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Hospital Variation in Mortality From Cardiac Arrest After Cardiac Surgery: An Opportunity for Improvement?

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Abstract

Background—Among all postoperative complications, cardiac arrest after cardiac surgical operations has the greatest association with mortality. However, hospital variation in the ability to rescue after cardiac arrest is unknown. The purpose of this study was to characterize the impact of cardiac arrest on mortality and determine the relative impact of patient, operative, and hospital factors on failure to rescue (FTR) rates and surgical mortality after cardiac arrest.

Methods—A total of 79,582 patients underwent operations at 17 different hospitals (2001 through 2011), including 5.2% ($n = 4,138$) with postoperative cardiac arrest. Failure to rescue was defined as mortality after cardiac arrest. Patient risk, operative features, and outcomes were compared among hospitals.

Results—Overall FTR rate was 60% with significant variation among hospitals (range, 50% to 83%; $p < 0.001$). Failure-to-rescue patients were slightly older, presented with increased preoperative risk, and underwent more emergent operations (all $p < 0.05$). After risk adjustment, the variable “individual hospital” demonstrated the strongest association with likelihood for FTR (likelihood ratio = 39.1; $p < 0.001$). Overall risk-adjusted mortality, cardiac arrest, and FTR rates varied across hospitals and did not correlate. High-performing hospitals with lowest FTR rates accrued longer postoperative and intensive care unit stays after the index operation (2 to 3 days; $p < 0.001$).

Conclusions—Significant hospital variation exists in cardiac surgical mortality and FTR rates after cardiac arrest. Institutional factors appear to confer the strongest influence on the likelihood for mortality after cardiac arrest compared with patient and operative factors. Identifying best practice patterns at the highest performing centers may serve to improve surgical outcomes after cardiac arrest and improve patient quality.

Failure to rescue (FTR) describes the clinical scenario in which mortality results from a potentially modifiable major complication. Recent evidence supports improvements in FTR

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as a mechanism to reduce postoperative mortality after surgery [1]. Moreover, the Agency of Health Care Research and Quality has identified FTR as one of 20 patient safety indicators for medical and surgical patients within the United States [2]. Reports addressing FTR after cardiac surgery, in particular, remain limited [3]. Among postoperative complications, cardiac arrest is one of the most attractive to study FTR as it represents the ultimate rescue from death and has the greatest association with death. Although most existing reports have analyzed FTR with respect to several well-documented major complications (ie, myocardial infarction, stroke, renal failure) [3–7], the implications of FTR exclusively limited to occurring after episodes of cardiac arrest remain unstudied within the existing cardiothoracic literature. Furthermore, the identification of factors influencing FTR after cardiac arrest within cardiac surgery patients has the potential to greatly affect patient outcomes and influence the reporting of individual hospital quality metrics for the future.

The Virginia Cardiac Surgery Quality Initiative (VCSQI) is a voluntary group of 17 different cardiac surgical centers, both academic and private, within the Commonwealth of Virginia. This group holds quarterly meeting to exchanges and compares select deidentified data in an effort to improve cardiac surgical care, quality, and costs. The primary objective of the organization is to identify quality-improvement opportunities in cases in which high cost, resource intensive, or frequently occurring preventable outcomes might occur. Collectively, the VCSQI centers perform approximately 99% of the Commonwealth's cardiac operations, and each center individually contributes patient data to the national Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database.

The purpose of this study was to characterize the impact of cardiac arrest on mortality to determine the relative impact of patient, operative, and hospital factors on FTR rates after cardiac arrest. We hypothesized that significant variations in hospital FTR rates after cardiac arrest exist after cardiac surgery within a multiinstitutional cohort of patients.

Material and Methods

This study was exempt from Institutional Review Board review at each participating hospital due to the secondary analysis of de-identified data abstracted from the VCSQI data registry and because the data is collected for quality analysis and purposes other than research.

Patients and Data Acquisition

Deidentified patient records were obtained from the VCSQI data registry for the study period January 1, 2001, through December 31, 2011 ($n = 79,582$). All records included patients undergoing cardiac surgery operations among 17 VCSQI centers who had a calculated STS predicted risk of mortality. The subset of patients experiencing postoperative cardiac arrest were then further identified and selected ($n = 1,486$). Within this study cohort, patient records were stratified according to FTR events (FTR versus no FTR), which were defined by mortality occurring after cardiac arrest. Analyzed cardiac operations represent standard surgical approaches. Patient preoperative risk was assessed by individual calculated STS predicted risk of mortality and STS predicted risk of mortality and morbidity.

Measured Outcomes

The primary outcomes of interest included risk-adjusted mortality, cardiac arrest, and mortality after cardiac arrest (ie, FTR) rates as well associations between FTR status and patient-, operation-, and hospital-related risk factors. Secondary outcomes included differences in association between FTR and patient risk profiles, operation-related factors, and hospital resource utilization. Traditional STS definitions for all analyzed variables were used [8].

Statistical Analysis

All statistical analyses were designed to test the null hypotheses that tested factors would not significantly differ as a function of FTR after cardiac arrest. Study outcomes and data comparisons were established a priori before data collection. Categorical variables are expressed as standard group percentages, and continuous variables are expressed as either mean $\pm$ standard deviation (SD) or median (25th, 75th percentile) depending on overall variable distribution. Descriptive, univariate statistics included either Pearson's χ^2 or Fisher's exact test for categorical variables and either independent sample single factor analysis of variance for comparisons of normally distributed data or the Mann-Whitney U test for nonnormally distributed data comparisons. Calculated test statistics were used to derive all two-tailed probability values with standard statistical significance set to alpha less than 0.05.

Hierarchical, multiple logistic regression was used to estimate confounder-adjusted associations between tested risk factors and the likelihood of the dependent outcomes (operative mortality, postoperative cardiac arrest, and FTR status). All model covariates were selected a priori on the basis of established clinical risk. Each model was adjusted for the influence of each modeled factor. Clustering at the hospital level was considered in the hierarchical structure of our statistical model to adjust for the influence of correlated events within hospitals in the data structure. The relative strength of association between modeled factors and the dependent outcome was determined by quantifying each factor's likelihood ratio (Wald χ^2 test statistic) within the logistic regression model. Model performance was assessed using the area under the receiver operating characteristics curve, whereas the Hosmer-Lemeshow test was used to verify model calibration across deciles of observed and predicted risk. Risk-adjusted rates of mortality, cardiac arrest, and FTR status were determined for each hospital and were calculated on the basis of the relationship between expected (or predicted) and observed event rates as determined by regression modeling and as described elsewhere [9]. Risk-adjusted event rates are adjusted for baseline STS predicted risk and case mix and were compared across hospitals.

Predictive Analytics SoftWare (PASW) with complex sampling module software, version 21.0.0 (IBM Corp, Somers, NY) was used for all data manipulation and statistical analyses.

Results

Differences in Patient Characteristics and Operative Features

The overall cardiac arrest event rate was 5.2% ($n = 4,138$) among all patients undergoing cardiac operations during the study period, with significant variation across hospitals (Fig

1). The overall FTR rate among the subset of patients experiencing cardiac arrest was 60% ($n = 2,483$). Table 1 displays patient characteristics and risk factors for all cardiac arrest patients stratified by survival (FTR status). Failure-to-rescue patients were on average older and demonstrated a higher burden of preoperative comorbid disease, including peripheral arterial disease, New York Heart Association class IV functional status, renal failure requiring hemodialysis, and heart failure. As expected, FTR patients had higher median STS predicted risk of mortality (5.0% versus 3.5%) and predicted risk of mortality and morbidity (26.3% versus 18.5%) compared with non-FTR patients (both $p < 0.05$). Failure to rescue after cardiac arrest was less common after elective operations and performance of isolated coronary artery bypass grafting and combined aortic valve replacement plus coronary artery bypass grafting operations, whereas FTR was more common after other, seemingly more complex, operations as well as emergent status (all $p < 0.05$).

Risk-Adjusted Associations Between Failure to Rescue After Cardiac Arrest and Patient-, Hospital-, and Operation-Related Factors

To account for baseline differences in patient risk profiles, risk-adjusted associations between the likelihood for mortality after cardiac arrest (ie, FTR status) and patient-, hospital-, and operation-related factors with significant unadjusted associations with FTR status on univariate analyses were estimated using hierarchical multiple regression methodology (Table 2). After adjusting for these influences, the variable “individual hospital” demonstrated the strongest association with FTR status. Other significant factors associated with likelihood of FTR after cardiac arrest included operating surgeon, hospital volume, nonelective operative status, procedure type, and preoperative renal failure or hemodialysis requirement. The statistical performance of the logistic regression model achieved adequate discrimination with an area under the receiver operating characteristics curve of 0.82. The calibration of the model was adequate across deciles of observed risk as reflected by a Hosmer-Lemeshow probability value of less than 0.95.

Interhospital Variability

After demonstrating that individual hospital was the most strongly associated factor with the risk-adjusted likelihood for FTR, we compared risk-adjusted mortality, cardiac arrest, and FTR rates among hospitals (Table 3). On stratification by individual hospital, significant variations were demonstrated in overall hospital risk-adjusted mortality rates (range, 1.8% to 4.5%; $p < 0.001$), cardiac arrest rates (range, 2.6% to 5.5%; $p < 0.001$), and FTR rates (range, 49.2% to 68.8%; $p < 0.001$) after adjustment for preoperative patient risk and case mix. Ranked hospital comparisons demonstrated little variation in risk-adjusted cardiac arrest rates, whereas risk-adjusted overall mortality and FTR status demonstrated greater variation across hospitals. A strong relationship between risk-adjusted mortality and FTR rates was not observed. Interestingly, when hospitals were ranked by FTR status, the highest performing centers (ie, hospitals with lowest FTR rates) demonstrated a trend toward longer median intensive care unit (range, 20 to 40 hours; $p < 0.01$) and postoperative lengths of stay (2 to 3 days; $p < 0.01$) compared with lower performing centers (ie, hospitals with highest FTR rates).

Comment

The present study reports on the affect of clinical and hospital factors on the likelihood for FTR after cardiac arrest among patients undergoing cardiac surgery throughout Virginia. These analyses of more than 79,000 cardiac surgical patients for a 10-year study period, including more than 4,100 cases of postoperative cardiac arrest, demonstrate that individual hospital is more strongly associated with mortality after cardiac arrest than patient preoperative risk profile or surgeon and that significant differences in variation exist for risk-adjusted rates of mortality, cardiac arrest, and FTR status among hospitals. The present report also demonstrates significant associations among various risk factors for FTR after cardiac arrest to better identify at-risk patient populations. To our knowledge, these data represent the largest, multiinstitutional analysis to exclusively examine the impact of postoperative cardiac arrest on patient mortality and to evaluate the variation in rescue after arrest. These results have significant clinical implications related to patient safety and quality efforts as well as clinical processes of care designed to avoid this potentially modifiable event.

The present results are complementary to accumulated surgical data devoted to the examination of FTR as it relates to interhospital variations in mortality. Several surgical series have demonstrated associations between postoperative complication rates and mortality, including cardiac surgical populations [3–7]. In one popular surgical series, more than 84,000 general surgery and vascular surgery patient records were evaluated using the American College of Surgeons National Surgical Quality Improvement Program Participant Use File (2005 through 2007) [5]. In this analysis similar complication rates were reported across hospitals, although significant variations in mortality existed. As a result, the high-performing (low-mortality) hospitals were determined to have significantly lower FTR rates compared with low-performing (high-mortality) hospitals (6.8% versus 16.7%). Similar results have been reported among surgical series that included analyses of both adult and pediatric cardiac surgical patient populations [3, 4, 7]. Ghaferi and colleagues [4] demonstrated differences in FTR rates (6.8% versus 16.7%) between lowest and highest performing hospitals for Medicare patients undergoing several different subspecialty operations, including coronary artery bypass grafting and aortic and mitral valve operations. Similarly, Reddy and associates [3] recently reported that low-mortality hospitals demonstrate superior FTR abilities compared with high-mortality hospitals among a cohort of 45,904 adult cardiac surgery patients within a multiinstitutional ($n = 33$) patient population throughout the state of Michigan. Pasquali and colleagues [7] have corroborated these trends among pediatric cardiac surgical populations in a recent nationwide analysis using the STS Congenital Heart Surgery Database (2006 through 2009). The results of our study are consistent with those of the aforementioned series. As in other reports, our data demonstrate little variation in overall risk-adjusted complication rates (ie, risk-adjusted cardiac arrest) among hospitals, although significant variation exists in overall risk-adjusted mortality rates. However, unlike the former series, which have defined FTR as mortality after composite complications that may include several different (ie, 17 to 33) complications, our study exclusively focuses on the relationship between cardiac arrest and mortality as an FTR event. Thus, when we examined mortality after cardiac arrest (ie, FTR),

we demonstrated that although variations in risk-adjusted FTR rates occurred among hospitals, there was little correlation to overall risk-adjusted mortality and cardiac arrest event rates. More importantly, there was disproportionate variation in overall risk-adjusted mortality and risk-adjusted FTR rates relative to the small variation observed with risk-adjusted cardiac arrest rates. These results not only demonstrate the inherent difficulty in rescuing patients from cardiac arrest in the postoperative setting but also suggest that it may be possible to identify processes of care for resuscitation and care after cardiac arrest within high-performing (low FTR rate) hospitals to reduce FTR rates in lower performing hospitals in the future. Further analyses by the VCSQI to better define these processes will serve as the subject of future investigation within our organization.

Several noteworthy observations are apparent in our analyses. First, significant risk-adjusted associations between patient risk factors and the likelihood for FTR after cardiac arrest were demonstrated. These analyses identify certain at-risk patient populations, including those undergoing nonelective operations and those with preoperative renal failure. In addition, we noted an interesting trend for longer total intensive care unit and postoperative lengths of stay among high-performing hospitals (low mortality after cardiac arrest) compared with lower performing hospitals (high mortality after arrest). Although the exact circumstances surrounding individual patient encounters could not be further explored in these analyses, it is possible that such trends may partially reflect differences in philosophy related to early and expedited patient discharge that may affect FTR events after cardiac arrest. It is also possible that differences in length of stay may reflect that rescue of more patients after cardiac arrest comes with longer lengths of stay owing to having to stabilize a “sick” patient with likely other comorbidities who has just recovered from a cardiac arrest. Further, despite differences in hospital case-mix among hospitals, incremental differences in risk-adjusted cardiac arrest rates were apparent among centers. These findings have important clinical implications, as prior studies suggest that postoperative complication rates are largely determined by patient-related characteristics and risk factors [1]. Finally, an association between hospital procedure volume and FTR status after cardiac surgery was demonstrated on logistic regression analysis. Although no definitive conclusions can be drawn from this observation without further investigation into practice patterns between high- and low-volume hospitals, these results are in agreement with many other surgical series that demonstrate low mortality rates among higher volume centers despite generally uniform rates of postoperative complications [1, 3, 4, 10–14]. Potential explanations for these findings include improved process of care measures such as enhanced nurse-to-patient ratios, increased number and staffing of intensive care unit physicians, enhanced hospital technology, and protocol-based efforts for timely and early recognition of adverse postoperative events, including cardiac arrest, at higher volume centers [15, 16].

The present results have significant clinical and health care policy-related implications. The findings of wide differences in FTR rates after cardiac arrest among 17 different cardiac surgical centers suggests that significant changes in the approach to management of postoperative cardiac arrest (and other complications) have the potential to greatly improve patient outcomes in select hospitals. Furthermore, although FTR has been evaluated as a quality metric for many adult surgical populations, including cardiac surgery, it has also been endorsed by the National Quality Forum as a performance measure for which hospitals

are subject to evaluation [1, 2, 4, 5, 17, 18]. As a result, cardiac surgeon involvement in hospital-specific efforts designed to facilitate early recognition and response to adverse cardiac events immediately before and after cardiac arrest is essential for the future practice of cardiac surgery. Moreover, the impact of cardiac arrest and the ability to truly rescue patients from mortality should be evaluated in nationwide cardiac surgical cohorts to comprehensively realize the potential for clinical and quality improvement that exists in the modern surgical era.

The present study has limitations. First, the secondary analysis of a deidentified data registry limits the ability to scrutinize certain data. As a result, more-specific details related to the circumstances surrounding instances of cardiac arrest (ie, cardiac arrest time [day versus night] and location [operating room, intensive care unit, or ward], underlying etiology, availability of rescue teams, and resuscitation techniques including the use of mechanical circulatory support) remain unknown, and insight into these data could help to better identify at-risk patient populations in anticipation of cardiac arrest events. As the VCSQI begins to further investigate individual center differences in ability to rescue after cardiac arrest, we plan to prospectively gather these and other data points. We look forward to providing further insight into these differences as well as best practice models in the near future. Second, the retrospective study design introduces the potential for inherent selection bias. Third, reported results describe observed associations among various factors and mortality after cardiac arrest. These analyses do not demonstrate direct cause and effect relationships. The influence of differences in postoperative critical care management among institutions can also not be fully accounted for in these analyses. Although we are unable in these analyses to determine the contribution of underlying process of care measures or individual center protocols on the ability to rescue from mortality after cardiac arrest, these data are hypothesis generating. As a result of these analyses, the VCSQI has begun to look into this very issue within each particular hospital to identify best practice techniques to reduce mortality after cardiac arrest. Further qualitative and quantitative analyses will be used to implement efforts to better rescue patients in the future. All analyses were limited to short-term, operative outcomes. Finally, there always exists a small potential for unrecognized miscoding of data that must be considered in any secondary data analysis.

In conclusion, the presented data demonstrate that significant hospital variation exists in cardiac surgical mortality and FTR rates after cardiac arrest. Using multivariable regression analyses, institutional factors appear to confer the strongest influence on the likelihood for mortality after cardiac arrest compared with patient and operative factors. Postoperative morbidity does not appear to significantly differ among institutions. As a result, identification of best practice patterns at highest performing centers that can be extrapolated to lower performing centers may improve outcomes after postoperative cardiac arrest for patients undergoing cardiac surgery in the modern surgical era.

DISCUSSION

DR VINAY BADHWAR (Pittsburgh, PA): Very nice presentation. A quick question regarding types of intervention in the higher volume centers and their use of ECMO (extracorporeal membrane oxygenation) or additional cardiovascular support devices in

these cases; was this data available through this data set and can you comment on how this may influence failure-to-rescue results?

DR LAPAR: You highlight some great points that really drive at the next step in this project, which is to look within our organizations and figure out really what it is that's allowing us to have such variation. In terms of specific therapy for cardiac arrest, that's currently one of the areas that we haven't captured well in past. As a result, the ECMO data for this subpopulation of patients remains underpopulated in our prior datasets, so I would hesitate to draw any primary conclusions in this area.

But this is certainly an interesting area for future investigation so that we can figure out why some centers do better at rescuing patients after cardiac arrest than others.

DR THOMAS M. BEAVER (Gainesville, FL): Another practical question I think you are just alluding to. You may not have the answer to my question, which is, what is it at those centers? Do they have in-house intensivists? Was it teaching hospitals where they had greater perhaps resident availability that did better than maybe the smaller programs, or was it program size? Maybe you haven't looked at that yet.

DR LAPAR: I can answer part of your question but not all of it, partially because of the blinded nature of our dataset.

Based on our data, however, there does appear to be a trend that higher volume centers tended to have better failure-to-rescue rates than lower centers. I am not able to determine whether they were teaching hospitals or not. But I think those are things that we plan to talk about within our organization to try and really figure this out. As for some of the other factors such as number of intensivists or nurse-to-patient ratios, other surgical series have suggested that these may play a role in rescuing patients. We didn't have this data available, however, in our series.

DR DANNY CHU (Pittsburgh, PA): I am curious as to whether or not you saw a correlation between your high-performing hospitals and low-performing hospitals in terms of other metrics or outcomes, especially perioperative mortality and other complications. It may be correlated.

DR LAPAR: When I looked at complication rates, I didn't see a big difference in composite major complications and cardiac arrest between high- and low-performing centers. Certainly cardiac arrest patients tended to have more complications in general. The lower performing centers or the ones with the highest failure-to-rescue rates did tend to have higher mortality as well.

DR SCOTT A. LEMAIRE: (Houston, TX): Other system issues that might play a role would be things like the use of stepdown units and nurse-to-patient ratios. Are these system issues something you are going to be able to study as you go forward?

DR LAPAR: Those are great points. In fact, there is some literature out there suggesting that, in general, failure-to-rescue rates are improved with higher nurse-to-patient ratios;

orientation, design, and structure of intensive care units; and early protocols designed toward early detection of complications and tracking patients when they deviate off an expected clinical course. Those are things that we can look at within our institutions in the future. The next step in our organization is to distribute a survey about these things and try and figure how these factors influence FTR (failure-to-rescue) rates after cardiac arrest.

DR FAISAL BAKAEEN (Houston, TX): Can we read between the lines that hospitals are under pressure to fast-track patients and get them out of the surgical intensive care units prematurely?

DR LAPAR: Absolutely. In fact, our data suggests that high-performing hospitals tended to have longer ICU (intensive care unit) lengths of stay and longer postoperative lengths of stay by a day or two. This may indicate that some higher performing centers are actually finding a better balance between the pressure for fast-track protocols and early discharge from the ICU. That will be something that we will look into as well.

DR T. BRETT REECE (Denver, CO): Damien, what about the precode patients? These are the worst of the worst; over half of them are dying. Are we missing the boat that it needs to be that step before? The people that need to be transferred to the unit, they need a little more attention than their heart has stopped and all the monitors are going crazy?

DR LAPAR: This is an important point that undoubtedly impacts our ability to rescue patients from cardiac arrest. I believe that the implications of our data support this notion as well. Efforts to identify the precode patients, whether this would be through the development of a clinical composite score similar to the HERO score in pediatrics or another alternative, to identify at-risk patients is an area for future investigation. I personally believe this is where we are going to be able to make the biggest impact for these patients.

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Fig 1. Distribution of unadjusted postoperative cardiac arrest rates across Virginia Cardiac Surgery Quality Initiative hospitals ranked by failure-to-rescue (FTR) rate after cardiac arrest.

Table 1

Patient Characteristics and Profiles for All Cardiac Arrest Patients Stratified by Failure to Rescue (Decedents) and Non-Failure to Rescue (Survivors) Status

Risk Factor	FTR (n = 2,483)	Non-FTR (n = 1,655)	p Value
Sex			0.11
Female	40.0%	35.9%	
Male	60.0%	64.1%	
Cerebrovascular disease	21.3%	19.5%	0.41
Chronic lung disease			0.02
None	71.7%	76.6%	
Mild	11.2%	11.9%	
Moderate	9.1%	4.9%	
Severe	5.9%	5.6%	
Diabetes	41.2%	41.7%	0.84
Dyslipidemia	69.4%	71.5%	0.37
Hypertension	81.8%	78.1%	0.09
Infective endocarditis	3.8%	2.5%	0.18
Peripheral arterial disease	25.3%	18.5%	0.002
Atrial fibrillation	10.1%	9.8%	0.88
Prior heart failure	3.1%	3.9%	0.13
NYHA class			0.04
I	6.1%	5.3%	
II	15.8%	20.4%	
III	37.3%	41.0%	
IV	40.9%	33.3%	
Renal failure	10.5%	7.6%	0.06
Hemodialysis	11.0%	5.9%	0.001
Previous CABG	12.0%	10.8%	0.51
Previous valve	5.1%	3.2%	0.07
Status			
Elective	34.0%	44.7%	<0.001
Urgent	47.5%	45.9%	
Emergent	18.4%	9.3%	
Procedure type			0.01
AV replacement	6.5%	7.3%	
AV replacement + CABG	6.4%	9.7%	
AV replacement + MV replacement	.9%	.2%	
CABG only	40.9%	46.7%	
MV repair	1.1%	1.2%	
MV repair + CABG	3.8%	4.6%	
MV replacement + CABG	3.1%	2.5%	
MV replacement only	2.0%	2.2%	

Risk Factor	FTR (n = 2,483)	Non-FTR (n = 1,655)	p Value
Other	33.3%	24.2%	

AV = aortic valve; CABG = coronary artery bypass grafting; FTR = failure to rescue; MV = mitral valve; NYHA = New York Heart Association.

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Table 2

Risk-Adjusted Associations Between Patient-, Operation-, and Hospital-Related Risk Factors for the Outcome of Failure to Rescue (ie, Mortality) After Cardiac Arrest^a

Risk Factor	Likelihood Ratio (Wald)	AOR	p Value
Hospital	45.51		<0.001
Surgeon	40.90		0.01
Volume	38.56		<0.001
Nonelective status	24.88	2.78	<0.001
Procedure type (ref = "other")	13.00		0.02
AV replacement		1.01	0.39
CABG only		0.51	<0.001
MV repair		0.67	0.01
MV replacement		0.78	0.37
NYHA class	7.51		0.19
Chronic lung disease (moderate-severe)	6.37	1.99	0.10
Hemodialysis	6.02	1.74	0.01
Renal failure	4.97	1.36	0.03
Sex	2.35	0.77	0.13
Hypertension	1.19	1.24	0.27
Year	0.53		0.69

AOR = adjusted odds ratio; AV = aortic valve; CABG = coronary artery bypass graft; MV = mitral valve; NYHA = New York Heart Association.

^aModel performance: area under receiver operating characteristics curve = 0.82; Hosmer-Lemeshow $p = 0.95$; Nagelkerke Pseudo $R^2 = 0.25$.

Table 3

Comparison of Risk-Adjusted Event Rates for Overall Operative Mortality, Postoperative Cardiac Arrest, and Failure to Rescue After Cardiac Arrest Status Stratified by Virginia Cardiac Surgery Quality Initiative Hospitals

Hospital	Overall Risk-Adjusted Mortality	Overall Risk-Adjusted Cardiac Arrest	Risk-Adjusted Mortality After Cardiac Arrest	<i>p</i> Value
1	1.77%	3.07%	54.32%	<0.001
2	1.84%	3.79%	49.17%	<0.001
3	2.11%	3.94%	51.25%	<0.001
4	2.49%	3.97%	59.29%	<0.001
5	2.68%	2.56%	51.65%	<0.001
6	2.90%	4.33%	56.06%	<0.001
7	3.02%	3.27%	60.71%	<0.001
8	3.06%	5.48%	54.51%	<0.001
9	3.18%	4.71%	57.04%	<0.001
10	3.24%	3.12%	53.34%	<0.001
11	3.30%	5.12%	52.86%	<0.001
12	3.43%	3.96%	55.99%	<0.001
13	3.52%	4.14%	59.16%	<0.001
14	3.78%	4.86%	68.80%	<0.001
15	4.00%	5.08%	54.70%	<0.001
16	4.01%	4.90%	55.93%	<0.001
17	4.50%	4.22%	52.05%	<0.001