Relationship among surgical volume, repair quality, and perioperative outcomes for repair of mitral insufficiency in a mitral valve reference center

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Objective: Although it has been demonstrated that the repair rates and quality of the repair of mitral insufficiency are superior in mitral valve reference centers, it has not been studied whether an advantage exists for perioperative morbidity and mortality. We report 1 surgeon's evolution over 7 years, specifically considering the changes in perioperative morbidity and mortality.

Methods: We performed a retrospective review of 1054 patients who had undergone elective, day-of-surgery-admission mitral valve repair by a single surgeon (D.H.A.) at our institution from April 2005 to June 2012. The outcome variables studied were operative mortality (30-day or in-hospital mortality, if longer), length of stay, low cardiac output state after cardiopulmonary bypass, and major morbidity.

Results: The overall operative mortality was 0.58%. Of the 1054 patients, 31% developed a low cardiac output state postoperatively and 6.52% experienced at least 1 of the composite morbidity events. Increased aortic crossclamp times were significantly and independently associated with a low cardiac output state, length of stay, and morbidity. When divided by service year, a statistically and clinically significant decrease was found in the aortic crossclamp time, despite an increase in the complexity of cases. The morbidity decreased concurrently with the decreases in crossclamp times.

Conclusions: As the number of mitral valve repairs performed each year by a single surgeon at a single institution increased, morbidity, including postoperative heart function and length of stay, decreased. This was demonstrated to occur in large part from a reduction in the aortic crossclamp times, despite an increase in the complexity of the procedures. This further demonstrates the value of reference centers for mitral valve surgery. (J Thorac Cardiovasc Surg 2014;148:2021-6)

Mitral valve (MV) repair has become the reference standard procedure for degenerative MV disease that requires surgical intervention.[1] Degenerative MV disease is different from other valvular heart diseases because most of the lesions caused by the degenerative changes are amenable to MV repair.[2] Additionally, many surgeons repair MV lesions resulting from other causes such as endocarditis or rheumatic heart disease. MV repair for mitral regurgitation has been associated with excellent long-term survival and remains superior to MV replacement after 10 years to ≤20 years after surgery.[3,4] The guidelines from the American College of Cardiology and the American Heart Association[5] strongly encourage referral to MV reference centers, in particular, for complex repairs, to ensure a successful repair rate of >90%.

Although it has been clearly demonstrated that the repair rates and repair quality are superior in reference centers,[6] it has not been studied extensively whether the immediate perioperative course, in terms of morbidity and mortality, will be better in a reference center. We report 1 surgeon's evolution by examining a consecutive series of patients during a 7-year period, considering the changes in perioperative morbidity and mortality after MV repair.

METHODS

After receiving institutional review board approval, we performed a retrospective review of a prospectively collected departmental database. The database included data from all patients who had undergone elective, day-of-surgery-admission MV repair, either isolated or combined with another procedure, by a single surgeon (D.H.A.) from April 2005 to June 2012. A total of 1054 patients were included in the present study. The medical record were then reviewed to obtain patient demographics and surgical characteristics, including age, weight, height, gender, procedure type, American Society of Anesthesiologists classification, European

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Abbreviations and Acronyms

EuroSCORE = European System for Cardiac Operative Risk Evaluation
ICU = intensive care unit
MV = mitral valve

System for Cardiac Operative Risk Evaluation (EuroSCORE),[7] preoperative cardiac function, other comorbidities, surgical date, type of MV dysfunction, and aortic crossclamp times. The outcome variables studied were operative mortality (30-day or in-hospital mortality, if longer), intensive care unit (ICU) length of stay, low cardiac output state after cardiopulmonary bypass, hospital length of stay, and a composite of major morbidities (because all occurred to infrequently to be analyzed individually) that included major stroke (permanent neurologic deficit), myocardial infarction (new Q waves on electrocardiogram), sternal wound infection, sepsis, reoperation for bleeding, respiratory failure (requiring tracheostomy), renal failure (requiring renal replacement therapy), and gastrointestinal bleeding (requiring transfusion).

For the analysis of the surgery type, the patients were divided into 3 groups. One group consisted of patients who had undergone isolated MV repair. The second group included patients who had undergone MV and tricuspid valve repair. The third group included all patients who had undergone MV repair with or without tricuspid repair combined with any other cardiac operation, including a cryomaze procedure for atrial fibrillation.

For the analysis related to the complexity of MV repair, the patients were divided into 3 categories. Category 1 included patients with Carpentier type I or IIIb dysfunction.[8] Category 2 included all patients with single segment posterior leaflet prolapse. Category 3 included patients with more complex dysfunction, including multisegmental posterior leaflet prolapse, any anterior leaflet prolapse, bileaflet prolapse, Carpentier type IIIa dysfunction (eg, rheumatic heart disease), primary systolic anterior motion, repeat repair of the MV, endocarditis, and complex congenital lesions.

A low cardiac output state after cardiopulmonary bypass was defined by the dose of epinephrine (the standard inotropic medication used at our institution after cardiopulmonary bypass) needed when leaving the operating room. A dose of 50 to 100 ng/kg/min was defined as a mildly impaired cardiac output state, 100 to 150 ng/kg/min was considered moderate, and >150 ng/kg/min was considered severe.

The procedures were performed through a midline approach in nearly all the patients with, predominately, central cannulation for cardiopulmonary bypass. All patients received bicaval venous cannulation. Direct aortic crossclamping and cardioplegic arrest, using cold blood cardioplegia given in both antegrade and retrograde fashion, was used. The cardiopulmonary bypass flow rates were maintained to provide a perfusion index of 2.2 to 2.4 L/min/m^2. The hematocrit was maintained at >18%, and mild hypothermia (34°C) was used. Lower temperatures were only used if the patients required circulatory arrest. The MV was accessed through a left atriotomy by dissection of Sondergaard's groove. The quality of the repair was assessed with saline testing and intraoperative transesophageal echocardiography after separation from cardiopulmonary bypass.

Statistical Analysis

The patient and disease characteristics are presented as percentages, median and interquartile range, or mean ± standard deviation. Univariate analyses of postoperative outcomes were performed for the crossclamp time (grouped as 0-2, 2-3, and >3 hours) and for service year, using chi-square tests or Kruskal-Wallis tests, as appropriate. Covariate-adjusted associations between the crossclamp time and postoperative outcomes were determined using various regression techniques: specifically, logistic regression for the composite of morbidities, linear regression for the dose of epinephrine, and Cox regression for the interval to ICU and hospital discharge. Stepwise forward selection, with both entry and stay criteria set at 0.05, was implemented to identify the most important risk factors for adjustment. The initial list included age, gender, body mass index, service year, EuroSCORE, procedure type, American Society of Anesthesiologists class (≥4 vs ≤3), preoperative medical conditions (eg, hypertension, chronic obstructive pulmonary disease, coronary artery disease, pulmonary hypertension, arrhythmia, and diabetes), right and left ventricular functional grade (ie, mild, moderate, or severe), and crossclamp time. The effects for the crossclamp time are expressed in terms of odds ratios (for the composite of morbidities), change (for epinephrine), and hazard ratios (for ICU and hospital length of stay), with the 95% confidence intervals.

RESULTS

A total of 1054 day-of-surgery-admission patients underwent MV repair by 1 surgeon (D.H.A.) during the study period, with a trend toward an increasing number of annual cases (Table 1). The repair rate was >99.9% for patients presenting for repair. The patient demographics, comorbidities, and surgical characteristics are summarized in Table 2. The overall 30-day mortality rate for the cohort

TABLE 1. Aortic crossclamp times and major morbidity by service year

Variable	2005 (Apr-Dec) (n = 64)	2006 (n = 79)	2007 (n = 128)	2008 (n = 144)	2009 (n = 172)	2010 (n = 170)	2011 (n = 203)	2012 (Jan-Jun) (n = 94)	*P* value
Crossclamp time (min)	179 (140-228)	183 (151-225)	151 (121-184)	140 (115-169)	115 (91-139)	108 (88-135)	94 (76-114)	94 (80-114)	<.001
Operative mortality	1		1		1	1	1	1	NA*
Epinephrine dose (ng/kg/min)	40 (0-80)	50 (0-100)	50 (0-100)	40 (0-80)	45 (0-100)	25 (0-50)	30 (0-70)	30 (0-50)	<.001
Epinephrine dose ≥ 50 ng/kg/min	67	72	56	48	50	45	47	39	<.001
Postoperative adverse event†	4 (6.9)	13 (16.88)	7 (5.56)	11 (8.46)	11 (6.4)	5 (2.94)	13 (6.4)	3 (3.3)	.006
Hospital length of stay (d)	6 (5-8)	7 (5-11)	6 (5-8)	6 (5-7.5)	6 (5-7)	6 (5-7)	7 (5-8)	6 (5-7)	<.001
ICU length of stay (d)	NA	NA	2 (1-3)	2 (1-3)	1 (1-2)	2 (1-2)	2 (1-3)	1 (1-2)	.077

Data presented as median (interquartile range), %, or n (%). *P* values compared the value over time and were based on chi-square test for categorical outcomes and the Kruskal-Wallis test for continuous outcomes. *NA*, Not available; *ICU*, intensive care unit. *Too few deaths to statistically evaluate. †The composite of morbidities included stroke, myocardial infarction, sternal wound infection, sepsis, reoperation for bleeding, respiratory failure (requiring tracheostomy), renal failure (requiring renal replacement therapy), and gastrointestinal bleeding (requiring transfusion).