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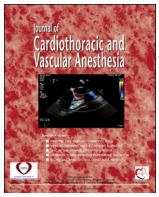

Original Article

Perioperative Strokes and Early Outcomes in Mitral Valve Surgery: A Nationwide Analysis

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Objective: To demonstrate the role of perioperative stroke as an independent risk factor for in-hospital morbidity and mortality after mitral valve surgery and review the trends in the early outcomes of mitral valve surgery over the past decade.
Design: Using data from the National Inpatient Sample database for analysis, all patients who underwent isolated mitral valve procedures were identified using International Classification of Diseases-Ninth Revision codes. Univariate and multivariate analyses of risk factors of in-hospital mortality and morbidity were performed.
Setting: Multi-institutional.
Participants: The study comprised patients who underwent mitral valve procedures from 1999 to 2011.
Interventions: Mitral valve repair or replacement.
Measurements and Main Results: Data on 21,821 patients showed an in-hospital mortality of 5.5% and morbidity of 63.30% ($p < 0.05$). Perioperative strokes were experienced by 3.89% of the cohort after isolated mitral valve surgery ($p < 0.05$). Independent predictors of adverse outcomes were age, female sex, emergency surgery, arrhythmias, hypertension, renal failure, coagulopathy, neurologic disorders, weight loss, anemia, postoperative cardiac arrest, and myocardial infarction. Perioperative strokes were found to be the strongest risk factor for postoperative mortality (odds ratio 2.34, 95% confidence interval 1.83-2.98) and morbidity (odds ratio 4.53, 95% confidence interval 3.34-6.15).
Conclusion: Age, female sex, emergency surgery, arrhythmias, hypertension, renal failure, coagulopathy, neurologic disorders, weight loss, fluid and electrolyte imbalance, anemia, postoperative cardiac arrest, and myocardial infarction were found to be significant predictors of morbidity and mortality after mitral valve surgery, with perioperative strokes posing the strongest risk. The trends in the last 10 years indicated a decrease in mortality and an increase in morbidity. Preoperative risk stratification and intraoperative identification for impending strokes appear warranted.
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Key Words: mitral valve surgery; perioperative stroke; in-hospital mortality; morbidity

MITRAL VALVE (MV) repair or replacement for MV disease, with nearly15,000 procedures reported annually in the United States, is one of the most common valve surgeries performed.[1] A surgical mortality of 1.2% and 4.8% has been reported for MV repair and replacement, respectively.[1,2] Perioperative strokes, defined as neurologic deficits developing within 30 days of the procedure, affects postoperative mortality rates and quality of life after MV surgery (MVS).[3-7] Previous studies have shown that adverse neurologic outcomes have significant economic implications, with patients requiring a longer stay in intensive care units and hospitals.[3,7]

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http://dx.doi.org/10.1053/j.jvca.2016.12.006
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Examining the factors that influence early morbidity and mortality rates may give insight on improved practices, better patient selection, and efficient management of patient comorbidities.[8,9] Therefore, identification of individuals at risk may lead to a significant reduction in cost and the improvement of resource allocation without compromising quality of care.[3,8,9]

Several institutional studies have reported the following risk factors to be associated with adverse postoperative outcomes after MVS: age, female sex, urgent or emergency admissions, diabetes mellitus (DM), hypertension, coronary artery disease (CAD), congestive cardiac failure (CHF), atrial fibrillation, bacterial endocarditis, previous history of symptomatic carotid stenosis (strokes or transient ischemic attacks), renal failure, hepatic disease, periprocedural myocardial infarction (MI), and arrhythmias.[10-12] A large-scale nationwide analysis on the impact of perioperative strokes on MVS outcomes has not been done before.

The primary aim of this study was to demonstrate the role of perioperative strokes as an independent risk factor for in-hospital mortality after MVS. The secondary aim was to study the role of stroke as an independent risk factor for postoperative morbidity, defined as a length of stay greater than 14 days and/or discharge to a location other than home. Finally, the authors also examined the trends over time in the postoperative outcomes after MVS. Understanding the implications of strokes on early postoperative outcomes warrants further investigation into strategies such as preoperative risk stratification,[13,14] intraoperative neurophysiologic monitoring,[15-17] and care pathways to better manage hospital stay and resource allocation.[8,9]

Methods

Patient Population

The study population was selected from the National Inpatient Sample (NIS) for the years 1999 to 2011 using International Classification of Diseases, Ninth Revision-Clinical Modification (ICD-9-CM) diagnosis and procedure codes. Patients who underwent isolated MV repair (ICD-9-CM-35.12) or MV replacement (ICD-9-CM-35.23 and 35.24) were selected for the study. Patients younger than 18 years were excluded from the selection. Baseline characteristics available for analysis included age, sex, race, admission status, transfer status, Elixhauser comorbidities and other additional comorbid conditions such as CAD, atrial fibrillation, bacterial endocarditis, postoperative cardiac arrest, and MI. The NIS database provides 29 Elixhauser comorbidities based on standard ICD-9 codes.[18] In addition to these, a complete list of ICD-9 codes that were used to define other variables is provided in Supplementary Table 1. Risk stratification was performed using the Van Walraven (VWR) score, which is a summary score for the Elixhauser Comorbidity Index developed by modeling in-hospital mortality with inpatient admission data.[19] The summary score is a weighted combination of the 29 Elixhauser comorbidities, in which a larger comorbidity weight indicates a stronger association between a comorbidity and in-hospital mortality. The primary outcome studied was in-hospital mortality. The secondary outcome, postoperative morbidity, was characterized as a long length of stay (greater than 14 days) or discharge to a place other than home.[20]

Statistical Analysis

All statistical analyses were performed using the SPSS software, Version 23 (IBM Corp, Armonk, NY); Stata Student Edition, Version 14.0 SE (StataCorp, College Station, TX); and SAS Student Edition, Version 9.3 TS1M2 Rev.15w25 (SAS Institute, Cary, NC). The Elixhauser Comorbidity Index was created using the comorbidity software, available at the Health Care Utilization Project (HCUP) website.[21] In order to create the comorbidity index, the authors matched the appropriate version of the software with the year and the discharge quarters of the study data set. To ensure that the data sample was weighted adequately, after extraction, the hospital weights file provided by HCUP were merged with the study's extracted data. This ensured that all hospitals were accounted for at least once. To ensure standard errors were accurate, the survey command in Stata was used for all analyses, grouping by the hospital identification and stratifying using the strata provided by HCUP. All data are presented as mean $\pm$ standard deviation or percentages. Univariate comparisons between groups were performed using unpaired *t*-tests for continuous variables and an adjusted Wald test for categorical variables. For the multivariate regression, only statistically significant variables were chosen, with a p value of < 0.05. Six models of multivariate regression for mortality and 5 for morbidity were run. Each subsequent model was adjusted for different variables. Variables that the authors believed might compromise their model (small group size, missing variables altering the population) were excluded sequentially, and the odds ratio (OR) for perioperative stroke across all models was compared. One model with the most patients to report was selected, and all other models are included in Supplementary Tables 2 and 3.

Results

Baseline Characteristics

Data on 21,821 patients who underwent isolated MV repair or replacement from 1999 to 2011 were obtained. Baseline characteristics of the study population are given in Table 1. The overall in-hospital mortality and morbidity rates were 5.5% (1,645) and 63.30% (18,877), respectively. Perioperative strokes occurred in 3.89% (1,160) of the total cohort ($p < 0.05$). The average age of the patient population was 62.47 ± 14.03 years. The majority of patients who underwent MVS were found to be younger than 65 years (52.86%, $p < 0.05$) and female (60.17%, $p < 0.05$). A statistically significant increase was observed in the incidence of in-hospital mortality and morbidity across age groups (Table 1). The incidences of in-hospital mortality and morbidity in patients who developed perioperative stroke were 15.94% and

Please cite this article as: Udesh R, et al. (2017), http://dx.doi.org/10.1053/j.jvca.2016.12.006

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