One thousand minimally invasive mitral valve operations: Early outcomes, late outcomes, and echocardiographic follow-up

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Objective: The present study assessed the clinical and echocardiographic outcomes for 1000 patients undergoing minimally invasive mitral valve surgery.

Methods: The Brigham Cardiac Valve database was reviewed. From August 1996 to November 2011, 1000 patients had undergone minimally invasive mitral valve surgery (median follow-up, 7 years). Data on the surgical approach, complications, reoperations, and late survival were tabulated. Late echocardiographic data on the recurrence of mitral regurgitation after mitral repair in myxomatous disease were also collected. Survival, freedom from reoperation and recurrent mitral regurgitation (grade $\geq$ 3+) were evaluated with life tables and Kaplan-Meier analyses.

Results: The mean patient age was 57 years. Of the 1000 patients, 41% were women. Myxomatous degenerative disease was the predominant pathologic entity (86%). A lower hemisternotomy was the predominant surgical approach (75%). Mitral repair was performed in 923 patients and replacement in 77. Eight operative deaths (0.8%) occurred. A total of 44 patients with failed mitral repairs underwent reoperation, with 1 mitral valve replaced again on the same operative day for atrioventricular groove disruption. Nine failed repairs were repaired again (9/44 [20%]). A total of 106 late deaths occurred. The overall survival at 15 years was 79% $\pm$ 3%. Freedom from reoperation at 15 years was 90% $\pm$ 3% for repairs and 100% for replacements. Late echocardiograms were acquired for 615 of 815 eligible mitral repair patients with myxomatous disease (75%). Freedom from recurrent mitral regurgitation (grade $\geq$ 3+) at 1, 5, and 10 years was 99% $\pm$ 1%, 87% $\pm$ 2%, and 69% $\pm$ 4%, respectively.

Conclusions: Minimally invasive mitral valve surgery is effective, with excellent late results. The durability of minimally invasive mitral valve repair compared favorably with conventional full sternotomy methods at late follow-up. (J Thorac Cardiovasc Surg 2013;145:1199-206)

ACD

Minimally invasive mitral valve surgery (mini-MVS) has been in use for 15 years.[1,2] Built on the premise that less invasive surgery could expedite postoperative recovery owing to a reduction in surgical trauma with limited access techniques, resulting in reduced hospital stays, reduced hospital costs, improved cosmesis, and increased patient satisfaction, mini-MVS continues to be steadily adopted, with more and more advocates over time.[3] At its inception, mini-MVS focused solely on smaller incisions, specifically the parasternal incision, and upper and lower hemisternotomy. Although the parasternal approach has fallen out of favor, the upper and lower hemisternotomy continue to be used by many, along with the now predominant approach at most centers, the small right anterior thoracotomy. In conjunction with these techniques, robotics and thoracoscopic instruments have gradually been introduced as adjuncts to further minimize the surgical trauma and have been championed at select cardiac centers.[4,5] A multitude of studies have supported the safety of mini-MVS in the immediate postoperative period, and a few select case series have shown excellent midterm outcomes with these techniques.[1-9] However, data to assess the long-term outcomes with mini-MVS remain relatively sparse. Although establishing the safety of mini-MVS is pertinent, the true testament to its continued assimilation will be twofold: (1) to ensure that limited exposure with mini-MVS is not a direct cause for mitral valve replacement instead of mitral valve repair in patients for whom repair would clearly be the preferred therapy; and (2) to ensure the long-term mitral valve durability is on par with that achieved using conventional full sternotomy methods. If the perceived early benefits of mini-MVS are achieved at the expense of a greater propensity to replace complex regurgitant valves that would otherwise have been repaired, or at the expense of a greater reoperation rate secondary to subpar repair durability, the minimally invasive techniques

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Abbreviations and Acronyms
mini-MVS = minimally invasive mitral valve surgery
MR = mitral regurgitation

will be counterproductive and arguably unwarranted. In an effort to critically appraise the long-term clinical and echocardiographic results with mini-MVS, we report on a consecutive series of 1000 patients who had undergone mitral valve surgery using minimally invasive techniques at the Brigham and Women's Hospital during a 15-year period.

METHODS

The present study was a retrospective, observational review of all patients who underwent a minimally invasive mitral valve procedure from July 1, 1996 to November 30, 2011. The institutional review board approved the study and waived patient consent.

The patient demographics, medical history, and operative and in-hospital outcomes were collected at each patient's admission and at each consecutive follow-up visit. The data were coded according to the defined definitions of the Society of Thoracic Surgeons Adult Cardiac Database, version 2.52. Long-term mortality was documented through to December 31, 2011, with a review of the data collected from routine clinic follow-up visits, in addition to a query of the Social Security Death Index. Data on late reoperations or reintervention were similarly sought through routine clinic follow-up visits, periodic patient questionnaires, and contact with the primary care practitioners or referring cardiologists. The main outcomes of interest were early and late mortality, mitral valve-related reoperations, and the recurrence of moderate (grade 3+) or severe (grade 4+) mitral regurgitation (MR). The postoperative in-hospital morbidity data for stroke, reoperation for bleeding, permanent pacemaker insertion, deep sternal wound infection, new-onset atrial fibrillation, renal failure, and packed red blood cell transfusions were also assessed.

Late follow-up echocardiograms (defined as ≥6 months) were sought for all eligible patients with myxomatous degenerative disease who had undergone minimally invasive mitral valve repair. Late echocardiograms absent from the Brigham Cardiac Valve database were obtained from the primary care practitioners or referring cardiologists, when available. When assessing late MR recurrence, the echocardiogram on file that was farthest from the initial surgery or, in the case of reoperation, the echocardiogram immediately before that reoperation, was used. Recurrent MR was defined as moderate or severe on a 4-point scale (1+ [trace], 2+ [mild], 3+ [moderate], and 4+ [severe]). The exclusion criteria for recurrent MR analysis were patients who had undergone mitral valve replacement, patients who had undergone mitral valve repair for a nonmxyomatous etiology, patients with less than 6 months of follow-up because of early death or early reoperation, and patients with less than 6 months from surgery to the start of the study. Of the 923 patients who underwent mitral repair, 108 patients met the exclusion criteria, leaving 815 eligible patients. Of these 815 patients, a late follow-up echocardiogram was acquired in 615 (75%).

Surgical Techniques

Patient selection was predicated by surgeon preference. Absolute contraindications to a minimally invasive approach included surgically significant coronary artery disease, chest wall deformities, and morbid obesity.

Surgical access was predominantly through a lower hemisternotomy. Our technique has been described previously.[10] In brief, a 6-cm skin incision, 2 fingerbreadths distal to the manubrium, was extended distal to a level 2 fingerbreadths proximal to the xiphoid process. A hemisternotomy was performed from the xiphoid to the second intercostal space and extended into the second intercostal space on the right side using an oscillating saw. The ascending aorta was cannulated directly with percutaneous cannulation of the inferior vena cava by way of the femoral vein with the assistance of transesophageal echocardiography.

When using a right anterior thoracotomy, our approach was similar to that described by others,[8] with slight modifications. Access was primarily through the fourth intercostal space by way of a 6-cm skin incision made either just below the nipple or within the inframammary crease for men and women, respectively. Cardiopulmonary bypass was initiated by way of the femoral artery and vein cannulation through a small transverse incision in the groin. An 8-mm tube graft was sewn to the femoral artery and attached to the arterial cannula, and the femoral vein was percutaneously accessed and guided up to the inferior vena cava–right atrial junction, again with transesophageal echocardiography guidance. Percutaneous cannulation of the superior vena cava was also instituted to maximize venous drainage. The aorta was crossclamped using the flexible Cosgrove aortic clamp (CareFusion V. Mueller, Waukegan, Ill) directly through the thoracotomy incision.

For both approaches, the lower hemisternotomy and right anterior thoracotomy, barring factors that would necessitate access to the right atrium (tricuspid valve pathologic features, patent foramen ovale), the mitral valve is preferentially approached through the interatrial groove. Moreover, undersize (16F-24F) vacuum-assisted cannulas are used with both techniques to optimize exposure and maintain venous drainage. Myocardial protection is primarily through antegrade cardioplegia for both techniques.

Statistical Analysis

All statistical analyses were performed with the assistance of a departmental statistician. Fisher's exact test was used to evaluate the dichotomous variables. *t* Tests with Levine's homogeneity of variance or the Mann-Whitney *U* test were used for continuous variables, as appropriate. Survival and freedom from recurrence of moderate or severe (grade ≥ 3+) MR were evaluated with life tables and Kaplan-Meier analyses. Categorical and dichotomous variables are presented as numbers and percentiles. Continuous variables are presented as the mean ± standard deviation (normally distributed) or median and interquartile range (non-normal distributions). All statistical analyses were performed using SPSS, version 13.0 (SPSS, Chicago, Ill).

RESULTS

A total of 3133-isolated mitral valve surgeries (defined as MVS without coronary artery bypass grafting) were performed from August 1, 1996 to November 30, 2011. Mitral valve reparative techniques were used in 2127 patients (68%), and 1006 underwent mitral valve replacement (32%). Of the patients from this cohort, 1000 (32%) underwent MVS with a minimally invasive approach and were the focus of the present review. Minimally invasive mitral valve repair was the predominant treatment choice (923/1000 [92%]), with a small percentage undergoing minimally invasive mitral valve replacement (77/1000 [8%]). The median cardiopulmonary bypass time for the complete cohort was 118 minutes, and the median crossclamp time was 88 minutes. A single surgeon (L.H.C.) performed 77% of the minimally invasive cases.

The patient demographics are listed in Table 1. The mean age was 57.2 ± 13.4 years, the mean ejection fraction was 62.5% ± 8%, and 408 of the patients were women (41%). Myxomatous degenerative disease was the predominant