Minimally invasive approach provides at least equivalent results for surgical correction of mitral regurgitation: A propensity-matched comparison

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Objective: Minimally invasive approaches to mitral valve surgery are increasingly used, but the surgical approach must not compromise the clinical outcome for improved cosmesis. We examined the outcomes of mitral repair performed through right minithoracotomy or median sternotomy.

Methods: Between January 2002 and October 2011, 1011 isolated mitral valve repairs were performed in the University of Pennsylvania health system (455 sternotomies, 556 right minithoracotomies). To account for key differences in preoperative risk profiles, propensity scores identified 201 well-matched patient pairs with mitral regurgitation of any cause and 153 pairs with myxomatous disease.

Results: In-hospital mortality was similar between propensity-matched groups (0% vs 0% for the degenerative cohort; 0% vs 0.5%, $P = .5$ for the overall cohort; in minimally invasive and sternotomy groups, respectively). Incidence of stroke, infection, myocardial infarction, exploration for postoperative hemorrhage, renal failure, and atrial fibrillation also were comparable. Transfusion was less frequent in the minimally invasive groups (11.8% vs 20.3%, $P = .04$ for the degenerative cohort; 14.0% vs 22.9%, $P = .03$ for the overall cohort), but time to extubation and discharge was similar. A 99% repair rate was achieved in patients with myxomatous disease, and a minimally invasive approach did not significantly increase the likelihood of a failed repair resulting in mitral valve replacement. Patients undergoing minimally invasive mitral repair were more likely to have no residual post-repair mitral regurgitation (97.4% vs 92.1%, $P = .04$ for the degenerative cohort; 95.5% vs 89.6%, $P = .02$ for the overall cohort). In the overall matched cohort, early readmission rates were higher in patients undergoing sternotomies (12.6% vs 4.4%, $P = .01$). Over 9 years of follow-up, there was no significant difference in long-term survival between groups ($P = .8$).

Conclusions: In appropriate patients with isolated mitral valve disease of any cause, a right minithoracotomy approach may be used without compromising clinical outcome. (J Thorac Cardiovasc Surg 2013;145:748-56)

During the past 20 years, the increasing popularity of less-invasive procedures has affected nearly every surgical specialty, including cardiac surgery. Advancements in imaging, surgical instrumentation, and robotic technology have enabled surgeons to perform complex cardiac surgical procedures through small incisions, often eliminating the need for sternotomy or cardiopulmonary bypass.[1-4] In addition to benefits of improved cosmesis, minimally invasive mitral valve surgery was pioneered with the intent of reducing morbidity, postoperative pain, blood loss, hospital length of stay, and time to return to normal activity.[5,6] Although clinical studies support many of the theoretical advantages of less-invasive approaches to mitral valve surgery, no definitive randomized trial has been conducted to date.[6-12] Treatment allocation bias inherent in retrospective studies begets significant differences in baseline risk profiles of minimally invasive and sternotomy groups, often with the higher-risk patients in the sternotomy cohort. Propensity score analysis helps to control for such bias, but requires a large study population, and only a handful of such studies have been published thus far.[13-17]

Just as novel operative techniques have developed, the management of mitral regurgitation (MR) continues to change as our knowledge of the disease pathophysiology evolves. Treatment paradigms have shifted to identify

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Abbreviation and Acronym
MR = mitral regurgitation

patients earlier in the disease course, before the development of adverse sequelae of long-standing MR on left ventricular function and geometry.[18] In the setting of degenerative mitral valve disease, there exists a growing advocacy for referral of asymptomatic patients for surgery.[18,19] As minimally invasive approaches to mitral valve surgery are increasingly used, and mitral valve repair has now extended to the asymptomatic population, it is essential that the surgical approach not compromise the clinical outcome for improved cosmesis. We sought to compare the early and late outcomes of isolated mitral valve repair performed through right minithoracotomy and median sternotomy at a high-volume academic health system.

MATERIALS AND METHODS

Study Population

Between January 2002 and October 2011, 4241 mitral valve operations were performed within the University of Pennsylvania Health system. The study population was limited to adult patients who underwent isolated mitral valve repair (n = 1011), defined as any mitral valve repair procedure performed in the absence of a major concomitant procedure (eg, coronary bypass, other valve surgery, or aortic surgery). To avoid intention-to-treat selection bias, a subgroup analysis of patients who underwent isolated mitral valve replacement (n = 272) during the same study period also was analyzed. Data were in part retrieved from the University of Pennsylvania's prospective Society of Thoracic Surgeon's registry and partially obtained from each patient's medical record. These data were approved for use in research by the University of Pennsylvania Institutional Review Board with a waiver of patient consent.

Operative Technique

The definition of minimally invasive mitral valve surgery is broad and generally inclusive of any operation performed through less than a conventional median sternotomy. For the purpose of the present study, this definition was narrowed to include only isolated mitral valve repairs performed through a right minithoracotomy. A conventional median sternotomy approach was used in 455 patients (44%), and a minimally invasive approach was used in 556 patients (66%). The main determinant of the surgical approach used was the preference of the patient or referring cardiologist, with absolute contraindications including only severe peripheral arterial disease and high-grade atheroma of the descending aorta.

Minimally invasive mitral valve repair was performed using standardized methods similar to those previously described.[1,3,10,13,20] Briefly, standard monitoring lines are placed and the patient is intubated with a double-lumen endotracheal tube. Before draping, the right internal jugular vein is cannulated with a 16F femoral cannula. Access to the thoracic cavity is achieved via a 4-cm incision in the inframammary groove that is carried through the third or fourth intercostal space. A soft tissue retractor is used to limit rib spreading. Femoral venous cannulation is performed with a 22F or 25F cannula, and femoral arterial cannulation is performed with a 14F, 16F, or 18F cannula depending on body size, or a 21F cannula with a side port if using endoaortic occlusion. The opened pericardium is retracted toward the right. Before cannulation, a complete echocardiographic assessment of the ascending aorta is performed. Cardiopulmonary bypass is initiated, and the heart is arrested with antegrade cold blood cardioplegia. When the heart is accessed through median sternotomy, myocardial protection is achieved with antegrade and retrograde cold blood cardioplegia. Use of retrograde cardioplegia during minimally invasive mitral repair depends on surgeon preference. In approximately 30% of cases, an endoaortic balloon (Edwards Lifesciences, LLC, Irvine, Calif) was used for proximal aortic occlusion. The balloon is positioned under transesophageal echocardiographic guidance just above the sinotubular junction with careful attention paid to bilateral radial artery pressures. Otherwise, central aortic cannulation was performed via the initial thoracotomy incision, and aortic occlusion was accomplished with transthoracic clamping (Chitwood clamp; Scanlan International Inc, Minneapolis, Minn). After cardiac arrest, the left atrium is entered along the interatrial groove. Mitral valve repair is performed using standardized techniques. Carbon dioxide field insufflation and standardized transesophageal echocardiography–guided de-airing techniques are routinely used to help minimize risk of air embolus. After atrial closure and separation from cardiopulmonary bypass, a complete postoperative transesophageal echocardiographic study is recorded. Postrepair echocardiographic data were obtained after incision closure.

Statistical Analysis

Continuous variables are expressed as the mean ± standard deviation, and categorical variables are presented as proportions. Comorbid diagnoses and perioperative outcome variables adhere to the definitions of the Society of Thoracic Surgeons National Database. Differences between groups were assessed using the Fisher exact test for categorical variables, the independent Student *t* test for normally distributed continuous variables, and the Mann–Whitney *U* test for non-normally distributed continuous variables. Survival analyses were performed using Kaplan–Meier survival analysis with log-rank tests. All tests were 2-tailed.

The propensity to undergo minimally invasive mitral valve repair was calculated using multivariable logistic regression to model a dichotomous outcome of minimally invasive or open repair for all patients in the sample, as well as for only patients with degenerative mitral valve disease. Eleven fixed-effect variables were included in the final model (Appendices 1 and 2). Patients with similar propensity scores were matched in a 1:1 nearest neighbor fashion across the total distribution of propensity scores. Although a difference in propensity score less than 0.1 was required for a match, the majority of matches did not approach this limit (median difference, 0.0015; interquartile range, 0.0005-0.008). Matched pairs were identified across a wide range of propensity scores (Figure 1). The statistical analysis was performed using SAS for Windows (SAS Institute, Inc, Cary, NC) and IBM SPSS Statistics for Macintosh, version 19.0 (SPSS, Inc, Armonk, NY).

RESULTS

Baseline demographics and comorbidity profiles are summarized in Table 1. Patients undergoing the minimally invasive procedure were more likely to have less symptomatic MR due to degenerative mitral valve disease, as well as higher ejection fractions and less concomitant tricuspid regurgitation. Fewer patients in the minimally invasive cohort had hypertension, chronic lung disease, or endocarditis. Two separate propensity score analyses were conducted to account for differences in baseline characteristics in the study population: (1) a matched comparison of patients with mitral valve disease of any cause (n = 402) or (2) a matched comparison limited to only patients with degenerative mitral valve disease (n = 306) (Table 2). In both comparisons, matched groups were similar with regard to all preoperative comorbidity, hemodynamic, and demographic categories.