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Original Research

Contemporary prevalence, in-hospital outcomes, and prognostic determinants of triple valve surgery: National database review involving 5,234 patients

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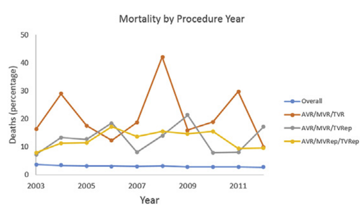
HIGHLIGHTS

- Little is known about the outcomes following triple valve surgery.
- Even in high volume centers the number of triple valve surgery performed is small.
- Pooling data from the National Inpatient Sample database helps overcome this limitation.
- Replacement strategies have high mortality and occurrence of major adverse events.
- Repair strategies, especially for the mitral and tricuspid valves, can reduce the risk of mortality.

GRAPHICAL ABSTRACT



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ABSTRACT

Background: Triple valve surgery (TVS) remains a challenging procedure with limited existing literature. We aim to evaluate the prevalence, in-hospital outcomes, and prognostic determinants of TVS in the current era.

Materials and methods: We reviewed the Nationwide Inpatient Sample database from 2003 to 2012 and included all patients who underwent aortic valve replacement (AVR) combined with mitral valve replacement (MVR) or repair (MVRep) and tricuspid valve replacement (TVR) or repair (TVRep). Logistic regression analysis was used to identify independent predictors of in-hospital mortality and propensity score matching was adopted to compare groups receiving different operations.

Results: Overall, 5234 patients were included. In-hospital mortality was 13.9%. Major adverse events occurred in 42.9% of the cases (44.9%, 40.3%, 44.4% and 74.2% in the AVR + MVR + TVR, AVR + MVR + TVRep, AVR + MVRep + TVRep and AVR + MVRep + TVR groups respectively, $p < 0.05$ for all intergroup comparisons). In-hospital mortality in the AVR + MVR + TVR, AVR + MVR + TVRep, AVR + MVRep + TVRep and AVR + MVRep + TVR groups was 19.9%, 13.3%, 12.9% and 0% respectively ($p < 0.05$ for all intergroup comparisons). At regression analysis, age, reoperation, and urgent/emergent operation were independent predictors of in-hospital mortality. Patients submitted to tricuspid valve

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repair and mitral and tricuspid repair had a 62% and 63% mortality risk reduction (OR:0.380, CI:0.19–0.76 p = 0.006 and OR:0.37, CI:0.18–0.78 p = 0.009 respectively). In the propensity matched comparisons, in-hospital mortality was statistically similar (p = 0.08 for AVR + MVR + TVR vs. AVR + MVR + TVRep comparison and p = 0.06 for AVR + MVR + TVR vs. AVR + MVRep + TVRep comparison).

Conclusions: TVS is associated with significant in-hospital mortality and morbidity. The use of valve repair strategies for the mitral and tricuspid valves can positively impact postoperative outcomes.

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1. Introduction

Triple valve surgery (TVS) remains a challenging operation. Despite improvements in surgical technique, myocardial protection, and intensive care treatment, postoperative mortality and complication rates range between 10 and 20% [1–3].

Due to the relative rarity of the disease, the published series from single centers include either a very long study period or a limited number of patients, so that the definition of contemporary outcomes and risk factors of TVS remains difficult. With an aging population and new techniques available for multiple valve repair or replacement, an understanding of prevalence, outcomes, and prognostic determinants is paramount. Standard surgical techniques must be compared to emerging technologies in order to ensure optimal outcomes for patients.

In this study, we use data from the Nationwide Inpatient Sample (NIS) from 2003 to 2012 in order to achieve a statistical power sufficient to allow a meaningful description of the in-hospital outcomes and prognostic determinants of TVS in the current era. In addition, we evaluated the effect of repair versus replacement of the mitral and/or tricuspid valve on in-hospital outcome using propensity matching and multivariate regression analysis.

2. Materials and methods

Data were obtained from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project, Nationwide Inpatient Sample (NIS) files between 2003 and 2012. The NIS is a 20% stratified sample of all nonfederal US hospitals [4]. In 2011, the NIS contained deidentified information for 38,590,733 discharges from 1049 hospitals and 46 states. Discharges are weighted based on the sampling scheme to permit inferences for a nationally representative population. Each record in the NIS includes all procedure and diagnosis International Classification of Diseases, Ninth Revision, Clinical Modification codes (ICD) recorded for each patient's hospital discharge.

Hospitalizations leading to triple cardiac valve surgery between January 2003 and December 2012 were selected by searching for the ICD-9-CM procedure codes 35.21, 35.22, 35.23, 35.24, 35.12, 35.27, 35.28, 35.14 in any of the 15 procedure fields in the database. Patients having procedure on the pulmonary valve and patients who underwent aortic valve repair were excluded from the analysis.

Patients were divided in four groups according to the type of procedure received on the aortic, mitral and tricuspid valve: aortic valve replacement + mitral valve replacement + tricuspid valve replacement (AVR + MVR + TVR group), aortic valve replacement + mitral valve replacement + tricuspid valve repair (AVR + MVR + TVRep group), aortic valve replacement + mitral valve repair + tricuspid valve repair (AVR + MVRep + TVRep group) and aortic valve replacement + mitral valve repair + tricuspid valve replacement (AVR + MVRep + TVR group).

Patient-level variables were included as baseline characteristics. The Agency for Healthcare Research and Quality's comorbidity measures based on the Elixhauser method were used to identify comorbid conditions [5]. The primary outcome was in-hospital all-cause mortality. Secondary outcome measures were stroke, myocardial infarction, need for tracheostomy, and need for hemodialysis. Stroke was identified by ICD-9-CM codes 430-436, 997.02. Myocardial infarction was identified by ICD-9-CM codes 410, 410.01, 410.11, 410.21, 410.31. Need for tracheostomy was identified by ICD-9-CM codes 31.1. Need for hemodialysis was identified by ICD-9-CM code 39.95.

Continuous variables are presented as medians; categorical variables, as frequencies (percentages). Baseline characteristics were compared using either the Mann-Whitney-Wilcoxon nonparametric test or Student-*t* test for continuous variables and the Pearson χ^2 test for categorical variables. All statistical tests were 2-sided, and a P value < 0.05 was set a priori to be statistically significant.

Multivariable logistic regression analysis was used to compare outcomes between groups adjusting for univariate predictors of outcomes ($P < 0.01$) from among dialysis, previous CABG, previous PCI, age, sex, race, hospital bed size, hospital teaching status, region, location, length of stay, total charges, endocarditis, previous heart valve failure, previous stroke, drug use, procedure status, anemia, collagen vascular disease, congestive heart failure, chronic pulmonary disease, pulmonary circulation disorder, diabetes mellitus, coagulopathy, hypertension, liver disease, neurologic disorders, obesity, peripheral vascular disorders, and renal failure.

Propensity score matching (PSM) was used to address differences in baseline characteristics between groups. PSM was performed according to a described method [6]. Selected variables for PSM were age, sex, hypertension, heart failure, endocarditis, failure of previous heart valve, chronic pulmonary disease, diabetes, and procedure status (elective vs urgent/emergent). Due to the low number of patients receiving AVR + MVRep + TVR, these were not included in the PSM analysis.

All statistical tests were 2-sided, and a P value < 0.05 was set a priori to be statistically significant. All multivariate regression analyses were performed using SAS version 9.2 [SAS Institute, Cary, NC] and SPSS version 20 [IBM, Armonk, NY].

3. Theory

With an aging population and new techniques available for multiple valve repair or replacement, an understanding of prevalence, outcomes, and prognostic determinants is paramount. Standard surgical techniques must be compared to emerging technologies in order to ensure optimal outcomes for patients.

4. Results

4.1. Patient population and temporal trends

Of 3,317,183 discharge records reviewed between 2003 and

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