Uniform standards do not apply to readmission following coronary artery bypass surgery: A multi-institutional study

Robert Lancey, MD,[a] Paul Kurlansky, MD,[b] Michael Argenziano, MD,[b] Michael Coady, MD,[c] Robert Dunton, MD,[d] James Greelish, MD,[e] Edward Nast, MD,[f] Samuel Gwin Robbins, MD,[g] Melissa Scribani, MPH,[h] Judy Tingley, MPH, RN,[b] Timothy Williams, MD,[i] Alex Zapolansky, MD,[j] and Craig Smith, MD[b]

Objectives: Reducing hospital readmissions is a national priority, with coronary artery bypass graft (CABG) surgery slated for upcoming reimbursement decisions. Clear understanding of the elements associated with readmissions is essential for developing a coherent prevention strategy. Patterns of readmission vary considerably based on diagnosis. We therefore sought to clarify the factors most clearly associated with 30-day readmission following CABG surgery in an academically affiliated community hospital network.

Methods: All patients undergoing isolated CABG in an 11-hospital network from 2007 to 2011 were entered into a Society of Thoracic Surgeons (STS) compliant registry that tracks hospital readmission within 30 days of surgery. Data were split at random into training and validation groups that were used to create and validate a logistic regression model of pre-, intra-, and postoperative factors associated with readmission. Subanalyses included development of logistic models predicting readmission for the 2 largest institutions individually, and relatedness of readmission to CABG procedure.

Results: The readmission rate for the entire 4861 patient group was 9.2% and varied between hospitals from 6.1% to 18.0%. Factors associated with readmission were moderate chronic obstructed pulmonary disease (odds ratio [OR], 1.81; 95% confidence interval [CI], 1.04-3.14; $P = .036$), cerebrovascular disease (OR, 1.56; 95% CI, 1.09-2.24; $P = .016$), diabetes (OR, 1.44; 95% CI, 1.08-1.93; $P = .014$), congestive heart failure (OR, 2.12; 95% CI, 1.23-3.66; $P = .007$), intra-aortic balloon pump (OR, 0.40; 95% CI, 0.19-0.83; $P = .015$), and use of blood products (OR, 1.76; 95% CI, 1.31-2.37; $P = .0002$). Although the *c* statistic for the training model (n = 2341) was 0.643, when applied to the validation dataset (n = 2520) the area under the receiver operating curve was reduced to 0.57. Separate analyses of factors for the 2 largest hospitals revealed marked differences, with only body mass index (OR, 1.08; 95% CI, 1.04-1.12; $P = .0001$) significantly associated with readmission at 1 hospital, and discharge to extended care (OR, 2.11; 95% CI, 1.02-4.33; $P = .043$) and renal failure (OR, 2.64; 95% CI, 1.21-5.76; $P = .0149$) significant at the other hospital. Most readmissions (60.8%) occurred within 10 days of discharge. Nearly one-third (31.3%) were categorized as unlikely to be CABG-related. The mean number of days from surgery to readmission was less for readmissions clearly related to CABG (15.5 ± 6.4 days), compared with those unlikely to be CABG-related (17.4 ± 7.0 days) ($P = .05$).

Conclusions: Analysis of CABG readmission data from a network of community hospitals that vary in size and patient demographic characteristics suggests that there are many nonclinical factors influencing readmission; readmission rates and associated risk factors may vary considerably between centers; earlier readmissions are more likely to be procedure-related than patient-related; and therefore, considerable caution should be exercised in attempting to apply uniform standards or strategies to address post-CABG readmission. (J Thorac Cardiovasc Surg 2015;149:850-7)

From the Maryview Medical Center,[a] Portsmouth, Va; Columbia University,[b] New York, NY; Stamford Hospital,[c] Stamford, Conn; Upstate University Hospital,[d] Syracuse, NY; Caromont Health,[e] Gastonia, NC; Arnot Ogden Medical Center,[f] Elmira, NY; Methodist LeBonheur Healthcare,[g] Germantown, Tenn; Bassett Medical Center,[h] Cooperstown, NY; St Francis Hospital,[i] Greenville, SC; and The Valley Hospital,[j] Ridgewood, NJ.

Disclosures: Alex Zapolansky reports lecture fees from CorMatrix and equity ownership in Atricure. The other authors have nothing to disclose with regard to commercial support.

Read at the 94th Annual Meeting of The American Association for Thoracic Surgery, Toronto, Ontario, Canada, April 26-30, 2014.

Received for publication April 18, 2014; revisions received July 9, 2014; accepted for publication Aug 18, 2014; available ahead of print Oct 5, 2014.

Address for reprints: Robert Lancey, MD, Cardiovascular and Thoracic Services, Maryview Medical Center, 3636 High St, Portsmouth, VA 23707 (E-mail: Robert_lancey@bshsi.org).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2014.08.059

See related commentary on page 858.

Supplemental material is available online.

With the shift in health care economics from volume-based purchasing to value-based purchasing, numerous initiatives by payers have focused on rewarding for care high in quality, safety, and service, and penalizing care that is not. In October 2012, the Centers for Medicare and Medicaid Services presented the Hospital Readmission Reduction

Abbreviations and Acronyms
CABG = coronary artery bypass grafting
IABP = intra-aortic balloon pump
STS = Society of Thoracic Surgeons

Program, which codified financial penalties on hospitals with excessive rates of readmission within 30 days of discharge.[1] Initially designed for medical conditions, recent iterations have targeted surgical procedures, with coronary artery bypass graft (CABG) surgery being considered as a candidate.

Many studies have examined the risk factors and predictors for readmission following heart operations. However, the findings have been inconsistent and in some cases contradictory. There is potential value in a predictive model for readmissions that would enable focusing finite resources on those at highest risk. We have previously reported such a model for patients following CABG in a single institution.[2]

Along with the variety of clinical factors that have been identified as associated with readmission, variations in patient demographic characteristics, including socioeconomic status, are also emerging as important predictors.[3] A predictive model based on clinical factors alone might then be at risk for losing adaptability across institutions if there are powerful, nonclinical predictors at play that vary widely across institutions.

We report an approach to identifying patients at risk for readmission following CABG surgery in a multicenter academically affiliated network of community hospitals.

METHODS

This study received institutional review board approval with waiver of patient consent for use of de-identified registry data.

Data-Related Methods and Definitions

Using a Society of Thoracic Surgeons (STS) compliant registry, data were collected on consecutive patients undergoing isolated CABG in an 11-hospital network from 2007 to 2011. Not all hospitals contributed data for the entire time period. Time from surgery to readmission was calculated as the date of readmission minus the date of surgery, and time from discharge to readmission was calculated as the date of readmission minus the date of discharge.

The binary outcome of interest was readmission to the hospital within 30 days of the surgical procedure. Records with missing values on the outcome variable were excluded (n = 68), as were patients who died without readmission within 30 days of surgery (n = 6). Patients who died within 30 days of surgery but were readmitted first were included in the study. Data on readmission were obtained by the hospital data managers for those patients who were discharged alive and had not been readmitted to the operative hospital by direct contact with the patient and/or family.

Predictor variables included preoperative, intraoperative, and postoperative factors, as well as demographic characteristics, insurance status, discharge location, and body mass index. Insurance status was classified as self-pay, Medicaid, Medicare, and third-party payers. Discharge location was classified as extended care/other hospital, nursing home, or home. All complications and risk factors were dichotomized as either present or absent, with missing values assigned as absent.

Among readmitted patients, reasons for readmission were categorized according to their relatedness to CABG: clearly, possibly, and unlikely. Reasons that were categorized as clearly procedure-related were acute vascular complication, infection (conduit harvest site), infection (deep sternum), infection (mediastinitis), pericardial effusion/tamponade, and arrhythmia/heart block. Reasons classified as possibly procedure-related were coronary artery dysfunction, myocardial infarction and/or recurrent angina, deep venous thrombosis or pulmonary embolism, permanent cerebrovascular accident or transient ischemic attack, and pneumonia or other respiratory complication. Reasons classified as unlikely to be directly procedure-related were anticoagulation complications, congestive heart failure, and renal failure.

Analytic Methods

Readmission rates were calculated by year and by hospital. Distributions of preoperative, intraoperative, and postoperative risk factors for all patients were summarized as frequencies and proportions (or means $\pm$ standard deviation, as appropriate). Comparison of risk factors between all readmitted patients and those not readmitted was carried out using χ^2 tests (for categorical variables) or the independent samples t test (for continuous variables).

Independent predictors of readmission were identified by first splitting the dataset at random into a training dataset and a validation dataset. The training dataset was used for variable selection and development of the logistic regression equation to predict readmission. The validation dataset was then used to apply the equation to the remaining group of patients as a means to assess its ability to predict readmission as a clinical tool.

In the training dataset, variables were tested at the univariate level for their relationship to readmission. For categorical variables, univariate tests were carried out using the χ^2 test. For continuous variables, univariate tests were carried out using the independent samples t test.

Statistically significant variables at the univariate level were entered into a stepwise logistic regression model to predict readmission. Variables independently predictive of readmission ($P < .05$) at the conclusion of the stepwise modeling process formed the final logistic regression model. All analyses comprising the construction of the final logistic model were adjusted for clustering by hospital.

The finalized logistic regression equation was applied to the validation dataset, and the probability of readmission was estimated for each record. Sensitivity and specificity were calculated at 30 levels of probability of readmission. A receiver-operator characteristic curve was constructed, with the area under the curve estimated using trapezoidal approximation.

A subanalysis of readmission was carried out for 2 large hospitals in the network. These hospitals were chosen specifically to have disparate geographic and patient characteristics. Logistic regression models were constructed according to the methods described above. Training and validation datasets were not employed for this analysis.

In an additional subanalysis of readmitted patients, comparison of time to readmission across the 3-level CABG relatedness was carried out using 1-way analysis of variance. The recorded reasons for readmission were divided into categories estimating the likelihood for the readmission to be directly related to the procedure itself, as noted above. Scheffe post-hoc tests were used for pairwise comparisons of the mean days to readmission in each of the 3 readmission groups.

To assess the relationship between readmission and crude mortality, adjusted mortality, and adjusted combined mortality/morbidity, Pearson correlation was used. Adjusted mortality was calculated using the average predicted risk of mortality (from the STS database) divided by the true mortality rate for each hospital. Combined risk-adjusted mortality/morbidity