Postoperative atrial fibrillation is associated with increased morbidity and resource utilization after left ventricular assist device placement

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ABSTRACT

Background: Postoperative atrial fibrillation (POAF) is a known risk factor for morbidity and mortality after cardiac surgery but has not been investigated in the left ventricular assist device (LVAD) population. We hypothesize that POAF will increase morbidity and resource utilization after LVAD placement.

Methods: Records were extracted for all patients in a regional database who underwent continuous-flow LVAD placement (n = 1064, 2009-2017). Patients without a history of atrial fibrillation (n = 689) were stratified by POAF for univariate analysis. Multivariable regression models calculated the risk-adjusted association of arrhythmias on outcomes and resource utilization.

Results: The incidence of new-onset POAF was 17.6%, and patients who developed POAF were older and more likely to have moderate/severe mitral regurgitation, a history of stroke, and concomitant tricuspid surgery. After risk adjustment, POAF was not associated with operative mortality or stroke but was associated with major morbidity (odds ratio [OR] 2.5 $P = .0004$), prolonged ventilation (OR 2.7, $P < .0001$), unplanned right ventricular assist device (OR 2.9, $P = .01$), and a trend toward renal failure (OR 2.0, $P = .06$). In addition, POAF was associated with greater risk-adjusted resource utilization, including discharge to a facility (OR 2.2, $P = .007$), an additional 4.9 postoperative days ($P = .02$), and 88 hours in the intensive care unit ($P = .01$).

Conclusions: POAF was associated with increased major morbidity, possibly from worsening right heart failure leading to increased renal failure and unplanned right ventricular assist device placement. This led to patients with POAF having longer intensive care unit and hospital stays and more frequent discharges to a facility. (J Thorac Cardiovasc Surg 2018;■:1-7)

HeartMate II left ventricular assist device (Images provided by St Jude Medical, Inc).

Central Message

POAF was associated with increased major morbidity, likely due to worsening right heart failure. This led to patients with POAF having longer ICU and hospital stays and more being discharged to facilities.

Perspective

This study clarifies that some known associations of POAF apply to the LVAD population, including increased morbidity and resource utilization. The likely detrimental impact on right heart function should spur further investigation to prevent complications. The impact of these complications represents a great opportunity to translate quality improvement initiatives to the LVAD population.

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Postoperative atrial fibrillation (POAF) after cardiac surgery is a common complication, occurring after 10% to 40% of cardiac cases.[1-3] The causes of POAF are multifactorial and include preoperative structural changes and perioperative proarrhythmic adrenergic activation, inflammation, and oxidative stress.[3] Development of

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Abbreviations and Acronyms

ICU = intensive care unit
LOS = length of stay
LVAD = left ventricular assist device
POAF = postoperative atrial fibrillation
RVAD = right ventricular assist device
STS = Society of Thoracic Surgeons
VCSQI = Virginia Cardiac Services Quality Initiative

POAF is associated with increased risk of morbidity, mortality, and resource utilization, including length of stay (LOS), readmission, and hospital cost.[4] However, the information regarding the impact of POAF after left ventricular assist device (LVAD) implantation is far less well understood. Ventricular arrhythmias garner far more concern than POAF, likely limiting investigation into the clinical and economic impacts of atrial arrhythmias.

Although the complication rate after LVAD surgery is high, at a rate of approximately 30% POAF is one of the most common complications reported.[5-8] With the cost of LVAD implantation in the hundreds of thousands of dollars, this therapy warrants scrutiny to identify quality and cost-improvement opportunities.[9-11] The Virginia Cardiac Services Quality Initiative (VCSQI) is a regional consortium of hospitals with the primary goal of improving patient quality, outcomes, and cost. The data available within this cohort represent an ideal opportunity to address quality and cost inefficiencies within a high-cost procedure.

The purpose of this analysis was to identify the potential associations of POAF with complications and resource utilization. We hypothesized that POAF is associated with risk-adjusted morbidity and mortality after LVAD implantation. Furthermore, we believe these differences will be evidenced by increased resource utilization, including postoperative LOS as well as health care–related cost.

PATIENTS AND METHODS

Patient Data

The VCSQI is a multistate regional collaborative consisting of 19 hospitals and surgical practices. Eight of these hospitals perform LVAD surgeries. Member hospitals submit administrative, demographic, and clinical data via the Society of Thoracic Surgeons (STS) standardized data entry forms to both VCSQI and the STS national adult cardiac surgery database. Early data versions collected mean pulmonary artery pressure, which were converted to estimated pulmonary artery systolic pressure ([mean pulmonary artery pressure – 2]/0.61).

Deidentified records for all continuous-flow LVAD implantations from January 2009 through June of 2017 were extracted from the VCSQI data registry. Continuous-flow LVADs included HeartMate II and III (Thoratec Corp, Pleasanton, Calif) and HVAD (HeartWare, Framingham, Mass). Patients were excluded for missing baseline arrhythmia or POAF data. The primary outcomes of interest were short-term (in-hospital or 30-day) complications and resource utilization. Specifically, the risk-adjusted associations between POAF and morbidity, mortality, LOS, and cost. Clinical variables used standard STS definitions.[12] Operative mortality is defined as either 30-day or in-hospital mortality. Major morbidity includes permanent stroke, prolonged ventilation, reoperation for any reason, renal failure, and deep sternal wound infection.

The primary objective of VCSQI is quality improvement with implementation of solutions across the collaborative. Business associate agreements are in place between VCSQI, members, and the database vendor (ARMUS Corporation, San Mateo, Calif). This analysis represents a secondary analysis of the VCSQI data registry without Health Insurance Portability and Accountability Act patient identifiers and was exempted from institutional review board review at the University of Virginia (IRB #20321).

Cost Data

The VCSQI cost collection, pairing, and estimation methodologies have been previously described.[13,14] To summarize in brief, STS clinical data are paired with patient-level hospital financial records using Uniform Billing-04 files, which include all final hospital charges. The matching success rate is 99%. The identified charges are sorted based on *International Classification of Diseases*, Ninth Revision–based revenue codes. Next, the charges are multiplied by a set of cost-to-charge ratios for each hospital that are publicly available and submitted to the Centers for Medicare and Medicaid Services. All costs are presented as 2016 dollars after adjusting for medical inflation using the market basket for the Centers for Medicare and Medicaid Services Inpatient Prospective Payment System.[15]

Statistical Analysis

Categorical variables are presented as counts (%) and continuous variables as median [25th, 75th percentile] due to skewedness except for cost data, which was also presented as mean ± standard deviation. Cost data are presented as both median and mean to more fully understand cost outliers. Patients were stratified by POAF and preoperative atrial fibrillation and compared by univariate analysis. Categorical variables were analyzed by the χ^2 test for and continuous variables by Mann–Whitney U test. For univariate analyses, no imputation for missing data was performed.

Multivariable regression modeling assessed the risk-adjusted associations between POAF and morbidity, mortality, and resource-utilization metrics. Predicted associations were adjusted for preoperative and operative risk factors, hospital volume, and operative year with the complete list of covariates listed in Table E1. All risk factors used in previous LVAD risk models were included, except for aspartate aminotransferase, which is not captured in the data set and pulmonary artery pressures due to the high number missing (Table E1).[16] For logistic regression models, a stepwise selection methodology was used to limit the number of covariates to 1 per 10 events, whereas for linear regression models all potential covariates were included.

For univariate analyses, missing data points were excluded from the corresponding analysis. For regression modeling, data imputation was performed based on STS methodology used in the creation of the STS risk models.[17] For missing continuous variables, the median cohort value and for categorical variables the lowest risk definition was applied. Some patients were missing multiple laboratory values; thus, if patients were missing 4 or more values, they were excluded from the regression models (n = 203). All statistical analyses were carried out using SAS Version 9.4 (SAS Institutive, Cary, NC) with significance determined by a P value less than .05.

RESULTS

Patient and Operative Characteristics

A total of 1064 patients underwent implantation of a continuous-flow LVAD, of whom 375 (35%) had a history of atrial fibrillation. Of the 689 patients without a history of atrial fibrillation, 568 (17.6%) developed POAF. The