Editorial

Going further of mitral ring annuloplasty: the role of surgery in atrial functional mitral regurgitation

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Atrial functional mitral regurgitation (AFMR) is a recently recognized entity within mitral valve pathology. Mitral regurgitation (MR) has classically been divided into primary or organic (MR with structural valve dysfunction) and secondary or functional (MR without structural valve dysfunction). Secondary MR has been associated with left ventricular (LV) dilatation in patients with ischemic coronary disease associated with papillary muscle shift and mitral apical tethering (ventricular function MR). AFMR has been recognized as an independent cause of MR in patients with left atrial overload such as long-standing atrial fibrillation or LV-preserved heart failure patients (1).

AFMR is usually associated with central MR in the early stages of left atrial enlargement (2). However, in advanced stages of disease, tethering of the posterior leaflet occurs due to displacement of the posterior annulus toward the posterior LV wall, termed "atriogenic leaflet tethering" (3), leading to pseudoprolapse of the anterior leaflet and an eccentric MR jet in the final stages of disease (2).

In addition, AFMR has been associated with compensatory leaflet remodelling leading to leaflet growth that could compensate for the annular dilation of AFMR in the initial phase of the disease (2). In this sense, Kagiyama *et al.* showed that decreased leaflet area was associated with more severe MR in patients with atrial fibrillation (3). On the other hand, atrial enlargement leading to enlargement of the annulus results in changes in mitral valve morphology with a loss of saddle-shaped appearance, reducing the effective coaptation area of the leaflet (1).

On this basis, AFMR would correspond to type I (annulus enlargement) and type IIIb (restriction of the posterior leaflet) according to Carpentier's classification (4).

Some authors have suggested the following requirements for echocardiographic diagnosis of AMFR: (I) normal size and function of LV (1,2) with normal indexed LV end-diastolic volume and LVEF >60% (2); (II) normal mitral leaflets (2); (III) presence of mitral annular dilatation; (IV) enlargement of the left atrium as defined by Farhan *et al.* (2), e.g., an indexed left atrial volume of >34 mL/m^2, and (V) loss of normal MV systolic valve concavity toward LV (1).

Treatment of AFMR includes rhythm restoration, transcatheter, and surgical procedures (2), but only surgery can potentially treat at least four mechanisms of disease: left atrial enlargement (atrial plication), annulus dilatation and pseudoprolapse of the anterior leaflet (annuloplasty with or without neochords), insufficient leaflet remodeling and atriogenic leaflet tethering (patch augmentation), and rhythm control (Cox-Maze procedure).

Morisaki *et al.* (5) compared mitral replacement with mitral repair with patch augmentation in a small sample of AFMR patients in the last stage of disease (2) who had

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posterior leaflet tethering. Patients included in the study met the previously proposed criteria with a preoperative left atrial volume index (LAVI) of more than 100 mL/m^2 and a left ventricular ejection fraction (LVEF) of >60% in both groups, and only patients with a shortened posterior leaflet and a tethering angle of >30º were included.

The most extensive papers (6,7), addressing surgical repair of AFMR mainly involved mitral annuloplasty, probably because of an early stage of disease in the included patients. Morisaki *et al.* (5) went a step further and analysed the results in a more complex group of patients with an advanced stage of disease who had posterior leaflet tethering. In search of a biological solution, the repair technique proposed in this article overcame anterior pseudoprolapse, posterior leaflet tethering, and enlargement of the left atrium.

No differences in postoperative outcomes were noted, with the repair group having a longer operative time and a trend toward fewer rehospitalizations and major adverse cardiac event (MACE) during follow-up. However, two patients experienced severe MR requiring reoperation.

On the other hand, an association between postoperative left atrial indexed volume and thromboembolic events was observed, suggesting an advantage of atrial plication in the cohorts (cut-off value of 106.9 mL/m^2). Surprisingly, left atrial appendage (LAA) closure was not associated with fewer thromboembolic events in this study.

After a follow-up period of nearly two years, the work of Deferm and the work of Wagner (6,7) found that 7% and 6% of moderate/severe MR recurrences occurred respectively. MR repairs with ring annuloplasty alone have been suggested to be not sufficient in AFMR (8), in which case leaflet augmentation or valve replacement could play a role. Although, some concerns are raised about calcification and duration of repair, the authors clarified that no patch calcification was observed in their sample, and they do not use pericardium fixed with glutaraldehyde in the study by Morisaki.

Another option in the treatment of AFMR is surgical or percutaneous atrial ablation in patients with atrial fibrillation. Restoration of sinus rhythm could improve annular dynamics, leading to an improvement in the effective regurgitant orifice area of MR in patients with atrial fibrillation 6 weeks after electrical cardioversion (9). In addition, Gertz *et al.* reported lower rates of significant MR in patients with sinus rhythm after 1 year of atrial fibrillation ablation compared with patients with recurrent atrial fibrillation (10). Although Morisaki's patients did not undergo surgical ablation, Cox-Maze surgery should be weighted in earlier stages of disease in our opinion. Of note, thirty percent of repairs in the work of Deferm underwent concomitant Cox-Maze procedure (6), and 60% of ablated patients in the study of Wagner (7) remained in sinus rhythm during follow-up.

Interestingly, in the study by Morisaki, left atrial plication was performed in approximately 50% of patients. Matsumori *et al.* (11) previously reported atrial plication data in a small study of AFMR with a left atrial diameter greater than 4 cm. They found that left atrial plication was associated with lower postoperative mitral valve angles and left atrial size. Morisaki *et al.* (5) associated indexed left atrial volume with the risk of thromboembolic events. Left atrial volume was also associated with MACE in patients with atrial fibrillation (12). However, in our opinion, the addition of atrial plication to the surgery may represent a nonnegligible risk for the procedure that should be weighted.

Some authors have emphasised the importance of tricuspid regurgitation (TR) in AFMR patients with atrial fibrillation, calling it "bilateral or dual-valve disease" (13,14). In Morasaki's study, thirty patients underwent tricuspid ring annuloplasty, with 40% of them having severe preoperative TR and 6% having moderate TR postoperatively. Wagner and Deferm reported concomitant tricuspid repair in 50% of AFMR patients (6,7), In addition, TR was associated with mortality after mitral annuloplasty (6); these data underscore the importance of TR in these patients.

On the other hand, transcatheter mitral valve repair (edge-to-edge repair and annuloplasty) or replacement are other treatment options to be considered in high-risk patients. Edge-to-edge repairs have been found to have 1-year recurrence rates of moderate MR between 10% and 20% (15-17). A European registry reported that postoperative MR was equal to or greater than mild in 38.6% of patients with AFMR who underwent MitraClip implantation (18). According to Farhan (2), "*Although transcatheter edge-to-edge repair reduces MR and improves symptoms*, *this procedure represents a valvular approach to an annular problem*." Another study comparing indirect transcatheter mitral annuloplasty with the MitraClip showed a significant reduction in left atrial volume with mitral annuloplasty, but MR higher than mild occurred in about 70% of annuloplasty patients after 1 year (19). To date, the results of percutaneous mitral valve replacement for AFMR are unknown (2).

Indeed, repair using leaflet augmentation is a more complex procedure than replacement, and after reading

Morisaki's article, some concerns remained. It is likely that repair with leaflet augmentation is not a feasible operation for all patients but is an option for younger and low-risk patients in whom simultaneous left atrial plication and Cox-Maze procedures should be weighed. The results of the Morisaki's study are limited, probably because of the small sample size and patient characteristics, but they open a line of investigation that should be clarified.

It is likely that AFMR will be recognized as a distinct condition in future guidelines, and numerous reports are emerging to determine the best management for these patients (20). On the other hand, AFMR may have a better prognosis than ventricular functional MR according to the Deferm's study (6), in which surgically repaired ventricular functional MR had a significantly higher recurrence and mortality rate than AFMR after a median follow-up of 3.3 years.

Currently, the best treatment for AFMR is still unclear, and larger and comprehensive studies with surgical registries and randomized trials are needed, but surgery is likely the best option in low- to intermediate-risk patients because of the potential for complete treatment of the entire spectrum of disease.

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