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EDITORIAL COMMENT

Risk-Adjusted Models of 30-Day Mortality Following Coronary Intervention

How Can They Be Made More Clinically Relevant?*

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Risk-adjusted prediction models of percutaneous coronary interventional (PCI) outcomes have several purposes. Foremost is their utility to assess programmatic and operator quality, and are now considered the standard for this purpose, supplanting procedural volume and unadjusted complication rates (1). Less successful has been their application in clinical practice to assist decision making. This seems surprising, given the success that the Society of Thoracic Surgeons (STS) Registry (2) and EuroSCORE (3) have achieved in assessing the risks of coronary artery bypass grafting (CABG).

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One critical limitation of PCI risk models is that although highly predictive of in-hospital mortality, most are not constructed to predict longer-term survival or other procedural complications (1). In this issue of *JACC: Cardiovascular Interventions*, Hannan et al. (4) present a highly accurate in-hospital and 30-day mortality prediction model derived from the New York State PCI Reporting System 2010 data (NYS-2010-score). There were 54,223 patients who underwent PCI at 58 hospitals included in the registry, with an overall in-hospital/30-day mortality rate of 1.03%. A logistic model was constructed to identify the factors that were significantly related to mortality, and each was then assigned an integer value reflecting its relative correlation with mortality. The resulting score is a straightforward additive calculation with results ranging from 0 to 43. Clinical factors included in the model are similar to those found in other PCI mortality models (1). The c-statistic for the model was 0.89, demonstrating quite similar discrimination to other mortality models, and the Hosmer-Lemeshow statistic was 16.11, indicating fair calibration. Predicted mortality ranged from 0.09% for a risk score of 0, to a maximum risk score of 43, denoting a mortality risk of 99.94%. This risk model has several strengths: it is easy to calculate, and the score is easily comprehended. The variables used to construct the model are objectively defined. The population cohort from whom the score is derived is large, reflecting the practices of a large and varied number of operators and institutions. Registry data collection is compulsory rather than voluntary, and is routinely audited for accuracy and completeness.

The NYS-2010-score presents an accurate, easy-to-use prediction tool that would appear to be useful in clinical decision making. So why hasn't a quantitative approach to pre-PCI risk assessment gained widespread utilization, similar to the CABG scores? In part, the distribution of low-risk versus high-risk patients undergoing PCI limits the clinical utility of all current risk scores. Using 1% and 5% in-hospital/30-day mortality as rough thresholds for low-risk and high-risk patients, respectively, the user finds a problematic distribution. In the registry, 87.9% of patients had risk scores $\leq$8, corresponding with a predicted risk of $\leq$1.31%. Hence, the vast majority of patients receiving PCI are at low risk, with little gradient of risk conveyed by the model. Conversely, only 3.8% of patients had risk scores $\geq$12, corresponding to a predicted risk $>$4.79%. Moreover, nearly all the individual risk factors contributing $\geq$5 points to the risk score are intuitively obvious (presence of shock, ST-segment elevation myocardial infarction—any timing, age $\geq$86 years, renal failure requiring dialysis, and recent non–ST-segment elevation myocardial infarction). Perhaps most significantly, just 9.3% of all patients are "intermediate" risk, and these are differentiated into only 3 levels of gradation.

The NYS-2010-score extends the mortality endpoint to 30 days from the index procedure to more accurately reflect short-term mortality after PCI. Thirty-day mortality was found to be 40% greater than in-hospital mortality, similar to previously reported data (5). In utilizing the NYS-2010-score for purposes of evaluating individual operator and institutional risk-adjusted outcomes, one must consider to what degree expanding the endpoint to include 30-day mortality may confound procedural-related mortality with that resulting from overall disease burden and/or inadequately treated comorbid conditions after discharge.

Inherent Limitations of Quantitative Mortality Models

There is little experience in developing risk scores to predict health status or quality of life, which may be what the majority of patients value most, particularly the elderly (6).

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By any measure, short-term survival is not the outcome that best captures what concerns patients, nor the best gauge of revascularization strategy (7,8), and may further emphasize the power of risk aversion in medical decision making (9).

The value of the models is determined entirely by the specific variables collected by the sponsoring registry. Therefore, although highly accurate as a metric of programmatic and operator quality in large populations, there are intrinsic limitations when applied to particular patients. For example, existing registries do not collect specific data concerning patient frailty (10), incomplete revascularization (7,11), patient preferences, many comorbid conditions, or other extenuating circumstances that may be highly relevant to the decisions being made.

Moreover, although the models accurately evaluate procedural risk, they do not assess potential benefit. Hence, they cannot be used to appraise the risk–benefit ratio, which is the foundation of clinical judgment. For this reason, they cannot be used to evaluate the appropriateness of the intervention and thus cannot be the determining factor in decision making (12).

Recent models incorporate integer-based risk scores to quantify the risk from the PCI procedure; this simplifies their use by patients and their healthcare providers. However, few busy clinicians will carry around the point systems for these models. Online open access to STS allowing calculation has facilitated the use of this model for CABG, and its value as a teaching tool as well as a useful instrument for the clinician is unquestioned. Why the National Cardiovascular Data Registry (NCDR) does not have similar access to its algorithms (5,13) for its users on its website is incomprehensible. NCDR also has excellent models that predict bleeding and renal dysfunction, as well as outcomes in specific patient subsets, that should not be relegated to a dusty library but rather used by doctors in everyday practice. Although less useful, there are free mobile device programs that allow lesion-specific calculations of PCI risk.

Probably the most significant limitation of these models, including the NYS-2010-score, is that each is statistically dominated by cardiogenic shock, acute MI, and poor left ventricular function. These evident associations limit the applicability of the models in the patients for whom an objective assessment of risk might be particularly impactful. One solution may be the development of separate models for stable coronary artery disease patients. Strictly speaking, this would not be necessary if there were adequate predictive discrimination in the intermediate range; however, as is clear in Hannan et al. (4), this is not typically the case because the majority of the population selected for PCI in contemporary practice present with an acute coronary syndrome.

The challenge for future PCI risk models is to overcome the limitations imposed by the existing structure of the registries from which they are derived and become more accessible for real-time clinical decision making. To accomplish this transformation, they must be modified to integrate factors and outcomes that will more effectively guide physicians and patients.

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