Predicting Long-Term Survival for Coronary Artery Bypass Graft Surgery and Percutaneous Coronary Intervention

Another Important Step Forward

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In this issue of the journal, 2 distinguished groups of investigators have published long-term (3-year) statistical models for predicting mortality following the 2 primary invasive treatments for coronary artery disease, coronary artery bypass graft (CABG) surgery and percutaneous coronary intervention (PCI). 1,2 The studies are noteworthy in a few respects: (1) they are huge in that they each comprise more than 340,000 patients who have undergone the procedure of interest; (2) they use registries maintained by national professional societies, the Society of Thoracic Surgeons and the American College of Cardiology Foundation; and (3) data from each of the registries are linked to mortality data from the Centers for Medicare and Medicaid Services to obtain long-term mortality for patients in the study.

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In addition, the methods used in the studies are characterized by meticulous attention to all of the nuances that are recommended to ensure that the most accurate possible models are obtained—training and validation samples, investigation of proportional hazards assumptions and the consequent separation of models into different time frames, investigation of the functional form of independent variables, testing for interactions, imputation of missing values, and assessment of calibration and discrimination. For PCI, different models were developed for patients with and without ST-elevation myocardial infarction to acknowledge the fundamental difference between those 2 types of patients.

The finding that some risk factors are more important in the early stages following the procedure and others are more important later on, also noted by MacKenzie et al, 3 is particularly interesting. Shahian et al 1 found that some early predictors of risk (smoking, insulin-dependent diabetes mellitus, and dialysis-dependent renal failure) increased over time, whereas others (emergency status, cardiogenic shock, acute myocardial infarction) were no longer significant as longer-term predictors after patients survived the procedure recovery period. Weintraub et al 2 found that male sex was protective within the first month but associated with significantly higher mortality after that. Also, preprocedure stenosis, emergent/urgent priority status, cardiogenic shock, and other acute presentation variables were associated with significantly higher mortality in the first month, but were not significantly related to mortality after that.

It is noted in the studies that these data can be used for shared decision making, comparative effectiveness research, quality improvement, and provider profiling. 1,2 The following are some observations/opinions about operationalizing the studies for these purposes. Shared decision making is perhaps the use for which the statistical models are most easily adopted. A patient’s clinical characteristics can be input into the models, and the expected survival following each procedure could be obtained. For short-term models, risk scores (risk indices) that do not require computations based on logistic models have also been developed to facilitate estimates, and this could also be done with the long-term models in these studies. 4,5 Obviously, quality of life, short-term mortality and other adverse outcomes, risk averseness to short-term mortality, possibility of various complications, rehabilitation period, and other considerations would also need to be taken into account in the final decision. A limitation of the studies with regard to using them simultaneously for shared decision making is that it would not be possible to determine definitively if the estimated survival times for the 2 procedures were significantly different (confidence intervals could be obtained for each of them, but the databases would need to be combined to determine whether the survival difference between the 2 procedures was different from zero).

Use of the models for comparative effectiveness research would yield determinations about the relative survival of the 2 competing interventions for all patients who are candidates for them, and for subsets of patients (eg, people with diabetes mellitus, patients with 3-vessel disease, and patients with renal failure), as well. Typically, the way this would be done would be to combine the data from The Society of Thoracic Surgeons (STS) and CathPCI registries before analysis. Then, there would be identical data elements used for evaluating the long-term survival for CABG surgery and PCI patients, and for subsets of patient with certain characteristics, as well. This would require confirming that the data elements that are used have common definitions (which I believe is true, for the most part, in the STS and CathPCI databases). Although there are large differences in the variables that are significant predictors of long-term mortality for CABG surgery and PCI as presented by Shahian et al 1 and Weintraub et al, 2 it would.
be curious to see if the degradation in calibration and discrimination would be large if the 2 models were constrained to use the same set of predictor variables. If the degradation were minimal, a more valuable product for future use in comparative effectiveness research would be a single model with common variables for CABG surgery and PCI patients and a dummy variable for CABG/PCI. Models for comparative effectiveness for patient subsets could be created in the same manner. Examples of this strategy are some comparative effectiveness studies for CABG surgery and PCI using the New York registries.\textsuperscript{6,7} This work is apparently underway with the use of the STS and CathPCI registries.\textsuperscript{8}

With regard to provider profiling, the authors correctly state that, because deaths among critically ill postoperative patients on advanced mechanical and pharmacological support after cardiac procedures may not occur until months afterward, it is desirable to obtain longer-term mortality to capture procedure-related deaths.\textsuperscript{7} This is certainly true, and it raises questions regarding the optimal time frame to use for provider profiling purposes. Obviously, >1 time frame (eg, in-hospital/30-day, 90-day, 1-year) can be used, and consistency of provider assessment (outlier status, risk-adjusted rate quartile) could be examined for each provider.

One obvious concern about using time frames that may be too long for profiling is that patients may die for reasons unrelated to the care they received during the index admission. This bias could be reduced by adding variables that may capture the tendency to die for reasons unrelated to the care in the index admission. Socioeconomic variables (race, payer, income) would be particularly important to examine, and it would be interesting to see whether these variables would emerge as significant when in competition with the significant predictors in the Shahian and Weintraub models.

However, a major limitation of these studies for provider profiling is the process for linking STS (or CathPCI) data to Centers for Medicare and Medicaid Services data to append the date of death to each patient. This matching process is hampered by the absence of unique identifiers in STS and CathPCI; consequently, variables such as site, age, sex, admission date, discharge date, and birth date were used in the matches. The apparent linking percentages were 66% for CathPCI and 72% for STS.\textsuperscript{1,2} Although matched and unmatched patients in the CathPCI database were shown to have similar characteristics, the loss of this many patients would render the linked CABG and PCI databases unusable for purposes of provider profiling because of the concern that missing patients may significantly bias risk-adjusted mortality assessments.

A limitation to using the results for any of the purposes mentioned above is that, because the linkage to long-term mortality involved Medicare data, the results apply only to patients $\geq 65$ years of age. This means that not only is the estimated survival time limited to older patients, but also the relative magnitude of the significant predictors of mortality may not be the same for younger patients as they are for patients $\geq 65$ years of age. Thus, the models are not really of use to patients $< 65$ years of age who undergo CABG surgery and PCI. Weintraub et al found that 50% of the patients in CathPCI were $< 65$ years of age, and although this percentage was not reported by Shahian et al for CABG surgery patients, it was 45% in 2009 in New York State. Thus, future efforts to create long-term mortality models for cardiac procedures should ideally include patients of all ages and should examine whether the impact of other significant risk factors on mortality is related to patient age (ie, should examine whether there are significant interactions between age and the other significant predictors of mortality).

In summary, the studies by Shahian et al and Weintraub et al are important contributions to the cardiac outcomes research literature and will serve as important building blocks for future studies and initiatives related to predicting, assessing, and improving outcomes for CABG surgery and PCI.

Disclosures

None.

References


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