgeons' that complex mitral valve repairs cannot be done through minimally invasive approaches with results that even approximate those through a sternotomy. Dr Seeburger has shown us today that mitral repairs and replacements can be done using these small incisions as well as we know that they use endoscopic techniques not only safely but also with excellent results that are similar to published large series of sternotomy-based operations. Also, they have applied several simplifying repair techniques that enable I think more surgeons to do operations such as repairs whether it is through a sternotomy or through a minimally invasive approach.

You presented the results in 1230 mitral valve repairs with a mean follow-up of 2.7 years in which 45% had either anterior or bileaflet pathology. That is fairly impressive. Of all patients, 94% had a repair, as you have just shown on your last slide. The operative mortality was low, at 1.8%, and freedom from reoperation was 95% at 8 years. These data signify that both anterior and bileaflet operations can have the same results long term as posterior leaflet repairs. This result is found in very few studies, as generally anterior leaflet repairs have an inferior repair rate and significantly more failures than posterior repairs. Our recently published results in 55 patients having a robotic bileaflet repair in which we did sliding plasty showed that the reoperative rate was 8% at 3 years. We were unhappy with that result, and this is also consistent with the number of sternotomy operations. Thus, anterior and bileaflet results of Dr Mohr alone make this a quite impressive series, especially as these patients underwent the operations through a minimally invasive incision.

Because of similar minimally invasive repair strategies, recently we combined our series with that of Dr Hargrove of the University of Pennsylvania, and we found that in 1178 mitral operations, we collectively repaired 80% of those valves. However, in our series we had a number of patients with rheumatic pathology, and 19% were reoperations. But most all, just as in your series, myxomatous valves were repaired. Our perfusion and our cross-clamp times were similar statistically to those presented, and we performed exactly the same number of atrial fibrillation operations, at 23%, and exactly the same number of tricuspid repairs, at 5%, as presented in this study. In our study, 97% of patients left the operating room with less than trivial mitral insufficiency. We had a 2% reoperative rate at 2 years.

Thus, when we combine the work in Leipzig and the work at the University of Pennsylvania and our institution, Dr Seeburger has confirmed that in nearly 2500 patients truly minimally invasive mitral valve operations are safe and have results similar or better than many conventional series. Impressive. It should be noted that in both the present series and in our series stroke and aortic dissection rates were significantly higher using the endo-balloon occlusion device as opposed to direct thoracic clamping.

From the paper presented and our data combined, we affirm that minimally invasive, this mini-thoracotomy approach, either using the clamp or the balloon with or without endoscopic or robotic assistance, should become the standard of care in both Europe and the United States for mitral repairs and replacements. Also, surgeons should be able to repair both complex and simple degenerative pathologies using this approach and with equally effective results. I have several questions for you, and we can take these one at a time.

Both of our groups, especially Dr Hargrove and Dr Mohr, are experienced users of the endo-balloon nearly since the inception of this device in 1996. With the data presented, what is the current method used in Leipzig for both primary repairs and reoperations, and can endoaortic occlusion be justified, especially by infrequent users of this technique?

Why don't you answer that one first and then we will go to the others.

Dr Seeburger: Doctor Chitwood, it is a great pleasure for me to be discussed by the current president of the STS. I would like to start answering your questions right away. The approach that we use in Leipzig is that we don't use the endoaortic balloon clamping anymore since we had too many problems with it. We do use the transthoracic clamp, introduced by you, in almost all of the cases. In reoperative cases in particular we mostly use ventricular fibrillation.

Dr Chitwood: So you use cold ventricular fibrillation in a competent aortic valve?

Dr Seeburger: Yes.

Dr Chitwood: If you have an incompetent aortic valve, do you clamp the reoperation patients?

Dr Seeburger: Yes.

Dr Chitwood: The second question. Many surgeons still have difficulty doing mitral valve repairs. We know this, that there are many valves that go into the pathologist's hands when they should be repaired. What new repair methods are you using to teach young surgeons in Leipzig a way to repair both single-leaf and bileaflet pathologies with a high chance of success, and should they used endoscopes or should they use direct vision?

Dr Seeburger: Well, this is a tough question for me because I am still what you call a young surgeon, I am constantly learning, and therefore I cannot tell you what I would teach other surgeons. However, I can tell you what Professor Mohr is teaching me. Thus, from my experience I can tell you in order to accomplish a successful repair we mostly use implantation of neochordae in the majority of cases, which has been our approach for the last several years. Although this has changed in a way that in earlier times we used mostly resection, we currently use more and more a loop or the implantation of neochordae for successful repair.

Dr Chitwood: So you are using the respect not resect modus with the chords?

Dr Seeburger: Yes.

Dr Chitwood: In our bileaflet repair failures, several patients had systolic anterior motion as the reason for reoperation. In these patients we had done sliding plasties. What simple methods can you use to prevent those? I noticed you had no reoperations for systolic anterior motion. What simple methods can be used to prevent failures in patients with long anterior leaflets and a tall posterior leaflet?

Dr Seeburger: Well, to prevent SAM in patients with a tall posterior leaflet we use 10 mm neochords just to cut the leaflet down and to reduce the height of the leaflet. That is what our approach is in most of the cases. Let's say if you have a large anterior leaflet, we usually use a 36 or a 38 ring to prevent SAM.

Dr Chitwood: So you meticulously size the valve and don't downsize the ring, is that correct?

Dr Seeburger: Yes.

Dr Chitwood: And you use chords to get greater coaptation?

Dr Seeburger: Yes.