

Decreasing prevalence but increasing importance of left ventricular dysfunction and reoperative surgery in prediction of mortality in coronary artery bypass surgery: Trends over 18 years

Khaled D. Algarni, MD, MHSc, Abdelsalam M. Elhenawy, MD, PhD, Manjula Maganti, MSc, Susan Collins, BSc, and Terrence M. Yau, MD, MSc, FRCSC

Objectives: The number of patients referred for coronary artery bypass grafting (CABG) has fallen, whereas their risk profile appears to be increasing. We evaluated changes in the predictors of hospital mortality among patients undergoing CABG during a span of 18 years.

Methods: Data were collected prospectively for all patients undergoing isolated CABG ($n = 23,445$) from 1991 to 2008. To examine the effect of time on patients' risk profiles and outcomes, we divided patients into 3 time cohorts (1991-1996, $n = 8280$; 1997-2002, $n = 9801$; 2003-2008, $n = 5364$). We used multivariable logistic regression model to identify predictors of mortality in the entire cohort and in each time cohort.

Results: Hospital mortality declined from 2.4% (1991-1996) to 1.2% (2003-2008; $P < .0001$). Urgent or emergency surgery, left ventricular dysfunction, reoperative CABG, increased age, female gender, hypertension, cardiogenic shock, congestive heart failure, peripheral vascular disease, left main disease, and earlier year of operation (1991-1996) were independent predictors of hospital mortality. The prevalence of most risk factors for mortality increased over the 18-year period of this study. In contrast, the prevalence of severe left ventricular dysfunction and reoperative CABG decreased significantly; however, their associated odds of mortality increased with time.

Conclusions: Whereas the prevalence of most risk factors increased with time, left ventricular dysfunction and reoperative CABG became significantly less common. However, the odds of mortality associated with these 2 predictors increased, indicating that although they occur less commonly, these 2 risk factors paradoxically play an increasingly important role in determining patient outcomes. (*J Thorac Cardiovasc Surg* 2012;144:340-6)

Supplemental material is available online.

During the past 2 decades, increasingly older patients with more comorbidities have been referred to cardiac surgeons for coronary artery bypass grafting (CABG). Despite increasing patient risk factors over time, many studies have shown consistent improvement in operative outcomes.¹⁻⁴

Over the past decade, however, many cardiac centers have noted decreasing volumes of isolated CABG. Aldea and colleagues⁵ reported a decrease of 37% in CABG volume, while

the volume of percutaneous coronary interventions (PCIs) increased by 71%. This reduction in CABG volumes may have multiple effects, including an impact on hospital outcomes. A number of studies have reported associations between hospital volumes and outcomes,⁶⁻⁸ although this relationship remains controversial. In the context of decreasing volumes and increasing risk profiles for patients undergoing isolated CABG, we analyzed our experience during an 18-year period to evaluate changes in patient risk profiles, document their outcomes, and determine changes in the independent predictors of hospital mortality.

METHODS

Data Collection and Definitions

Clinical, operative, and outcome data were collected prospectively in a computerized database for 23,445 consecutive patients undergoing isolated CABG at our institution between January 1, 1991, and December 31, 2008. Patients undergoing CABG with other concomitant procedures were excluded.

The study was approved by our institutional research ethics board. The primary outcome was hospital mortality, which was defined as any postoperative death during the index hospitalization. Variables collected included age, sex, left ventricular (LV) grade (by LV ejection fraction [LVEF]: grade 1, LVEF $\geq 60\%$; grade 2, LVEF 40%-59%; grade 3, LVEF 20%-39%; grade 4, LVEF $< 20\%$), previous CABG, urgency of operation (semiurgent, indicating an operation during the same admission as a cardiac

From the Division of Cardiovascular Surgery, Peter Munk Cardiac Center, University Health Network, Department of Surgery, University of Toronto, Toronto, Ontario, Canada.

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Address for reprints: Terrence M. Yau, MD, MSc, FRCSC, Division of Cardiovascular Surgery, Toronto General Hospital, 4N-470, 200 Elizabeth St, Toronto, Ontario, Canada M5G 2C4 (E-mail: terry.yau@uhn.on.ca; khaled.algarni@utoronto.ca). 0022-5223/\$36.00

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Abbreviations and Acronyms	
BMI	= body mass index
CABG	= coronary artery bypass grafting
LV	= left ventricular
LVEF	= left ventricular ejection fraction
OPCAB	= off-pump coronary artery bypass grafting
OR	= odds ratio
PCI	= percutaneous coronary intervention

catheterization or a cardiac event; urgent, indicating an operation within 72 hours of an event; emergency, indicating an operation within 12 hours of an event), number of diseased coronary arteries, presence of greater than a 50% stenosis of the left main coronary artery, and severity of angina, among other data.

Statistical Analyses

All statistical analyses were performed with SAS version 9.2 (SAS Institute, Inc, Cary, NC). To examine the effect of time on patient risk profiles and outcomes, we divided patients into 3 groups according to the year of operation (1991-1996, 1997-2002, and 2003-2008). Contingency table analysis was then used to evaluate changes with time in prevalence of preoperative, intraoperative, and postoperative variables. Univariate analyses were performed with χ^2 or Fisher’s exact test for categorical variables and analysis of variance for continuous variables. Variables that had a univariate *P* value less than .25 or those of known clinical importance were submitted to a multivariable logistic regression model using a stepwise backward elimination method to calculate risk-adjusted mortality and factor-adjusted odds ratios (ORs). Model discrimination was evaluated by the area under the receiver–operator characteristic curve, and calibration was assessed with the Hosmer-Lemeshow goodness-of-fit statistic. The model was evaluated for multicollinearity with the variance inflation factor where variance inflation factor less than 2.5 indicates multicollinearity.

RESULTS

Baseline Characteristics and Survival

A total of 23,445 patients underwent isolated CABG between 1991 and 2008. A trend in volume of isolated CABG over the 18-year span is depicted in Figure 1. The number of patients increased progressively from 1991, peaked in 1998

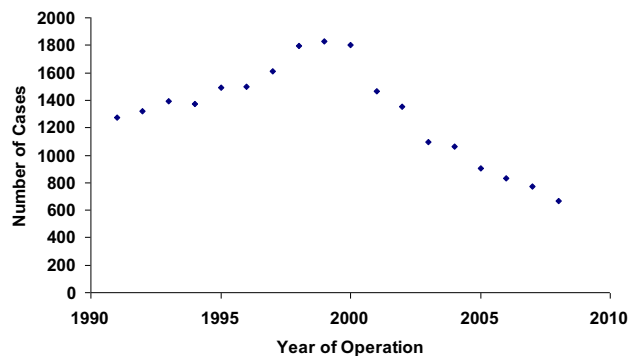


FIGURE 1. Trends in number of patients undergoing isolated coronary artery bypass grafting between 1991 and 2008.

(n = 1829), and then decreased substantially, by almost 70%, from 1998 to 2008.

Preoperative patient characteristics are detailed in Table 1. The prevalence of most risk factors increased steadily. The rate of left main disease almost doubled between the first and the last time cohort (18.6% vs 33.3%). The number of patients undergoing semiurgent surgery has increased over the last 2 cohorts, whereas the number of patients undergoing elective, urgent, or emergency surgery has declined significantly. The prevalence of patients with LV dysfunction (LVEF < 60%) has decreased over time, from 70% in the first time cohort to 50% in the last one. The prevalence of reoperative CABG declined as well. The changing risk profile of patients undergoing CABG during this 18-year span is depicted in Figure E1.

Intraoperative variables and postoperative outcomes are detailed in Table 2. The overall in-hospital mortality declined significantly from 2.4% in the first time cohort to 1.2% in the last one. Although the duration of intensive care unit stay has fluctuated, the duration of hospital stay declined significantly with time. Trends of postoperative outcomes are shown in Figure 2.

Predictors of Hospital Mortality

Analysis of the 23,445 patients undergoing operation during the entire 18-year period of the study using stepwise multivariable logistic regression showed the following factors to be independent predictors of hospital mortality: increased age, female gender, hypertension, peripheral vascular disease, LV dysfunction, cardiogenic shock, congestive heart failure, reoperative CABG, left main disease, urgency of surgery, and earlier year of operation (Table E1). Emergency CABG carried the most significant risk (OR, 4.5), followed by LVEF less than 20% (OR, 4.2) and then reoperative CABG (OR, 3).

Trends in Multivariable Risk Factors for Hospital Mortality

The changing trends in independent predictors of hospital mortality by time cohort are detailed in Table 3. Unadjusted hospital mortality associated with individual predictors is shown in Figure E2.

LV dysfunction. Moderate (LVEF 20%-39%) and severe (LVEF < 20%) LV systolic dysfunction were predictors of hospital mortality in the first time cohort. In the second cohort, however, LVEF did not predict mortality. LV systolic dysfunction then reappeared as a significant predictor of mortality in the last time cohort. The overall mortality for patients with an LVEF less than 20% declined significantly from 11.1% in the first time cohort to 6.4% and 6.3% in the second and the third time cohorts, respectively. Similarly, for patients with an LVEF of 20% to 39%, the observed mortality declined from 3.6% in the first time cohort to 1.8% in the second and 2.3% in the last time cohort.

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