



Long-term results of mitral repair for functional mitral regurgitation in idiopathic dilated cardiomyopathy[†]

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Received 30 August 2011; received in revised form 13 December 2011; accepted 22 December 2011

Abstract

OBJECTIVES: While the results of mitral repair in ischaemic mitral regurgitation have been repeatedly reported, less data are available about the outcome of surgical repair of functional mitral regurgitation (FMR) in idiopathic dilated cardiomyopathy (iDCM) which represents the topic of this study.

METHODS: Fifty-four iDCM patients (mean age 63 ± 10.5 years) underwent mitral valve repair for severe FMR. Coronary angiography confirmed the absence of coronary disease in all patients. Most of the patients (77.7%) were in New York Heart Association (NYHA) class III–IV. Pre-operative ejection fraction (EF) was $30.4 \pm 8.5\%$, left ventricle end-diastolic diameter (LVEDD) 67.5 ± 7.8 mm, left ventricle end-systolic diameter (LVESD) diameter 53.9 ± 8.3 mm. Concomitant procedures were atrial fibrillation (AF) ablation (19 patients) and tricuspid repair (17 patients). Follow-up was 100% complete (mean 4.2 ± 2.5 years, median 4.2 years, range 3.3 months–11.1 years).

RESULTS: In-hospital mortality was 5.6%. Actuarial survival at 6.5 years was $69 \pm 8.8\%$. Patients submitted to successful AF ablation and/or cardiac resynchronization therapy (CRT) had a significantly better survival (91 ± 7.9 vs $67 \pm 9.5\%$, $P = 0.01$). Freedom from $MR \geq 3+/4+$ was $89.1 \pm 5.7\%$ at 6.5 years. Follow-up echocardiography showed a reduction in LVEDD ($P < 0.0001$) and LVESD ($P = 0.0003$). Mean EF increased to $38.7 \pm 12.4\%$ ($P < 0.0001$). Multivariate analysis identified successful ablation of AF and/or CRT ($P = 0.01$) and higher pre-operative EF (0.03) as predictors of overall survival. Successful ablation of AF and/or CRT ($P = 0.02$) and lower preoperative systolic pulmonary artery pressure (0.04) were identified as independent predictors of reverse LV remodelling at follow-up. At last follow-up, 86.2% of the patients were in NYHA II or less.

CONCLUSIONS: Mitral repair for FMR in well-selected iDCM patients is associated with low hospital mortality and significant clinical benefit at late follow-up. Concomitant successful AF ablation and/or CRT provide a major symptomatic and prognostic advantage and should be associated to mitral surgery whenever indicated.

Keywords: Mitral valve • Functional mitral regurgitation • Dilated cardiomyopathy

INTRODUCTION

In patients with idiopathic dilated cardiomyopathy (iDCM), left ventricular (LV) remodelling and dysfunction lead to functional mitral regurgitation (FMR) [1] which is associated to a marked excess of cardiac mortality and congestive heart failure (CHF) episodes independently of all other baseline patient characteristics [2]. Surgical correction of FMR has been demonstrated to improve symptoms and quality of life and promote reverse LV remodelling in a significant proportion of patients with ischaemic and non-ischaemic cardiomyopathy [3–8]. However, while the results of mitral repair in ischaemic DCM have been repeatedly reported [3–6], less data are available about the long-term outcome of surgical repair of FMR in non-ischaemic

LV dysfunction [7–8]. Considering the relative lack of knowledge in that specific subset of patients, we decided to review our data to assess the long-term outcome of a series of consecutive patients submitted to mitral repair for FMR in advanced iDCM.

METHODS

Study population

From 2000 to 2011, 54 patients with advanced idiopathic DCM and moderately severe (3+/4+) or severe (4+/4+) FMR, refractory to medical therapy, underwent surgical mitral repair. Coronary angiography confirmed the absence of coronary artery disease in all patients. All patients had LV dysfunction. The baseline clinical and echocardiographic characteristics of the study

[†]Presented at the 25th Annual Meeting of the European Association for Cardio-Thoracic Surgery, Lisbon, Portugal, 1–5 October 2011.

Table 1: Preoperative clinical and echocardiographic data

Age (mean \pm SD)	63 \pm 10.5 (range 25–80)
EF (%)	30.4 \pm 8.5
SPAP (mmHg)	40 \pm 11
LVEDD (mm)	67 \pm 7.8
LVESD (mm)	53 \pm 8.3
LVEDVI (ml/m ²)	122 \pm 40
LVESVI (ml/m ²)	89 \pm 30
Tenting area (cm ²)	2.9 \pm 1.4
Coaptation depth (cm)	1.3 \pm 0.8
NYHA (n, %)	
II	12 (22.2)
III	32 (59.3)
IV	10 (18.5)
Rhythm (n, %)	
Sinus	30 (55.5)
AF	20 (37.0)
Pacemaker	4 (7.5)
LBB block (n, %)	19 (35.2)

SD: standard deviation; EF: ejection fraction; SPAP: systolic pulmonary artery pressure; LVEDD: left ventricular end-diastolic diameter; LVESD: left ventricular end-systolic diameter; LVEDVI: left ventricular end-diastolic volume index; LVESVI: left ventricular end-systolic volume index; NYHA: New York Heart Association; AF: atrial fibrillation; LBBB: left bundle branch block.

population are summarized in Table 1. Most of them (59.3%) were in New York Heart Association (NYHA) class III. Thirty-two patients (59.2%) had permanent atrial fibrillation (AF) and/or left bundle branch block (LBBB). In particular, among them, 13 patients (13/32, 40.6%) had permanent AF, 12 patients (12/32, 37.5%) had LBBB and the remaining seven patients (7/32, 21.9%) had both AF and LBBB. After surgery, all patients underwent clinical and echocardiographic follow-up in a dedicated heart failure outpatient clinic. A computerized database was prospectively generated with all the preoperative, postoperative and follow-up data which were retrospectively reviewed for the purpose of this study.

The institutional ethical committee approved the study and waived the informed consent for this retrospective analysis.

Echocardiography and surgery

Preoperatively, a transthoracic echocardiography (TTE) followed by a transoesophageal echocardiography (TEE) was performed in all patients. The severity of mitral regurgitation (MR) was graded as: mild, 1+ (jet area/left atrial area <10%); moderate, 2+ (jet area/left atrial area 10–20%); moderately severe, 3+ (jet area/left atrial area 20–45%); and severe, 4+ (jet area/left atrial area >45%) [9]. The *vena contracta* width, at the narrowest portion of the regurgitant jet and the site of origin of the jet were also measured and analysed [10]. More recently, besides left atrial jet extension and *vena contracta* width, the effective regurgitant orifice (ERO) and the regurgitant volume (RVol) have been included in the multiparametric approach adopted to quantify the severity of MR. As a general rule, cut-off values of 0.2 cm² for ERO, 60 ml for RVol and 0.4 cm for *vena contracta* were used to define severe FMR [11]. The end-diastolic and end-systolic volumes

Table 2: Operative data

Concomitant AF ablation (n, %)	19 (35.1)
Concomitant tricuspid repair (n, %)	17 (31.4)
Mitral repair technique	
Undersized ring	33 (61.1)
Undersized ring + edge-to-edge	21 (38.8)
Ring type (n, %)	
St Jude Medical Seguin (St Jude Medical, MN, USA)	27 (50)
GeoForm (Edwards Lifesciences, CA, USA)	20 (37)
Carpentier Edwards Classic (Edwards Lifesciences, CA, USA)	7 (12.9)
Ring size	
26-mm	19 (35.1)
28-mm	27 (50)
30-mm	5 (9.2)
32-mm	3 (5.5)

AF: atrial fibrillation.

were indexed (LVEDVI and LVESVI, respectively) by the body surface area. 'Reverse LV remodelling' was defined as a decrease \geq 15% in the LVESVI or in both LVESVI and LVEDVI at the last echocardiographic follow-up compared to the preoperative values. Immediately after surgery, TEE was repeated to assess residual MR. Serial TTEs were then performed at hospital discharge and at follow-up. Left ventricular diameters and volumes were measured before and after surgery.

Operative data and associated surgical procedures are reported in Table 2. All patients underwent mitral valve (MV) repair by means of an undersized annuloplasty with a complete rigid or semirigid ring. An edge-to-edge repair was concomitantly performed in 21 patients (38.8%), operated on at the beginning of our experience, when this technique was usually associated to the undersized annuloplasty in patients with significant tethering (coaptation depth \geq 1 cm) with the aim of increasing the durability of the repair. Although in our experience, the results of the edge-to-edge repair were better compared to the isolated undersized annuloplasty [12], when new shaped rings such as the Geoform (Edwards Lifesciences, CA, USA) became available, we started to routinely use this new device which, in a standardized and reproducible manner, was somehow simulating a central edge-to-edge repair by aggressively decreasing the septal-lateral dimension of the mitral annulus [13]. The ring type and size are detailed in Table 2. As a general rule, patients submitted to isolated undersized annuloplasty, received a ring at least two sizes smaller (mostly 26 or 28-mm) than the one measured according to the intertrigonal distance and the surface of the anterior leaflet. On the other hand, in patients undergoing concomitant edge-to-edge repair, slightly larger rings (usually 28 or 30-mm) were preferred to avoid the risk of stenosis. Ablation of permanent AF was performed before the mitral repair procedure by using an isolated left atrial approach. The mitral line was also performed with the same bipolar radiofrequency device with the technique used in our Institution which has previously been reported [14].

Patients with spontaneous SR (no AF ablation) underwent warfarin therapy for 3 months after surgery (INR between 2 and 3), which was stopped after 3 months. In patients in SR following AF ablation, warfarin was stopped after 6 months if no recurrence of AF occurred.

Follow-up

All patients were followed up in a dedicated heart failure outpatient clinic with physical examination, electrocardiography and TTE. All of them had at least one echocardiographic exam at follow-up. The length of follow-up ranged from 3.3 months to 11.1 years with a mean of 4.2 ± 2.5 years and a median (interquartile range) of 4.2 years (2.5–6.2).

Statistical analysis

Calculations were performed using SPSS version 11.5 (SPSS Inc., Chicago, IL, USA) for Windows (Microsoft Corp, Redmond, WA, USA) software package. Continuous data were expressed as mean \pm SD. If they were normally distributed, comparison between two groups was performed with the Student's *t*-test for (un)paired samples, as indicated. If continuous data were not normally distributed, the Mann-Whitney *U*-test or the Wilcoxon signed rank test were employed for independent or related samples, respectively. Comparison of categorical variables was performed using χ^2 and Fisher's test. NYHA functional class and grade of MR were treated as ordinal variables and compared with the Wilcoxon signed-rank test (related samples) or with the Mann-Whitney *U*-test (independent samples). Survival and freedom from events were evaluated by Kaplan-Meier analysis. Comparison among groups was performed according to the log-rank method. Univariate analysis of predictors of overall mortality and reverse LV remodelling was performed with Cox proportional hazards regression and variables with a *P*-value < 0.05 were entered in a multivariable model. All data are presented as mean \pm standard deviation (for actuarial estimates, standard error is reported instead).

RESULTS

All patients underwent mitral repair by means of an isolated undersized ring annuloplasty (33 patients, 61.1%) or an undersized annuloplasty associated to an edge-to-edge technique (21 patients, 38.8%). Concomitant tricuspid annuloplasty was associated in 17 patients (31.3%; in four patients a suture bicuspidation, in five patients a De Vega technique and in eight patients an annuloplasty with a rigid prosthetic ring). Moreover, among the 32 patients with permanent AF and/or LBBB, 12 underwent concomitant radiofrequency ablation of their AF and seven were submitted to both intraoperative AF ablation and cardiac resynchronization therapy (CRT). In one patient, permanent AF was left untreated due to very severe biatrial enlargement. Finally, 12 patients with LBBB underwent CRT within 6 months after mitral repair. Overall, 31 of the 32 patients with preoperative AF and/or LBBB received AF ablation and/or CRT.

Hospital outcome

Hospital mortality was 5.6% (3/54 patients). Two patients died from multi-organ failure, one patient required veno-arterial extracorporeal membrane oxygenation support because of severe cardiogenic shock and developed *Staphylococcus aureus* mitral endocarditis with ring detachment and severe MR. She

required MV replacement and died 17 days after the first operation. The three in-hospital deaths occurred in patients who had not received an associated edge-to-edge, but no statistical difference was observed compared to patients who had an associated edge-to-edge procedure (*P* = 0.1).

Major adverse events were: one of the 54 patients (1.8%) had a major cerebrovascular event, one patient (1.8%) had mediastinitis requiring surgical revision and ten patients (18.5%) had acute kidney injury. The mean length of stay was 12.5 ± 8.7 days with a median of 10 days (IQR 7;15). At hospital discharge, 30 patients (58.8%) had no residual MR, 18 patients had mild MR (35.2%) and three patients (6%) had moderate (2+/4+) mitral insufficiency. Radiofrequency ablation of AF, concomitantly performed in 19 patients, failed in five patients and was successful in the remaining 14 patients, who already had restoration of sinus rhythm at hospital discharge.

Follow-up results

Ten late deaths occurred during follow-up. One was a non-cardiac death due to gastric cancer and nine were cardiac related (three sudden deaths, four from refractory CHF, one from mitral endocarditis, one from pulmonary embolism). The patient with mitral endocarditis underwent bioprosthetic MV replacement but died from postoperative septic shock.

During follow-up, one patient required MV replacement 2.5 months after surgery because of Gram-positive mitral endocarditis. Overall, actuarial survival at 6.5 years was $69 \pm 8.8\%$ (Fig. 1). At multivariate analysis, lower preoperative left ventricular ejection fraction (LVEF) was a predictor of overall mortality (*P* = 0.0001), whereas being submitted to successful ablation of AF and/or to CRT had an important protective effect (HR 0.08, 95% CI 0.01–0.4, *P* = 0.002) (Table 3). Long-term survival of the patients having successful ablation of AF and/or CRT was significantly better than that of patients who had MV repair alone (91 ± 7.9 vs $67 \pm 9.5\%$ at 5 years, *P* = 0.01) (Fig. 2).

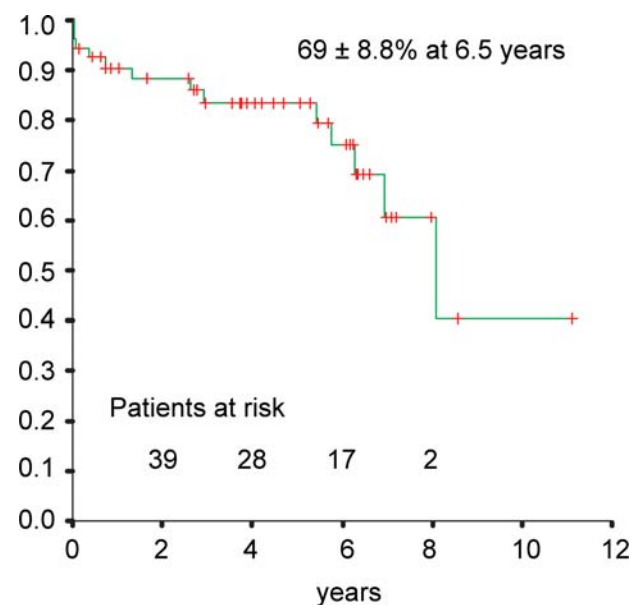


Figure 1: Overall actuarial survival.

Table 3: Predictors of overall mortality

	Univariate			Multivariate		
	HR	95% CI	P-value	HR	95% CI	P-value
NYHA >3	3	0.3-2.3	0.2			
EF	0.8	0.7-0.9	0.01	0.8	0.7-0.9	0.0001
SPAP	1	0.9-1.0	0.09			
MR at discharge	0.6	0.2-1.6	0.3			
AF ablation and/or CRT	0.1	0.03-0.7	0.02	0.08	0.01-0.4	0.002

NYHA: New York Heart Association; SPAP: systolic pulmonary artery pressure; MR: mitral regurgitation; AF: atrial fibrillation; CRT: cardiac resynchronization therapy; HR: hazard ratio; CI: confidence interval.

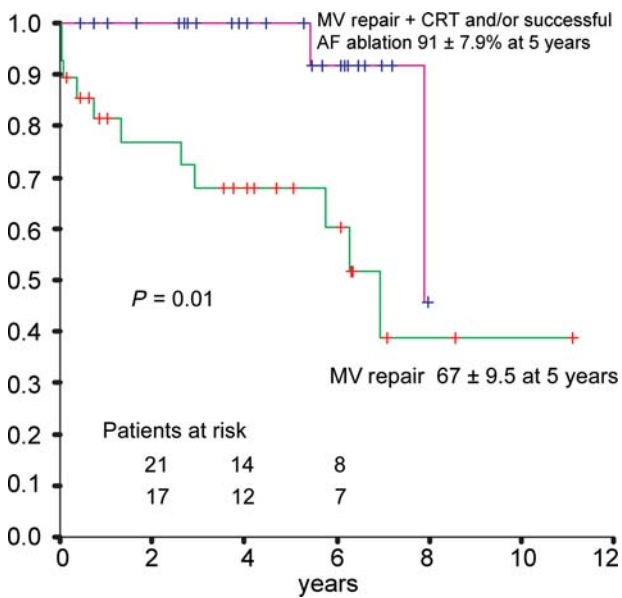


Figure 2: Actuarial survival in patients submitted to MV repair alone compared to those who underwent concomitant successful AF ablation and/or cardiac resynchronization therapy.

At follow-up, MR was 0+/4+ in 14 of 51 patients (27.4%), 1+/4+ in 22 patients (43.1%), 2+/4+ in 11 patients (21.5%), 3+/4+ in two patients (3.9%) and 4+/4+ in two patients (3.9%). Although MR 3+ or 4+ was documented only in four patients (7.8%), 21.5% of the patients (11/51) had moderate residual or recurrent MR. At 6.5 years, freedom from MR \geq 3+/4+ was 89 \pm 5.7% (Fig. 3) and freedom from MR \geq 2+ was 66 \pm 9%.

At last echocardiographic follow-up, an increase in LVEF was documented (from 30.4 \pm 8.5 to 38.7 \pm 12.4%, $P=0.0001$) and a reduction in LV dimension occurred (left ventricular end-diastolic diameter from 67.5 \pm 7.8 to 59.2 \pm 9.4 mm, $P=0.0001$; left ventricular end-systolic diameter from 53.9 \pm 8.3 to 49 \pm 11.8 mm, $P=0.003$).

Reverse LV remodelling was documented in 30 patients (30/51, 58.8%) and an increase in EF at last follow-up of at least 10 points was demonstrated in 22 cases (22/51, 43.1%). At multivariate analysis, predictors of reverse remodelling were successful AF ablation and/or CRT (HR 3.4, 95% CI 1.2-9.7, $P=0.02$) and systolic pulmonary artery pressure (HR 0.9, 95% CI 0.9-1, $P=0.04$).

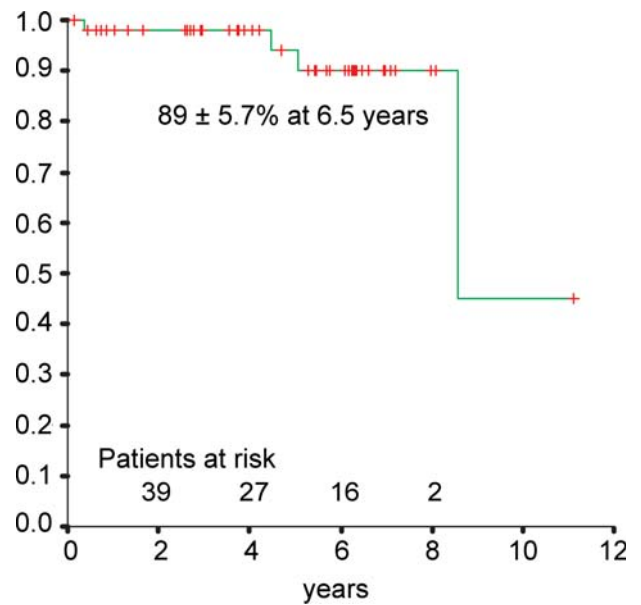


Figure 3: Actuarial freedom from MR \geq 3+.

Overall actuarial survival at 5 years was 77.7 \pm 9.9% for patients having an associated edge-to-edge technique to undersized annuloplasty and 87.7 \pm 5.8% for patients who had not ($P=0.5$); freedom from MR \geq 3+/4+ was 93.3 \pm 6.4 and 84.6 \pm 10.1%, respectively ($P=0.1$). The use of the edge-to-edge technique showed a trend towards favouring reverse LV remodelling but without reaching the statistical significance (univariate analysis HR 2.3, 95% CI 0.9-6.1, $P=0.07$; multivariate HR 1.8, 95% CI 0.6-4.8, $P=0.2$).

No correlations have been observed between the type of implanted surgical rings and outcome.

A significant clinical improvement was observed at follow-up with most of the patients being in NYHA class II (29/51, 56.8%) or I (15/51, 29.4%) ($P=0.0001$ compared to preoperative values).

DISCUSSION

Functional mitral regurgitation is a common finding in patients with heart failure [15-16] and is associated with poor prognosis in both ischaemic and non-ischaemic DCM [2, 17-19]. The majority of the published studies on the prognostic impact of FMR refer to ischaemic cardiomyopathy [18-20]. However, recent data confirm that, also in patients with idiopathic DCM, moderate to severe secondary MR remains an independent predictor of cardiac death and heart failure [2]. Surgical correction of FMR has been demonstrated to improve symptoms and quality of life and promote reverse LV remodelling in ischaemic patients [3-6]. The outcome of mitral repair for FMR secondary to non-ischaemic DCM is less well established. Some important information in this specific setting has been recently provided by the long-term results of the Acorn trial, a prospective, randomized, multicentre study whose primary objective was to determine whether the addition of the CorCap cardiac support device added incremental value to mitral surgery in patients with idiopathic DCM [8]. In the MV surgery stratum, a long-term improvement in LV structure and function was demonstrated for up to 5

years. Actuarial survival at 5 years was 70% and the recurrence rate of 3–4+ MR (or repeat mitral surgery) was 19% [8]. These data support the use of mitral repair for patients with non-ischaemic heart failure and LV dysfunction who have been medically optimized yet remain symptomatic with significant MR.

The results of our study are consistent with those of the Acorn trial and demonstrate that MV repair for FMR in iDCM can be performed with a low in-hospital mortality if patient selection is appropriate. The actuarial survival of 69% at 6.5 years registered in our series is similar to that reported in the Acorn trial and much better than the 36% at 6 years described by Agricola *et al.* [2] for patients with non-ischaemic DCM and severe FMR on maximal medical therapy. Long-term benefits in terms of NYHA functional class and LV dimensions and function were documented at follow-up: almost 60% of the patients had evidence of reverse LV remodelling and freedom from MR \geq 3+ was 89% at 6.5 years. Since repair durability is strictly related to the occurrence of reverse remodelling [21], we can speculate that the low rate of repair failure registered in our series is probably the result of the relatively high incidence of reverse remodelling observed in these patients. Besides FMR, other important predictors of morbidity and mortality in patients with non-ischaemic heart failure are low EF, AF and advanced NYHA functional class, whereas CRT has a protective effect with regard to cardiac death and heart failure episodes [2]. With regard to this issue, an important finding of our study is that, in addition to the surgical correction of FMR, all the other pathophysiological components of the non-ischaemic heart failure picture should be addressed to improve patient outcome. In particular, in our experience, the association of successful ablation of AF or CRT (or both of them) to mitral repair significantly improved the outcome at follow-up in terms of survival, reverse LV remodelling and symptoms [22]. The possible explanation for this observation is that permanent AF and mechanical dyssynchrony due to LBBB play a major role in further worsening the degree of LV dysfunction in patients with advanced iDCM and FMR [23–25]. When sinus rhythm is restored by radiofrequency ablation of AF or mechanical LV, dyssynchrony is abolished by CRT or, even better, when both goals are reached by associating these two procedures, the positive effect produced on LV function and dimensions is much more pronounced compared to that provided by mitral repair alone. The afterload mismatch, which inevitably occurs after correction of MR, is tolerated much better if these additional procedures can exert their beneficial effect on the LV performance by eliminating mechanical dyssynchrony and/or permanent AF. According to these results, patients with FMR, permanent AF and/or LBBB should be offered the combined approach described in this study.

Further studies with a much larger sample size are necessary to confirm these findings and to assess if the clinical and echocardiographic results here described may translate into a significant survival advantage.

LIMITATIONS

This study has several limitations. It is a retrospective review of data prospectively entered into a computerized database with all the limitations of a retrospective analysis. The number of patients included is relatively small. The ERO and the RVol were not routinely used in the past in the multiparametric approach adopted to quantify the severity of FMR. Therefore, they were not available in

a substantial proportion of the patients and could not be used for analysis and comparison. Moreover, the size of the left atrium and the preoperative duration of AF were missed in some patients and were not used for analysis. Other than those receiving mitral repair, patients who received CRT alone or radiofrequency ablation of AF or both of them, had to be merged in a single group to reach a meaningful number of cases and enable an assessment of the impact of those procedures on the outcome. Actually, this made it impossible to differentiate between the impact of CRT and that of radiofrequency ablation of AF on the outcome of the patients at follow-up.

Conflict of interest: Ottavio Alfieri discloses that he has a financial relationship with Edwards LifeSciences.

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APPENDIX. CONFERENCE DISCUSSION

Dr G. D'Ancona (Palermo, Italy): I have to say that, in my opinion, the true winners are resynchronization therapy and atrial fibrillation ablation, and I am actually quite impressed by the positive impact upon reduction of mortality and improvement of left ventricular function.

I have two questions for you. Are you nowadays, on the basis of your findings, being more liberal in the surgical indication for these patients when you know that you can do, and there is indication actually to do, a concomitant type of atrial fibrillation ablation and resynchronization?

The second question concerns the edge-to-edge repair; there was no statistical significance, but I am sure if you had had more patients you would have reached statistical significance. This is an important statistical trend. I noticed that the cohort comes from a long period of time, dating from 2001 to 2011. Do you recognize that there are patients in this cohort who nowadays you would treat with a hybrid sort of approach using, for example, percutaneous edge-to-edge resynchronization therapy and atrial fibrillation ablation, either percutaneously or minimally invasively performed, and if you see any limitations in this approach, they would be mainly limitations in the U-clip placement or a limitation in the indication for atrial fibrillation ablation or resynchronization therapy?

Dr De Bonis: I agree with you that the winners are successful ablation of atrial fibrillation and cardiac resynchronization therapy. This study came out from the fact that, indeed, we have been following those patients in a dedicated outpatient clinic since 1999, so it is about 12 years. What we were seeing, asking ourselves if this type of surgery was really beneficial for the patients, is that patients with restoration of sinus rhythm by radiofrequency ablation and possibly with concomitant CRT, were completely different patients at follow-up. I mean, if you do isolated undersized repair, usually in most of the cases, at least the cases in our experience, ejection fraction remains almost the same, the patients feel better, but still from an echocardiographic point of view there is no impressive improvement. On the other hand, in those patients with restoration of sinus rhythm and maybe resynchronized, the ejection fraction goes up to 45%, even 50%. I am talking about patients followed for six, seven, eight years. So this was very important. So the winner is that and we should try to apply these procedures as much as possible.

When to apply them? I think any time they are indicated, which basically means, as you can see, out of 20 patients, we performed radiofrequency ablation of atrial fibrillation in 19. One was excluded because of a too-huge left atrium, too long-standing atrial fibrillation. So whenever you have a relatively short duration of AF, whenever you have a left atrium which is not enormous, and the patient is not over, I don't know, 80 years or 75 or something like that, it does make sense absolutely to perform the procedure.

And this is, as you say, the more liberal surgical indication. Probably we are less afraid, meaning that if we know that we are going to help this ventricle even more by restoring sinus rhythm or by using CRT, we feel that we are doing the right thing for the patient.

In terms of edge-to-edge, yes, edge-to-edge showed a trend towards reverse remodelling, which was not statistically significant. It could become statistically significant with more patients, but I have no answer on that point. We already saw this trend in another paper published in *Circulation* a few years ago, but, again, it did not reach statistical significance.

And, yes, we do have a hybrid approach for those patients, but still patients undergoing Evalve MitraClip implantation, with CRT usually before the clip, are those patients who are considered to be at too high risk for surgery. So I don't see at the moment a great competition between surgery and MitraClip because we reserve the percutaneous solution for patients who are at too high risk to be submitted to surgery. So they are complementary techniques, I would say.

Dr F. Mohr (Leipzig, Germany): You had a number of patients, 58%, who did show reverse remodelling. Did you have any preoperative MRI stress testing, for example, to define those patients who might have reverse remodelling or not?

Dr De Bonis: Yes. We did not perform MRI; probably we should, but we didn't in this series. On the other hand, we almost invariably performed echo dobutamine preoperatively in the patients submitted to this type of surgery to decide whether to operate or not. So if before surgery we find no contractile reserve at echo dobutamine, we do not operate on them. So those patients had 58% reverse remodelling, but they were all with contractile reserve. These are non-ischaemic dilated cardiomyopathy patients, but I think that echo dobutamine can still give you important information. It can tell you how the patient is going to answer to the inotropic support you are going to give postoperatively. If he has got contractile reserve in response to dobutamine, it will better respond after surgery to inotropic support and is very important for risk stratification. So this is 60% reverse remodelling in patients with contractile reserve.

Dr R. Dion (Genk, Belgium): Your results are very comparable to what we obtained in Leiden at the time. I absolutely agree with you on the CRT. I was involved in a jury of a PhD thesis in Leiden a few days ago, and they showed again a potential very important influence of CRT on mitral regurgitation in ischaemic and in non-ischaemic dilated cardiomyopathy. Therefore I think it is absolutely important to insist on it and to come off bypass with atrial biventricular pacing, that you can place temporarily, in cases of persistent or suspected dyssynchrony. And if it works, I think you should leave an epicardial definitive LV lead to facilitate the installation of a definitive CRT later. And the second point is a question. When you associate undersizing and an Alfieri stitch, does it alter the grade of undersizing? Do you undersize less?

Dr De Bonis: Yes, we do undersize less. In patients submitted to concomitant edge-to-edge repair, the mean size of the ring was 28, whereas it was less than 26.5 in those with isolated, undersized mitral annuloplasty. Otherwise you can have a risk of stenosis, of course. We use a small suture but we undersize less. And I am very glad to hear what you just said, because I am rather pleased to see that in the recently published literature, also from the Leiden group, in terms of CorCap and cardiac resynchronization therapy, and also the five-year results of the Acorn CorCap trial, they are all going in the same direction. The results are almost comparable. So we are learning.

Dr Ž. Jonjev (Novi Sad, Serbia): As I noticed, the end-diastolic dimension of the left ventricle is about 78 mm and you have a huge mitral valve coaptation depth of 2.9, which is very challenging. According to our experience, those patients deserve a lot of effort from everybody, not only in the operating room but in the IC unit as well. However, according to the theory of Torrent-Guasp, the heart is a functional unit that consists of two chambers, right and left as well, and a lot of papers have demonstrated that overall results would be much, much improved if right-sided heart failure is treated at the same time when mitral valve repair is performed. I didn't notice that you had anything written or published here about patients who actually deserve tricuspid valve repair at the same time as mitral valve repair is performed.

And secondly, we witnessed Michael Mack's comment a couple of days ago that in the United States there is an ongoing study started in 2009 with just such a very challenging group of patients, and they believe that one of the improvements in this approach could be implantation of an artificial biological valve in the mitral valve position. What is your feeling about that?

Dr De Bonis: I will try to be brief. Right ventricular function is extremely important. Severe right ventricular dysfunction is another exclusion criterion for surgery; we use a TDI measurement of the systolic movement of the tricuspid annulus to decide whether or not to operate on those patients; if you have important right ventricular dysfunction, you should not operate. But in terms of tricuspid function (you might have missed one of my slides), we performed about 30% concomitant tricuspid annuloplasty, which is very low but is due to an old-fashioned style, which we are changing, in terms of concomitant tricuspid repair. So 30% had tricuspid annuloplasty, but this rate, which is certainly low, is due to the fact that in the beginning we were not using more aggressive surgery from that point of view.

As far as your second question is concerned, this morning we presented our data on a propensity score matched population of 132 patients submitted to mitral valve repair and mitral valve replacement. We are waiting for results of the randomized trial. Unfortunately in our series of consecutive patients, propensity score adjusted, we had hospital mortality of 2.3 in mitral valve repair, 12.7 in mitral valve replacement, highly significant, and a difference in terms of survival at 2.5 years of more than 20%. So, as far as our data is concerned, we are still afraid that replacement has a major impact on LV function, much more so than mitral valve repair. We will see the randomized trial.

Dr A. Golino (Bradenton, FL, USA): A couple of questions. You said you use the GeoForm now for all the patients, right?

Dr De Bonis: Yes, I said that.

Dr Golino: How do you address people with P3 tethering with the GeoForm? Have you ever seen any paravalvular leak with the GeoForm? Also the last quick question is, you showed an increase in ejection fraction. That is different from the classical style, as shown by Bolling, where there was increased quality of life but no increase of ejection fraction. Do you do resynchronization or do you see the same without resynchronization therapy?

Dr De Bonis: I will start from the last question. We have seen increasing ejection fraction also in patients without CRT and ablation of atrial fibrillation, but the rate is less compared to the other group. So, of course, you can also have reverse remodelling in patients without ablation of atrial fibrillation and resynchronization. It depends on how dilated the ventricle is before surgery. But the rate is much higher when you do associate the other two procedures.

As far as P3 tethering is concerned, of course you can have P3 tethering and also a regurgitant commissural jet, but you should take into consideration that the GeoForm ring as well as the IMR ring have an antero-posterior distance which is very, very small. So when you apply a GeoForm ring, certainly you are acting on the central portion of the valve, but you are working very aggressively as well on the commissure. So I don't see a problem from that point of view. You can correct the commissural jet and P3 tethering by putting in a GeoForm ring.

Dr Golino: So the GeoForm does the same as IMR for P3?

Dr Mohr: Can you have a private discussion afterwards as we must continue with the next talk, please.

Dr De Bonis: No paravalvular leak, anyway.

European Journal of Cardio-Thoracic Surgery 42 (2012) 646–647
doi:10.1093/ejcts/ezs132 Advance Access publication 18 April 2012

EDITORIAL COMMENT

Mitral repair for functional mitral regurgitation in idiopathic dilated cardiomyopathy: a good operation done well may help

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Keywords: Heart failure • Cardiomyopathy • Mitral regurgitation • Mitral valve repair

In this issue, De Bonis *et al.* [1] described a very interesting retrospective series of 54 patients with idiopathic dilated cardiomyopathy who underwent mitral valve repair for severe functional mitral regurgitation. No patients had coronary artery disease. These patients, very typically, had severe mitral regurgitation, class III–IV New York Heart Association failure with large ventricles, poor ejection fractions, and many had atrial fibrillation and tricuspid regurgitation. In this series, as has been shown by others, the patients underwent correction of their mitral regurgitation with low in-hospital mortality (5%). The actuarial survival at 6.5 years was ~70%. The survival was further improved if the patients had either atrial fibrillation ablation or cardiac resynchronization therapy. In follow-up, patients showed improvement in their left ventricular geometry, ejection fraction and in NYHA class. Most importantly, in this series, the freedom from recurrence of significant mitral regurgitation was ~90% at 6.5 years.

Functional mitral regurgitation is a complication of idiopathic dilated cardiomyopathy, occurring secondary to left ventricle

geometrical distortion from stenting, inferobasilar migration, apical displacement, annular dilation and posterior leaflet restriction, with altered ventricular shape and/or regional LV wall dysfunction. Mitral regurgitation (MR) leads to a vicious cycle of LV volume overload, geometric distortion and progressive MR. MR complicating congestive heart failure (CHF) predicts poor survival [2]. Mitral reconstruction surgery to treat MR in dilated cardiomyopathy has been undertaken with an acceptably low operative mortality [3, 4]. However, MR surgery for these patients remains controversial, as substantial residual or recurrent MR has been noted, and may mitigate any benefits. In fact, some series show an early (6 months) recurrence rate of significant MR of up to 50%, which certainly negatively influences or obscures potential survival advantage [5, 6]. When reviewing literature series of both surgical and percutaneous outcome studies on patients with MR in dilated idiopathic cardiomyopathy, one should be critically aware of the negative impact, mechanism and rates of recurrent MR.