Minimally invasive aortic valve replacement provides equivalent outcomes at reduced cost compared with conventional aortic valve replacement: A real-world multi-institutional analysis

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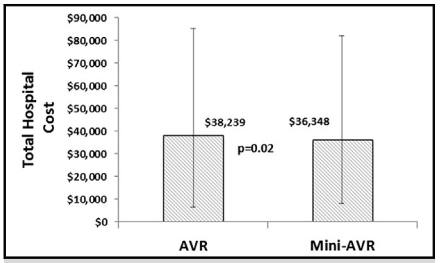
ABSTRACT

Background: Several single-center studies have reported excellent outcomes with minimally invasive aortic valve replacement (mini-AVR). Although criticized as requiring more operative time and complexity, mini-AVR is increasingly performed. We compared contemporary outcomes and cost of mini-AVR versus conventional AVR in a multi-institutional regional cohort. We hypothesized that mini-AVR provides equivalent outcomes to conventional AVR without increased cost.

Methods: Patient records for primary isolated AVR (2011-2013) were extracted from a regional, multi-institutional Society of Thoracic Surgeons database and stratified by conventional versus mini-AVR, performed by either partial sternotomy or right thoracotomy. To compare similar patients, a 1:1 propensity-matched cohort was performed after adjusting for surgeon; operative year; and Society of Thoracic Surgeons risk score, including age and risk factors (n = 289 in each group). Differences in outcomes and cost were analyzed.

Results: A total of 1341 patients underwent primary isolated AVR, of which 442 (33%) underwent mini-AVR at 17 hospitals. Mortality, stroke, renal failure, and other major complications were equivalent between groups. Mini-AVR was associated with decreased ventilator time (5 vs 6 hours; $P = .04$) and decreased blood product transfusion (25% vs 32%; $P = .04$). A greater percentage of mini-AVR patients were discharged within 4 days of the operation (15.2% vs 4.8%; $P < .001$). Consequently, total hospital costs were lower in the mini-AVR group ($36,348 vs $38,239; $P = .02$).

Conclusions: Mortality and morbidity outcomes of mini-AVR are equivalent to conventional AVR. Mini-AVR is associated with decreased ventilator time, blood product use, early discharge, and reduced total hospital cost. In contemporary clinical practice, mini-AVR is safe and cost-effective. (J Thorac Cardiovasc Surg 2015;149:1060-5)



Median total hospital cost was $1891 ($P = .02$) lower in mini-AVR compared with conventional AVR.

Central Message

Mortality and morbidity outcomes of mini-AVR are equivalent to conventional AVR in a real-world multi-institutional analysis. Mini-AVR is associated with decreased ventilator time, blood product use, early discharge, and reduced total hospital cost. In contemporary clinical practice, mini-AVR is safe and cost-effective.

Perspective

Previous studies evaluating mini-AVR have been primarily limited to single high-volume centers. The contemporary outcomes and cost of mini-AVR as it has disseminated to centers to real-world clinical practice is unknown. In this study, we compare contemporary outcomes and costs mini-AVR and conventional AVR outcomes and cost in a multi-institutional regional cohort. Mini-AVR is associated with decreased ventilator time, blood product use, early discharge, and reduced total hospital cost. In contemporary clinical practice, mini-AVR is safe and cost-effective.

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Aortic valve replacement (AVR) via a full sternotomy has long been the standard approach to treat aortic valve pathology and can be performed with minimal morbidity and mortality.[1] Introduced in the 1990s, minimally invasive aortic valve replacement (mini-AVR), performed via a partial upper sternotomy or right thoracotomy, is increasingly performed at cardiac surgery centers across the United States.[2] Several groups have demonstrated that mini-AVR can be performed with excellent outcomes, less patient discomfort, decreased blood product transfusion, and reduced length of stay (LOS) compared with conventional AVR.[3-7] Mini-AVR has been criticized for increased cardiopulmonary bypass, crossclamp, and operating room

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Abbreviations and Acronyms

AVR = aortic valve replacement
ICU = intensive care unit
LOS = length of stay
Mini-AVR = minimally invasive aortic valve replacement
PROM = predicted risk of mortality
PROMM = predicted risk of morbidity and mortality
STS = Society of Thoracic Surgeons
VCSQI = Virginia Cardiac Surgery Quality Initiative

time, and higher cost.[8,9] Because partial sternotomy or thoracotomy provide limited exposure to the heart, myocardial protection, de-airing, and valve exposure can be more challenging.[10] Previous published studies on mini-AVR have been limited to single, high-volume centers. The contemporary outcomes of mini-AVR as it has disseminated to centers with more diverse volume and experience is unknown. Furthermore, no previous study has evaluated outcomes and cost of mini-AVR in a multi-institutional cohort.

In this study, we compare contemporary mini-AVR and conventional AVR outcomes and cost in a multi-institutional regional cohort. We hypothesize that mini-AVR provides equivalent outcomes to conventional AVR without increased cost.

PATIENTS AND METHODS

The Virginia Cardiac Surgery Quality Initiative (VCSQI) is a voluntary group of 17 hospitals and 13 cardiac surgical practices providing cardiac surgery in the Commonwealth of Virginia. VCSQI members perform more than 99% of the commonwealth's cardiac surgery procedures. The VCSQI data registry is a Society of Thoracic Surgeons (STS) certified database (version 2.73). This investigation was exempt from formal institutional review board review at each participating center because it represents a secondary analysis of the VCSQI data registry with the absence of Health Insurance Portability and Accountability Act patient identifiers and because the data are collected for quality analysis and purposes other than research.

Patients and Data Acquisition

Starting in 2011, operative approach for AVR was recorded within the VCSQI database, allowing for identification of minimally invasive procedures. De-identified patient records for all patients who underwent isolated primary AVR for the study period of January 1, 2011, to December 31, 2013, were obtained from the VCSQI registry. Exclusion criteria included endocarditis, reoperative status, and any other concomitant surgical procedure. Patient records were then stratified by operative approach: full sternotomy, partial-sternotomy, or right thoracotomy. Patients undergoing full sternotomy were placed in the conventional AVR group. Patients undergoing partial sternotomy and right thoracotomy were combined into the mini-AVR group. Patient preoperative, operative, and postoperative variables were retrieved from the VCSQI database for each patient. STS predicted risk of morbidity and mortality (PROMM) and predicted risk of mortality (PROM) were individually calculated.

Cost Data and Acquisition

The VCSQI data registry combines standardized clinical data extracted from the STS data entry forms with hospital inpatient discharge financial data. Hospital inpatient data from UB-92 and UB-04 files are matched with each STS patient record. By the use of center-specific cost-to-charge ratios, estimated hospital costs are determined with previously described methods.[11,12] VCSQI maintains a 99% matching rate between STS patient records and billing data.

Measured Outcomes

The primary outcomes were frequency of postoperative complications, LOS, operative mortality, and hospital cost. Operative mortality was defined as all patient deaths occurring during hospitalization as well as those within 30 days of the date of surgery despite discharge status. Ventilation time, intensive care unit (ICU) hours, and hospital LOS from surgery to discharge were measured. Early discharge was defined as discharge by the fourth postoperative day. Standard STS definitions for postoperative events and complications were used, including cerebrovascular accident, renal failure (increase in serum creatinine level >2.0 or doubling of the most recent preoperative creatinine), prolonged ventilation (>24 hours of mechanical ventilation), presence of any new onset atrial fibrillation, deep sternal wound infection, and administration of intraoperative or postoperative blood product.[11]

Statistical Analysis

All study group comparisons were unpaired. Categorical variables were compared using either Pearson χ^2 or Fisher exact tests, and continuous variables were compared using the Student t test for normally distributed data or the Wilcoxon rank sum test for nonnormally distributed data where appropriate. Propensity score matching was performed to generate a study cohort of matched patients undergoing conventional AVR and mini-AVR adjusted for potential confounding. Propensity scores were estimated using binary logistic regression models with performance of mini-AVR as the response variable and STS PROM, operative year, and operating surgeon as possible confounding predictor variables. Propensity scores were then used to match conventional AVR and mini-AVR patients in a 1:1 ratio using nearest neighbor greedy methodology, resulting in equal study cohorts. Postoperative outcomes were then compared between matched groups using standard univariate statistical tests of association.

RESULTS

Patient Characteristics

In our regional cohort, a total of 1341 patients underwent isolated AVR during the study period, of whom 442 (33%) underwent mini-AVR at 17 hospitals. Patient characteristics for the overall cohort are reported in Table 1 and grouped by surgical approach. Mini-AVR patients were older (aged 74 years vs 69 years; $P < .001$) and had a greater incidence of peripheral vascular disease (12.7% vs 8.0%; $P < .001$) and end-stage renal disease (3.6% vs 1.3%; $P < .01$). In the unmatched cohort, conventional AVR patients had a higher STS PROM (1.8% vs 1.3%; $P < .001$) and STS PROMM (14.2% vs 11.8%; $P < .001$). Moderate or severe aortic insufficiency, which some groups use as a relative contraindication for mini-AVR, was present in 26.2% (n = 116) of patients undergoing mini-AVR. There were no statistically significant differences in other comorbidities such as hypertension, chronic obstructive pulmonary disease, diabetes, or heart failure between the 2 unmatched groups. The patient