Trends, clinical outcomes, and cost implications of mitral valve repair versus replacement, concomitant with aortic valve replacement

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Objective: This study evaluated national trends, clinical outcomes, and cost implications of mitral valve (MV) repair, versus replacement, concomitant with aortic valve replacement (AVR).

Methods: Patients who underwent MV surgery concomitant with AVR, between 1999 and 2008, were identified in the Nationwide Inpatient Sample (NIS) registry. Mitral stenosis, endocarditis, and emergency cases were excluded. Inpatient clinical outcomes and costs were compared. Costs were derived using cost-to-charge ratios supplied by the dataset for each individual hospital. Multivariable logistic and linear regression analyses were used for risk adjustment.

Results: A total of 41,417 concomitant cases were identified, of which 11,472 (28%) were MV repairs. Repair rates increased from 15.3% in 1999 to 43.5% in 2008 ($P < .001$). Major postoperative morbidity rates were similar with MV repair, versus replacement, concomitant with AVR (each 29%, $P = .54$). Unadjusted inpatient mortality (7.9% vs 10.1%, $P = .005$); length of hospital stay (median: 8 vs 9 days, $P < .001$); and costs (median: $45,455 vs $49,648, $P < .001$) were lower with MV repair. After risk adjustment, MV repair was associated with lower odds of inpatient mortality, and with lower costs (each $P < .001$).

Conclusions: Mitral valve repair concomitant with AVR is associated with reduced inpatient mortality and costs, compared with MV replacement, supporting its use when technically feasible. Although use has increased substantially, MV repair continues to comprise a minority of concomitant AVR cases, in centers reporting to the NIS registry. Increasing repair rates, particularly in NIS-participating hospitals, seems prudent. (J Thorac Cardiovasc Surg 2015;149:1614-9)

ACD

See related commentary on pages 1620-1.

In isolated mitral valve (MV) surgery, MV repair has been employed with increasing frequency. An analysis[1] of the Society of Thoracic Surgeons (STS) database found that MV repair rates in participating hospitals rose from 51% in 2000 to 69% in 2007. The main advantages of MV repair, compared with replacement, include avoidance of anticoagulation and prosthesis-related complications. In addition, multiple studies have demonstrated that isolated MV repair is a durable operation associated with reduced perioperative mortality and improved long-term survival, compared with replacement.[2-4]

In the setting of MV surgery concomitant with aortic valve replacement (AVR), compared with isolated cases, considerably less evidence is available regarding choice of MV repair versus replacement. Mitral valve surgery concomitant with AVR is less common than isolated MV surgery or AVR, constituting <15% of these cases.[5-7] A recent report using data from the STS registry found that MV repair was associated with lower adjusted odds of operative mortality, compared with MV replacement, in the setting of concomitant AVR.[8] Whether this early survival advantage is demonstrable in other multi-institutional datasets is unclear. In addition, isolated MV repair has been associated with lower inpatient costs, compared with replacement, although the cost benefit in cases concomitant with AVR remain to be elucidated.[9] In this study, we evaluated "real-world" trends, clinical outcomes, and cost implications of MV repair, versus replacement, concomitant with AVR.

METHODS

Data Source

The data source for this study was the Nationwide Inpatient Sample (NIS). The NIS registry contains deidentified patient-level data and is provided as part of the Agency for Healthcare Research and Quality Healthcare Cost and Utilization Project. The database is robust and provides a snapshot of the "real world," containing a 20% stratified sample of all hospitals in the United States. Data on 8 million inpatient hospitalizations from >1050 participating hospitals are included.[10] In addition to patient-level data, operative variables, hospital characteristics, and inpatient cost data are provided.

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Abbreviations and Acronyms
AVR = aortic valve replacement
CABG = coronary artery bypass grafting
MV = mitral valve
NIS = Nationwide Inpatient Sample
STS = Society of Thoracic Surgeons

Study Population

The study population included patients undergoing MV repair or replacement, concomitant with AVR, between January 1, 1999 and December 31, 2008, who are included in the NIS database. Codes from the International Classification of Diseases (9th edition) were used to identify the study cohort. The procedural codes 35.21 and 35.22 were used to identify AVRs. Code 35.12 was used for MV repair, and codes 35.23 and 35.24 were used for MV replacement. To create a homogenous study population that was more likely to be amenable to MV repair, we excluded patients who had mitral stenosis and infected endocarditis, as well as emergency cases.

Baseline Characteristics and Trend Analysis

Baseline characteristics were compared for the cohorts who underwent MV repair, versus replacement, concomitant with AVR. These included: patient demographics; comorbidities; primary insurance type; presence of aortic stenosis; mechanical aortic valve versus aortic bioprosthesis; rheumatic disease; concomitant procedures, including coronary artery bypass grafting (CABG) and tricuspid valve repair and replacement; and hospital characteristics, including teaching status, size, rural versus urban location, and region. In addition, year of operation and surgeon and hospital MV-surgery volume were evaluated. A trend analysis was performed that demonstrated the number of concomitant AVR and MV cases that were comprised of MV repairs per year.

Clinical Outcomes

The primary clinical outcome was inpatient mortality. All causes of death were factored into assessing this outcome. Major postoperative morbidity rates for MV repair versus MV replacement were compared. Complications that were evaluated included: pneumonia, hemorrhage, acute renal failure, stroke, sepsis, gastrointestinal bleeding, wound complication, cardiac shock, and pulmonary embolus. Other clinical outcomes included the need for a postoperative ventricular assist device as postcardiotomy support, a postoperative intra-aortic balloon pump, and permanent pacemaker or automatic internal cardioverter-defibrillator implantation. In addition, length of hospital stay for the 2 groups was compared.

Cost Outcomes

Another principal outcome was inpatient costs of care associated with MV repair, versus replacement, concomitant with AVR. The NIS registry provides total charges for the inpatient stay. Costs are then derived using cost-to-charge ratios that are developed for each individual hospital by the Agency for Healthcare Quality and Research, using Centers for Medicare and Medicaid data. These ratios are used to account for the inherent variability among hospitals and regions in how much is charged for a given procedure. Inpatient costs, rather than charges, were used as the primary economic outcome because costs better reflect actual resource use, whereas charges reflect pricing decisions related to payer policies and other factors that are unrelated to resource use.

Risk-Adjusted Analyses

Multivariable logistic regression analysis was conducted to evaluate the risk-adjusted impact of MV repair on inpatient mortality. All of the baseline variables discussed previously, including the use of concomitant procedures, were evaluated for potential inclusion in the multivariable model. Entry criteria for the multivariable model included an association with inpatient mortality in univariate logistic regression analysis (exploratory P value <.20) and <20% missing data.

In addition, a multivariable linear regression model was created to evaluate the risk-adjusted impact of MV repair on inpatient costs. Again, all of the baseline patient, operative, and hospital-related variables listed previously were evaluated for potential inclusion. Entry criteria for this model were the same as for the mortality model: univariate association ($P < .20$) and <20% missing data. Continuous data are presented as mean ± SD; frequency data are presented as number (percentage), unless otherwise noted. Statistical analyses were performed with STATA software, version 11 (Stata Corporation, College Station, Tex).

RESULTS

Baseline Characteristics

An estimated total of 41,417 eligible patients undergoing concomitant MV surgery and AVR were identified. This number included 29,945 (72%) MV replacements and 11,472 (28%) MV repairs. A comparison of baseline characteristics between the cohorts showed several significant differences. The group of patients who underwent MV repair was older, had a higher percentage of men, and had a higher percentage of Medicare insurance (Table 1). This group had a lower percentage of patients who had atrial fibrillation or chronic obstructive pulmonary disease, but a higher percentage who had prior myocardial infarction, peripheral vascular disease, and diabetes mellitus.

Most patients who underwent replacement had a mechanical MV valve implanted. For the AVR, a lower percentage of the cohort who underwent MV repair, versus MV replacement, had mechanical aortic valves placed (Table 1). Concomitant CABG was more common in the group undergoing MV repair, as was tricuspid valve repair, although rates of tricuspid valve replacement were lower. Mitral valve repairs concomitant with AVR were more commonly performed at teaching hospitals than were MV replacements.

Clinical Outcomes

The overall unadjusted inpatient mortality rate after MV surgery concomitant with AVR was 9.5%. The unadjusted inpatient mortality rate was significantly lower in the MV repair group (8% vs 10%; $P = .005$) (Table 2). Overall major morbidity rates were similar between the cohorts, although rates of sepsis and acute renal failure were higher, and rate of hemorrhage was lower, with MV repair (Table 2). The need for a postoperative ventricular assist device, intra-aortic balloon pump, permanent pacemaker, or automatic internal cardioverter-defibrillator were each comparable between groups. The mean and median lengths of hospital stay were significantly shorter with MV repair (Table 2).

In multivariable analysis, MV repair, as opposed to replacement, concomitant with AVR was associated with a 37% risk-adjusted decrease in the likelihood of inpatient mortality ($P < .001$) (Table 3). Other patient-related variables that