Echocardiographic Follow-up of Robotic Mitral Valve Repair for Mitral Regurgitation due to Degenerative Disease

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Abstract

Background: Mitral valve (MV) repair can now be carried out through small incisions with the use of robotic assistance. Previous reports have demonstrated the excellent clinical result of robotic MV repair for degenerative mitral regurgitation (MR). However, there has been limited information regarding the echocardiographic follow-up of these patients. The present study was therefore to evaluate the echocardiographic follow-up outcomes after robotic MV repair in patients with MR due to degenerative disease of the MV.

Methods: A retrospective analysis was undertaken using data from the echocardiographic database of our department. Between March 2007 and February 2015, 84 patients with degenerative MR underwent robotic MV repair. The repair techniques included leaflet resection in 67 patients (79.8%), artificial chordae in 20 (23.8%), and ring annuloplasty in 79 (94.1%). Eighty-one (96.4%) of the 84 patients were eligible for echocardiographic follow-up assessment, and no patients were lost to follow-up.

Results: At a median echocardiographic follow-up of 36.0 months (interquartile range 14.3–59.4 months), four patients (4.9%) developed recurrent mild MR, and no patients had more than mild MR. Mean MR grade, left atrial diameter (LAD), left ventricular end-diastolic diameter (LVEDD), and left ventricular ejection fraction (LVEF) were significantly decreased when compared with preoperative values. Mean MR grade decreased from 3.96 ± 0.13 to 0.17 ± 0.49 (Z = −8.456, P < 0.001), LAD from 43.8 ± 5.9 to 35.5 ± 3.8 mm (t = 15.131, P < 0.001), LVEDD from 51.0 ± 5.0 to 43.3 ± 2.2 mm (t = 14.481, P < 0.001), and LVEF from 67.3 ± 7.0% to 63.9 ± 5.1% (t = 4.585, P < 0.001).

Conclusion: Robotic MV repair for MR due to degenerative disease is associated with a low rate of recurrent MR, and a significant improvement in MR grade, LAD, and LVEDD, but a significant decrease in LVEF at echocardiographic follow-up.

Key words: Degenerative Disease; Mitral Regurgitation; Mitral Valve Repair

Introduction

Degenerative disease of the mitral valve (MV) is the most common etiology of mitral regurgitation (MR) requiring surgery.[1] The most common finding in patients with degenerative MV disease is leaflet prolapse due to elongation or rupture of the chordae, resulting in varying degrees of MR.[2] Degenerative MV disease is recognized as an important cause of cardiovascular morbidity and mortality in patients with significant MR.[2]

MV repair is the optimal surgical treatment for patients with severe MR due to degenerative disease.[3] Conventional MV repair has been fulfilled through a median sternotomy under direct vision, which provides generous surgical exposure and allows ample access to all cardiac structures and proximal great vessels. However, it carries the disadvantage of disrupting the integrity of the chest wall and causing significant surgical trauma. Minimally invasive MV surgery continues to evolve as a treatment option. Today, MV repair can be carried out through small incisions with the use of robotic assistance.[4] The main advantages of this approach are represented by better cosmetic results, minimized surgical trauma, reduced postoperative pain, and faster recovery.[5]

Previous reports have demonstrated the excellent clinical result of robotic MV repair for degenerative MR.[6,7]
However, there has been limited information regarding the echocardiographic follow-up of these patients. The present study was therefore to evaluate the echocardiographic follow-up outcomes after robotic MV repair in patients with MR due to degenerative disease of the MV.

**Methods**

**Patients**

A retrospective analysis was undertaken using data from the echocardiographic database of the department of cardiovascular surgery of Chinese People’s Liberation Army (PLA) General Hospital. Between March 2007 and February 2015, a total of 112 consecutive patients with MR underwent isolated primary robotic MV repair at Chinese PLA General Hospital. Patients with MR of etiologies other than degenerative (rheumatic in 3 patients, congenital in 11, and infective in 14) were excluded from the study. The remaining 84 patients with robotic MV repair for degenerative MR formed the study cohort of this analysis. Seventy-seven patients (91.7%) of the 84 patients had severe MR. Coronary angiography was conducted in the patients older than 40 years to rule out the significant coronary disease. Computed tomography of the aorta and ultrasound of the femoral and carotid vessels were conducted routinely in all patients to rule out significant arteriosclerosis. We retrospectively analyzed all relevant medical record and echocardiographic data gathered prospectively for the cohort of interest. The study was approved by the Ethics Committee, and written informed consent was obtained from all patients.

**Surgical procedure**

All procedures were carried out with peripheral cardiopulmonary bypass (CPB), transthoracic aortic cross-clamp, and antegrade cardioplegia utilizing the da Vinci Si Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) by an experienced surgeon (Gao). Peripheral CPB was established using femoral arterial inflow and kinetic venous drainage using the femoral vein and right internal jugular vein. The MV morphology was analyzed by the surgeon with CPB and cardiopulmonary arrest, according to Carpentier’s pathophysiological triad (etiology, lesions, and dysfunctions) and segmental valve analysis.4,9 Valve repair was done according to Carpentier’s techniques.10 The repair techniques varied according to morphologic findings of the surgeon at the time of operation. All patients received warfarin sodium postoperatively during the first 3 months if in sinus rhythm and permanently if in atrial fibrillation or flutter.

**Echocardiographic examinations and follow-up**

Serial echocardiographic examinations and follow-up were accomplished by the same echocardiographer (Wang) using the same commercially available GE Vivid 7 Dimension Imaging System (GE Healthcare, Horten, Norway) equipped with M3S and 6T transducers (before December, 2009) or the Philips iE33 Ultrasound System (Philips Medical Systems, Andover, MA, USA) equipped with S5-1 and X7-2t matrix array transducers (after January, 2010). Preoperative transthoracic echocardiography (TTE) was achieved within 1 week prior to robotic MV repair. The MV morphology was analyzed by TTE according to the same criteria as by the surgery. The severity of MR, left atrium dimension (LAD), left ventricular end-diastolic dimension (LVEDD), and left ventricular ejection fraction (LVEF) was evaluated according to published guidelines.11,12 Intraoperative transesophageal echocardiography (TEE) was done during the operation. Before CPB, TEE was used to reassess MV, and after weaning from CPB, to assess the competency of valve repair, determine the mechanism and severity of any residual MR, and to exclude clinically significant mitral stenosis, systolic anterior motion (SAM) of the MV or other procedure-related complications.13 Predischarge TTE was used within 1 week after surgery to reassess the competency of valve repair. Echocardiographic follow-up was conducted at 6 and 12 months after the procedure through direct contact with patients in our outpatient clinic, where TTE was done together with clinical assessment. Subsequent echocardiographic follow-up was done every 1–2 years or when clinically indicated. Whenever the report from an outside hospital indicated the presence of MR, the study was repeated in our outpatient clinic. The severity of MR, LAD, LVEDD, and LVEF was evaluated by follow-up TTE according to the same criteria as by preoperative TTE. All echocardiographic data were entered prospectively into the echocardiographic database of our department. Echocardiographic follow-up data (defined as > or = 6 months) were analyzed on the basis of the records. The follow-up for this study was closed on August 31, 2015.

**Statistical analysis**

Data were expressed as mean ± standard deviation (SD) for continuous normally distributed variables as median (interquartile range) for continuous nonnormally distributed data and as frequencies and/or percentages for categorical data. Analysis of normality was made with the Kolmogorov-Smirnov. The severity of MR by follow-up TTE was compared with that by preoperative TTE using Wilcoxon signed rank test. Patient’s LAD, LVEDD, and LVEF were compared with baseline preoperative measurements by the paired Student’s t-test. P < 0.05 was considered significant. All analyses were made using the SPSS for Windows version 18.0.1 (SPSS, Inc., Chicago, IL, USA).

**Results**

**Baseline characteristics**

The baseline characteristics of participants are summarized in Table 1. Of the 84 patients undergoing robotic MV repair for MR due to degenerative disease of the MV, there were 60 (71.4%) men and 24 (28.6%) women. Age ranged from 21 to 70 years (mean 47.8 ± 11.9 years). Body surface area 1.41–2.39 m² (mean 1.81 ± 0.20 m²). Twelve patients (14.4%) had preoperative atrial fibrillation. On preoperative TTE, the severity of MR was graded as severe in 77 patients (91.7%).
Procedural outcomes

The MV morphology analysis by echocardiography or by surgical inspection during the operation is summarized in Table 2. Valve analysis showed that the etiology of MR was degenerative in the 84 patients, the type of valve dysfunction and the corresponding valvular lesions were Type II dysfunction (leaflet prolapse) in all 84 patients (55 owing to chordae rupture, 28 chordae elongation, and 1 chordae rupture plus elongation). The leaflet prolapse involved the posterior leaflet in 66 patients (78.6%), the anterior leaflet in 11 (13.1%), and both leaflets in 7 (8.3%).

The operative procedures carried out are summarized in Table 3. Of the 84 patients, there were no intraoperative conversions to a sternotomy. The repair techniques included leaflet resection in 67 patients (79.8%), artificial chordae in 1 (1.2%), and both leaflets in 7 (8.3%).

Table 1: Baseline clinical characteristics of the patients undergoing robotic MV repair (n = 84)

| Characteristic       | Value                     |
|----------------------|---------------------------|
| Age (years)          | 47.8 ± 11.9 (21–70)       |
| Gender, n (%)        |                           |
| Male                 | 60 (71.4)                 |
| Female               | 24 (28.6)                 |
| Body surface area (m²) | 1.81 ± 0.20 (1.41–2.39)  |
| Moderate to severe MR (%) | 7 (8.3)               |
| Severe MR, n (%)     | 77 (91.7)                 |
| Coronary artery disease | 0 (0)                  |
| (older than 40 years) |                           |
| Preoperative atrial fibrillation, n (%) | 12 (14.4)               |

Data are expressed mean ± SD (range) or frequency (percentage).

Table 2: The MV analysis of the patients undergoing robotic MV repair by echocardiography or by surgical inspection (n = 84), n (%)

| Characteristic                          | Value                     |
|-----------------------------------------|---------------------------|
| Etiology of MR                          |                           |
| Degenerative                            | 84 (100)                  |
| Types of dysfunction and valvular lesions |                           |
| Type II (leaflet prolapse)              | 84 (100)                  |
| Chordae rupture                         | 56 (66.7)                 |
| Chordae elongation                      | 28 (33.3)                 |
| Localization of prolapse leaflet        |                           |
| Single P1                               | 4 (4.8)                   |
| Single P2                               | 44 (52.4)                 |
| Single P3                               | 17 (20.2)                 |
| Single A1                               | 0 (0)                     |
| Single A2                               | 2 (2.4)                   |
| Single A3                               | 8 (9.5)                   |
| A >1 (>1 segment involved)              | 1 (1.2)                   |
| P >1 (>1 segment involved)              | 1 (1.2)                   |
| A + P                                   | 7 (8.3)                   |

A: Anterior leaflet; A1, A2, and A3: Lateral, middle, and medial third of the anterior leaflet; MV: Mitral valve; MR: Mitral regurgitation; P: Posterior leaflet; P1, P2, and P3: Lateral, middle, and medial scallops of the posterior leaflet.

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reported the rate of recurrence of MR in long-term follow-up after robotic MV repair. Chitwood et al. reported at a mean echocardiographic follow-up time of 815 ± 459 days (n = 279) that 68.8% had no or trace MR, 23.6% had mild MR, 5.3% had moderate MR, and 2.2% had severe MR. Our results were better than those reported in the previous study. These differences are likely related to patients’ selection. Recurrent MR is a potential problem in patients with degenerative MV disease after initial adequate repair because this disease is progressive and MV repair does not cure the degenerative process. Patients with isolated anterior leaflet prolapse had an increased risk of reoperation when compared with those with posterior leaflet prolapse.

In our series, follow-up echocardiography shows that mean MR grade, LAD, and LVEDD were significantly decreased as compared to preoperative values. These findings are in concordance with the previous reports from conventional MV repair. Chronic degenerative MR is often associated with volume overload resulting in dilatation (remodeling) of the left atrial and left ventricular. Successful MV repair result in significant reduction of MR grade and has been shown to induce improvement of LAD and LVEDD at follow-up because of correction of the volume overload.

The present study shows that the decrease in LVEF was also a statistically significant finding in our series and is in keeping with previous reports from conventional MV repair. Thus, the ability to perform robotic MV repair should regard a potential LV dysfunction. This complication is associated with poor postoperative prognosis and should be taken into account in the clinical decision-making process.

There are several limitations to this study. First, it is a retrospective study. Although all of the echocardiographic data are gathered prospectively, patients had to be retrospectively contacted. Second, this is a single-center observational analysis without comparison with sternotomy experience other than historical data. Most patients were referred specifically for a robotic MV operation, which precluded the option of randomization. Third, all the operations were carried out by an experienced surgeon (Gao) and therefore the results might not be generalizable.

In conclusion, robotic MV repair for MR due to degenerative disease is associated with a low rate of recurrent MR, and a significant improvement in MR grade, LAD, and LVEDD, but a significant decrease in LVEF at echocardiographic follow-up.

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Conflicts of interest
There are no conflicts of interest.

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