Echocardiographic assessment of mitral durability in the late period following mitral valve repair: Minithoracotomy versus conventional sternotomy

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Objective: To compare the long-term echocardiographic mitral valve (MV) durability after MV repair performed through a minithoracotomy versus conventional sternotomy.

Methods: A total of 299 patients who underwent MV repair for degenerative mitral regurgitation (MR) through minithoracotomy (n = 179) or sternotomy (n = 120), between April 2004 and January 2010, were evaluated. To adjust the differences in baseline characteristics between the 2 groups, weighted Cox proportional-hazards regression models and inverse-probability-of-treatment weighting were used.

Results: There were no 30-day deaths in both groups and no significant differences in early complication rates. Clinical follow-up was complete in 294 patients (98.3%), with a median follow-up of 55.4 months (interquartile range, 34.4-66.9 months), during which there were 10 late deaths, 2 strokes, and 3 reoperations for recurrent MR. After adjustment, the minithoracotomy group had similar risks for major adverse cardiac events (hazard ratio, 0.77; 95% confidence interval, 0.22-2.68; $P = .68$). Echocardiographic evaluation in the late period (>6 months) was possible in 292 patients (97.7%), with a median follow-up of 29.4 months (interquartile range, 13.3-49.7 months), during which 21 patients (12 in the minithoracotomy group and 9 in the sternotomy group) experienced significant MR (>2+). Freedom from significant MR at 5 years was 86.1% ± 4.8% versus 85.3% ± 5.5% ($P = .63$). After adjustment, the minithoracotomy group had similar risks for significant MR (hazard ratio, 0.81; 95% confidence interval, 0.31-2.14; $P = .67$).

Conclusions: A minithoracotomy approach for MV repair showed comparable clinical outcomes and efficacy to conventional sternotomy for MV repair. (J Thorac Cardiovasc Surg 2014;147:1547-52)

Minimally invasive cardiac surgery (MICS) techniques for mitral valve (MV) repair have advanced during the past decade, and favorable results have been reported. Several single institutional studies have shown excellent clinical outcomes of the MICS approach, such as comparable short- and long-term mortality/morbidity, reduced sternal complications, and shortening of duration of ventilation and intensive care unit (ICU) and hospital stays.[1-5] A recent consensus statement of the International Society of Minimally Invasive Surgery 2010 also documented that MICS enables complex valve surgery to be performed, with results equivalent to those of conventional valve surgery in experienced centers[6]; a systemic review of the literature with a meta-analysis of all important series has been published.[7] However, limited data have been available regarding the long-term efficacy of MV repair performed with MICS techniques. Although there have been several reports focused on comparing the long-term freedom from reoperation between MICS and sternotomy, few studies demonstrated the long-term quality of the repaired MV (regurgitation or stenosis) and freedom from significant MR based on long-term regular echocardiographic follow-up.[8-10] In addition, previous studies have limitations for comparing outcomes between 2 groups, with significant differences in baseline characteristics. We, therefore, sought to compare the long-term clinical and echocardiographic outcomes of MV repair performed through a minithoracotomy versus a traditional sternotomy in a homogeneous population with degenerative MR using inverse-probability-of-treatment weighting (IPTW) to reduce baseline differences.

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METHODS

Study Population

From April 2004 to January 2010, a total of 544 patients underwent MV repair for degenerative MR at Asan Medical Center (Seoul, Korea). Patients with combined aortic valve diseases, coronary diseases, and aortic diseases were excluded. Patients who underwent previous cardiac surgery were also excluded. However, patients with combined tricuspid regurgitation or atrial fibrillation (AF) were not excluded. Finally, a total of 299 patients who underwent MV repair for degenerative MR, with or without concomitant tricuspid annuloplasty or AF ablation, were identified and

Abbreviations and Acronyms
AF = atrial fibrillation
ICU = intensive care unit
IPTW = inverse-probability-of-treatment weighting
LA = left atrial
MICS = minimally invasive cardiac surgery
MR = mitral regurgitation
MV = mitral valve

were divided into 2 groups, a minithoracotomy group (n = 179) and a sternotomy group (n = 120). A video-assisted MICS technique for MR had been performed by a single surgeon (J.W.L.) for patients with degenerative MR in the absence of risk factors for the MICS approach, such as peripheral arterial obstructive disease or a severely tortuous abdominal aorta, difficult chest wall shape for port access surgery (eg, funnel chest), or difficulty in single-lung ventilation as the result of poor lung function. In addition, if a patient had preoperative AF with the high risk factors for ablation failure, such as giant left atrial (LA) size, low ejection fraction, or long-standing persistent AF with a fine wave, a median sternotomy approach was favored to routinely obliterate or resect LA auricle to prevent thromboembolism. The decision between MICS and conventional sternotomy depended primarily on the patient's condition and the patient's preference, based on the informed consent. We retrospectively reviewed patients' preoperative characteristics and early and late clinical and echocardiographic outcomes.

This study was approved by our institutional Ethics Committee/Review Board (Institutional Review Board No. 2011-0981), which waived the requirement for informed patient consent because of the retrospective nature of this study.

Surgical Procedures

The sternotomy approach used conventional ascending aorta and bicaval cannulation, whereas the minithoracotomy involved peripheral cannulation through the right internal jugular vein and right femoral artery and vein. In the minithoracotomy approach, a 4- or 5-cm horizontal incision was made over the fourth intercostal space between the anterior and median axillary lines and a thoracoscope was inserted through a 1-cm port at the third right intercostal space on the median axillary line (Figure 1). Details of these procedures have previously been described.[11] Myocardial protection during conventional sternotomy was achieved with antegrade and retrograde tepid blood cardioplegia and during the minithoracotomy approach with antegrade cold crystalloid cardioplegia. After cardioplegic arrest and aortic crossclamping, the MV was exposed through an interatrial groove. Concomitant maze procedures were performed in 83 patients (27.8%), for whom a modification of the maze procedure was performed.[12]

Echocardiographic Evaluation

All patients underwent 2-dimensional echocardiographic analysis and Doppler color-flow imaging using a Hewlett-Packard Sonos 2500 or 5500 imaging system equipped with a 2.5-MHz transducer (Hewlett-Packard, Andover, Mass) within 2 months before the operation. Preoperative transesophageal echocardiography was also performed for more accurate analysis of MV morphology. MR was detected and semiquantitatively graded as trace, mild, moderate, or severe using color Doppler flow imaging.[13]

Follow-up

Data were obtained until July 2011 during biannual visits to the outpatient clinic. *Early mortality* was defined as death within 30 days of surgery. Data on vital status, dates of death, and causes of death were obtained from the Korean national registry of vital statistics. *Major adverse cardiac event* was defined as all-cause death or valve-related complication, the latter of which included thromboembolism, reoperation, infective endocarditis, or warfarin-related hemorrhage.

Statistical Analysis

Categorical variables were presented as frequencies and percentages, and continuous variables were expressed as mean ± SD or medians with ranges. Differences in baseline characteristics between patients in the minithoracotomy group and those in the sternotomy group were compared using the *t*-test or the Mann-Whitney *U* test for continuous variables and the χ^2 test or Fisher exact test for categorical variables, as appropriate. To reduce the impact of treatment selection bias and potential confounding in an observational study, we performed rigorous adjustment for significant differences in patient characteristics by using Cox proportional-hazards regression models and IPTW.[14-16] With this technique, weights for patients undergoing MV repair through a minithoracotomy were the inverse of propensity score, and weights for patients with conventional sternotomy were the inverse of 1 – propensity score. Stabilized weights were used to reduce the weights of either those treated subjects with low propensity scores or those untreated subjects with high propensity scores.[17] The propensity scores were estimated by multiple logistic regression analysis.[14] All prespecified covariates were included in full nonparsimonious models for the minithoracotomy group versus the sternotomy group (Table 1). The discrimination and calibration abilities of each propensity score model were assessed by C statistics and the Hosmer-Lemeshow test. The model was well calibrated (Hosmer-Lemeshow test, $P = .12$) with reasonable discrimination (C statistic, 0.73). Results were expressed as hazard ratio (HR) with 95% confidence intervals. All reported *P* values are 2 sided, and values of $P < .05$ were considered to indicate statistical significance. All statistical analyses were performed using SPSS, version 18.0 (IBM, Armonk, NY) and R, version 2.15.1 (http://www.r-project.org).

RESULTS

Baseline Characteristics and Operative Data

Baseline characteristics of the patients are shown in Table 1. Before adjustment, the proportions of preoperative New York Heart Association classification III/IV, AF, and significant tricuspid regurgitation were higher in the sternotomy group. Preoperative LA dimension and estimated pulmonary artery systolic pressure (tricuspid valve pressure gradient) were also higher in the sternotomy group. After adjustment with the use of IPTW, the significant differences in baseline characteristics between the 2 groups were well balanced (Table 1).

The cardiopulmonary bypass time was 131.7 ± 38.5 minutes in the minithoracotomy group and 126.6 ± 43.2 minutes in the sternotomy group ($P = .30$), and the aortic crossclamp times were 84.3 ± 28.7 and 80.5 ± 32.0 minutes, respectively ($P = .39$). Concomitant maze procedures were conducted in 24.6% of patients in the minithoracotomy group and in 32.5% of patients in the sternotomy group ($P = .15$). Except for the performance of concomitant tricuspid annuloplasty, other operative variables were not significantly different (Table 2).

Clinical Outcomes

There were no early deaths in either group and no differences in immediate postoperative complications (Table 3). The lengths of hospital stay and ICU stay of the