Left Cardiac Chambers Reverse Remodeling after Percutaneous Mitral Valve Repair with the MitraClip System

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Background: Successful mitral valve surgical repair, decreasing volume overload, has been shown to provide reverse left ventricular (LV) and/or left atrial remodeling in most patients. Percutaneous mitral valve repair with the MitraClip system (Abbott, Abbott Park, IL) has been associated with favorable clinical outcomes in patients with mitral regurgitation at high risk of surgery. However, specific data on left cardiac chambers reverse remodeling after such procedures are limited.

Methods: This was a prospective observational study of consecutive patients at high risk of surgery, with moderate-to-severe or severe mitral regurgitation undergoing MitraClip system implantation. Follow-up echocardiography was performed at 6 months. The evaluated parameters were the LV end-diastolic and end-systolic volume indexes, LV sphericity index, LV ejection fraction, and left atrial volume index. Reverse LV remodeling was defined as a decrease of 10% in the LV end-diastolic volume index.

Results: The study population included 44 patients: 14 with degenerative and 30 with functional mitral regurgitation. At 6 months of follow-up, significant reductions in the median and interquartile range of the sphericity index (from 0.57 [interquartile range 0.54–0.62] to 0.54 [interquartile range 0.50–0.58]; $P < .001$), LV end-diastolic volume index (from 79.4 mL/m^2 [interquartile range 63.0–102.2] to 60.7 mL/m^2 [50.8–84.4]; $P < .001$), and LV end-systolic volume index (from 49.3 mL/m^2 [interquartile range 28.2–70.5] to 28.9 mL/m^2 [interquartile range 22.2–55.8]; $P < .001$) were observed. The LV ejection fraction improved significantly (from 38.0% [interquartile range 30.0–55.0%] to 46.0% [interquartile range 35.0–58.0%]; $P < .001$) from baseline to 6 months. Minor differences in the left atrial volume index were observed. Reverse remodeling, according to the specified definition, was observed in 77.3% of the patients.

Conclusions: The present study reports positive LV reshape effects after mitral valve repair with the MitraClip system, showing significant improvements in LV size and function. (J Am Soc Echocardiogr 2012;25:1099-105.)

Keywords: Mitral regurgitation, MitraClip, Left ventricular remodeling

Mitral regurgitation (MR), the second most common valvular disease in Europe, has become progressively more prevalent.[1] The disorder commonly evolves insidiously over many years, owing to the heart's ability to adapt to chronic volume overload, leading to significant hemodynamic and structural changes in the case of severe MR. Persistent severe MR negatively affects left ventricular (LV) and atrial chamber geometry and function, predicting poor clinical outcomes.[2-7]

Effective mitral valve surgical repair, decreasing the LV volume overload, has been shown to result in reverse LV and/or left atrial remodeling in most patients.[8,9] Percutaneous mitral valve repair has been shown to be associated with favorable clinical outcomes in high-risk patients with functional or degenerative MR.[10-15] Only a few detailed data on left cardiac chambers reverse remodeling after percutaneous mitral valve repair in high-risk patients are available.[14,15]

In the present study, LV and left atrial remodeling after percutaneous mitral valve repair with the MitraClip system (Abbott, Abbott Park, IL) was assessed in a cohort of high surgical risk patients with moderate-to-severe or severe MR.

METHODS

This was a prospective observational study of consecutive high surgical risk patients with moderate-to-severe or severe MR who underwent percutaneous mitral valve repair with the MitraClip system at our institution from October 2008 to March 2011.

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0894-7317/$36.00

http://dx.doi.org/10.1016/j.echo.2012.07.015

Abbreviations

EROA = Effective regurgitant orifice area

LV = Left ventricular

LVEDVI = LV end-diastolic volume index

LVESVI = LV end-systolic volume index

MR = Mitral regurgitation

Patients with either degenerative (due to intrinsic valvular disease) or functional (without structural abnormalities of the valve and with primary LV dysfunction) MR were included. Patients with previous surgical or percutaneous aortic prosthetic valve implantation were also included. High surgical risk was established by consensus between a local independent cardiologist and a cardiac surgeon that conventional surgery would be associated with excessive morbidity and mortality. The high-risk criteria included the logistic European System for Cardiac Operative Risk Evaluation ≥20%, the presence of comorbidities not included in the European System for Cardiac Operative Risk Evaluation such as hepatic cirrhosis, systemic autoimmune disease, severe renal failure requiring hemodialysis, or any contraindication to extracorporeal circulation (e.g., pre-existing cancer, pulmonary or cerebral disease), as previously reported.[11]

All enrolled patients underwent transthoracic two-dimensional echocardiography (Philips X5-1 Transducer, Siemens Acuson Sequoia 5V2 Ultrasound Probe, Siemens, Munich, Germany) at 6 months after the procedure of percutaneous mitral valve repair. The evaluated parameters were compared with the baseline echocardiographic assessments. Although the confidence of interpretation concerning mitral valve pathologic features and catheter-clip system location has been shown to be enhanced by combining two- and three-dimensional imaging modalities, the data presented in our study refer exclusively to two-dimensional echocardiography, because only patients enrolled during the past year were evaluated with both two- and three-dimensional echocardiographic imaging technologies.[16] The baseline and follow-up functional status, assessed according to the New York Heart Association criteria, was also reported. The local ethics committee approved the present study, and all patients provided written informed consent.

All echocardiographic assessments were performed by 2 experienced echocardiographers. The presence of MR at baseline was qualified by color Doppler and quantified by the vena contracta width and the proximal isovelocity surface area method in accordance with the American Association of Echocardiography recommendations.[17] All patients were assigned a MR severity score of 1 (mild), 2 (mild to moderate), 3 (moderate to severe), or 4 (severe), according to the quantitative measure of the effective regurgitant orifice area (EROA) and regurgitant volume.[17] The EROA was obtained using the proximal isovelocity surface area method; the area of interest was optimized by lowering the imaging depth and reducing the Nyquist limit to 15–40 cm/sec; the proximal isovelocity surface area radius was measured at mid-systole using first aliasing and EROA was calculated using the standard formula. The regurgitant volume was estimated as the EROA multiplied by the velocity time integral of the regurgitant jet. After the intervention, MR severity was assessed using the technique reported by Foster *et al.*[18] Device success was defined as clip implantation with reduction of the MR severity score to 2 or less.

To evaluate the LV changes in size and function, the following parameters were considered: LV end-diastolic and end-systolic volume index (LVEDVI and LVESVI, respectively), calculated using the Simpson method from the apical biplane imaging windows; the LV sphericity index, measured using the LV short/long axis dimension ratio in the end-diastolic four-chamber apical view; and the LV ejection fraction, obtained using the biplane Simpson method. Reverse LV remodeling was defined as a decrease of 10% in the LVEDVI. Reverse remodeling of the atrial chamber was evaluated using the left atrial volume index and was measured from a single-plane apical imaging window.

Continuous variables are presented as the mean ± SD or median and interquartile range and were compared using Student's *t* test or the Mann-Whitney rank sum test for unpaired comparisons, as appropriate, and the Wilcoxon rank sum test for paired comparisons. The mean differences between the baseline and 6-month echocardiographic parameters are reported. The categorical variables are expressed as counts and percentages and were compared using the χ^2 test or Fisher exact test, as appropriate. Correlations between the echocardiographic measurements were tested, and only those statistically significant are reported, providing the Spearman correlation coefficient. Differences were considered statistically significant when $P < .05$. Statistical analyses were performed using the Statistical Package for Social Sciences, version 17.0 (SPSS, Chicago, IL).

RESULTS

Of the 49 patients undergoing percutaneous mitral valve repair with the MitraClip system, 5 died within 6 months of the procedure of noncardiac causes (Table 1). The 44 patients surviving at the 6-month follow-up point were evaluated in the present analysis. Of the 44 patients, MR was classified as degenerative in 14 and functional in 30 (Figure 1). The clinical baseline characteristics of the overall population and subgroups according to MR etiology are presented in Table 2. The mean age of all included patients was 71.9 ± 11 years, and for most (84.1%), the New York Heart Association class was III/IV. One clip was implanted in 65.9% of patients, with 2 clips used in the remaining patients. According to the provided definition, in no case was clip implantation unsuccessful.

The patients with functional MR, compared with those with degenerative MR, were more often men (83.3% vs 57.1%, $P = .06$), more often had diabetes (46.6% vs 0%, $P = .002$), and had a significantly greater prevalence of LV ejection fraction less than 30% (26.7% vs 0%, $P = .04$; Table 2). In addition, in patients with functional MR, the baseline LVEDVI, LVESVI, and sphericity index were significantly greater than those in patients with degenerative MR (Table 2).

Results at Follow-Up

Regarding left chamber remodeling, in the overall population, the 6-month echocardiograms showed significant reductions in the sphericity index and in the degree of MR compared with the baseline echocardiograms (Figure 2). The individual sphericity index values for all the evaluated patients are shown in Figure 3A. The 6-month sphericity index correlated positively with the baseline LVEDVI ($r = 0.633$, $P < .001$; Figure 4). Significant reductions in LVEDVI and LVESVI were observed (Figure 5A,B). The LV ejection fraction increased from 38.0% (interquartile range 30.0–55.0) to 46.0% (interquartile range 35.0–58.0; $P < .001$), with a more than 5% absolute increase occurring in 48% of the overall population. The individual ejection fraction values of all evaluated patients are shown in Figure 3B. The pulmonary artery pressure decreased from 45.0 mm Hg (interquartile range 40.0–54.5) to 35.0 mm Hg (interquartile range 33.2–45.0; $P < .001$). Reverse remodeling, according to the specified definition, was observed in 77.3% of all patients.

The significant changes detected in the overall population were also confirmed within both the degenerative and the functional MR