Predicting New-Onset Post-Coronary Artery Bypass Graft Atrial Fibrillation With Existing Risk Scores

Benjamin D. Pollock, PhD, MSPH, Giovanni Filardo, PhD, MPH, Briget da Graca, JD, MS, Teresa K. Phan, MS, MS, Gorav Ailawadi, MD, Vinod Thourani, MD, Ralph J. Damiano, Jr, MD, and James R. Edgerton, MD

Office of the Chief Quality Officer, Baylor Scott & White Health, Dallas, Texas; The Heart Hospital Baylor Plano, Plano, Texas; Division of Thoracic and Cardiovascular Surgery, University of Virginia, Charlottesville, Virginia; Division of Cardiothoracic Surgery, Emory University, Atlanta, Georgia; and Department of Cardiac Surgery, Washington University School of Medicine and Barnes-Jewish Hospital, St. Louis, Missouri

Background. **New-onset atrial fibrillation (AF) after coronary artery bypass graft (CABG) operation is associated with poorer survival. Blanket prophylaxis efforts have not appreciably decreased incidence, making targeted prevention for high-risk patients desirable. We compared predictive abilities of existing scores developed/used to predict adverse CABG outcomes (Society of Thoracic Surgeons' [STS] risk of mortality) or AF not associated with cardiac operation (the Cohorts for Heart and Aging Research in Genomic Epidemiology [CHARGE]-AF score, the CHA_2DS_2-VASc score), and a risk model for predicting postoperative AF following cardiac operations (POAF score), with age (the most consistently identified post-CABG AF risk factor).**

Methods. **Data submitted to the STS Adult Cardiac Surgery Database were used to assess new-onset AF in 8,976 consecutive patients without preoperative AF undergoing isolated CABG from 2004 to 2010 at five participating centers. Five logistic regression models (for CHA_2DS_2-VASc score, CHARGE-AF score, POAF score, STS risk score, and age, respectively, all modeled with restricted cubic splines) with a random effect for site were fitted to predict post-CABG AF. Estimates were used to compute and compare receiver operating characteristic (ROC) areas.**

Results. **New-onset AF occurred in 2,141 patients (23.9%). The ROC area was greatest for CHARGE-AF (0.68, 95% confidence interval [CI]: 0.67–0.69), followed by age (0.66, 95% CI: 0.65–0.68), POAF score (0.65, 95% CI: 0.64–0.66), CHA_2DS_2-VASc (0.59, 95% CI: 0.58 to 0.60), and STS risk of mortality (0.58, 95% CI: 0.56–0.59). CHARGE-AF was significantly more predictive than age ($p < 0.0001$); the other scores were significantly less predictive ($p < 0.0001$).**

Conclusions. **Only CHARGE-AF performed better than age alone. Its performance was moderate and comparable with published risk models specifically targeted at new-onset post-isolated CABG AF. Future research should continue to focus on developing better predictive models.**

(Ann Thorac Surg 2017;■:■–■)

The 30% to 40% of coronary artery bypass graft o (CABG) surgical patients who experience postoperative atrial fibrillation (POAF) are at increased risk of myocardial infarction [1], stroke [1–3], ventricular arrhythmias [4], persistent congestive heart failure [1], renal dysfunction/failure [3–5], gastrointestinal complications [3], and cognitive changes [5]; their postoperative course also consumes more health care resources through longer hospital and intensive care stays [1, 5]. The large number of studies seeking to identify predictors of post-CABG AF, together with the lack of any meaningful decrease in risk-adjusted incidence of post-CABG AF over time [6], demonstrates the failure of blanket prophylactic strategies to prevent this serious complication [7]. A method that accurately identifies patients at high risk would enable targeted preventive/therapeutic interventions, without exposing the overall CABG population to the risk of antiarrhythmic toxicity or the added drug costs [8]. As such, there is substantial value in being able to identify patients at high risk for post-CABG AF to ensure they receive optimal perioperative prophylaxis. Preventing the development of AF in this context could not only improve patients' short- and long-term outcomes but also help hospitals contain costs, particularly as implementation of Medicare's bundled payment for the 90-day "episode of care" initiated by a CABG procedure approaches [9].

Currently, there is no widely accepted risk model for predicting post-CABG AF, despite multiple efforts over the past 15 years to develop one [5, 7, 8, 10–13]. However, routinely used risk scores, such as The Society of Thoracic Surgeons (STS) risk of mortality score, have demonstrated utility for predicting outcomes other than operative mortality after cardiac operation, including stroke, renal failure, reoperation, acute kidney injury,

Accepted for publication June 28, 2017.

Address correspondence to Dr Filardo, Office of the Chief Quality Officer, Baylor Scott & White Health, 8080 North Central Expressway, Ste 900, Dallas, TX 75206; email: giovanfi@baylorhealth.edu.

0003-4975/$36.00
http://dx.doi.org/10.1016/j.athoracsur.2017.06.075

Abbreviations and Acronyms

AF = atrial fibrillation
CABG = coronary artery bypass graft
CHARGE = Cohorts for Heart and Aging Research in Genomic Epidemiology
CI = confidence interval
POAF = postoperative atrial fibrillation
ROC = receiver operating characteristic
STS = The Society of Thoracic Surgeons

prolonged ventilation, and length of stay [14–16]. Mortality risk scores have not yet been tested for the prediction of post-CABG AF. If such a score performs adequately in predicting post-CABG AF, it may ease implementation of explicitly considering risk of this complication during clinicians' and patients' shared decision-making process about treatment options, because it would be a familiar and trusted clinical tool being applied in a new manner, rather than an entirely new process around which trust and habit needs to be built.

Similarly, there are existing risk scores that predict new onset of AF outside the context of cardiac operations that may translate well into the population of patients undergoing CABG. These include the Cohorts for Heart and Aging Research in Genomic Epidemiology (CHARGE)-AF score, which was developed for this purpose, and the $CHADS_2$ and CHA_2DS_2-VASc risk scores, which were developed to predict risk of stroke in individuals diagnosed with AF, but show reasonable discrimination for the prediction of AF, especially when sex is excluded from the model [17, 18]. Previous studies have investigated CHA_2DS_2-VASc scores for the prediction of POAF but have included patients undergoing different types of cardiac operation (which carry different risks of POAF [19, 20]) and have used the CHA_2DS_2-VASc score to categorize patients into low-, intermediate-, or high-risk groups [21, 22].

Here, using data from a cohort of more than 9,000 isolated CABG patients without a history of AF, we investigate the ability of the STS risk of mortality score, the CHARGE-AF score, the CHA_2DS_2-VASc score, age (the most consistently identified risk factor for post-CABG AF [8]), and the risk model underlying the POAF score (developed as a bedside tool to predict POAF after cardiac operation [13]) to predict new-onset post-CABG AF as reported and defined in the STS Adult Cardiac Surgery Database.

Patients and Methods

Study Setting and Design

This large, multicenter, observational study included 9,416 consecutive patients, without a history of AF, preoperative endocarditis, or a ventricular assist device, who underwent isolated CABG between January 1, 2004, and December 31, 2010, at Baylor University Medical Center (Dallas, TX), The Heart Hospital Baylor Plano (Plano, TX), Emory University (Atlanta, GA), University of Virginia (Charlottesville, VA), or Washington University (St. Louis, MO). Patients for whom the STS Predicted Risk of Mortality score (n = 150, 1.5%) or the data needed to calculate CHARGE-AF (n = 285 missing both systolic and diastolic blood pressure, 3.1%; n = 5 missing systolic blood pressure only) were missing were excluded, resulting in a study population of 8,976.

The study was approved by the institutional review board for each center.

Study Data

Data about patients' demographic, operative, and clinical characteristics (including STS risk of mortality scores) were obtained from the participating institutions' routine submissions to the STS Adult Cardiac Surgery Database. These data were used to calculate the CHA_2DS_2-VASc [23], CHARGE-AF [24], and POAF [13] scores.

Outcome

The outcome of interest was development of new-onset post CABG AF, defined and reported in the STS database as "AF/flutter requiring treatment" [25].

Statistical Analysis

Patient characteristics were reported as frequencies (%) for categorical variables, mean (±SD), or median (interquartile range [IQR]) for continuous variables. The respective predictive abilities of the four risk scores and age for new-onset post-CABG AF were assessed by using five separate logistic regression models (one for each score and one for age): (1) STS Predicted Risk of Mortality score [26], (2) CHA_2DS_2-VASc score [23], (3) CHARGE-AF score [24], (4) POAF score [13], and (5) age [9].

To address variability in incidence of post-CABG AF among the sites, each model used a random effect for site. The models also included an independent variable (the relevant risk score or age) modeled using three-knot restricted cubic spline functions. Model estimates were used to generate receiver operating characteristic (ROC) curves, which were compared [27]. Age was used a "reference" group, given its straightforward utilization and role as the most consistently identified risk factor for new-onset post-CABG AF [9]. All analyses were performed using SAS 9.4 (SAS Institute, Cary, NC).

Results

The demographic, clinical, and operative characteristics of the study cohort are shown in Table 1. Incidence of new-onset post-CABG AF was 23.9% (n = 2,141). Patients who experienced AF were more likely to be male and white and had higher rates of preexisting chronic lung disease, cerebrovascular disease, peripheral vascular disease, congestive heart failure, left main disease, and prior valve operation. For the predictive scores of interest (age, STS risk of mortality, CHA_2DS_2-VASc, CHARGE-