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Percutaneous Intervention and In-Hospital Mortality: A Contemporary Risk-Prediction Model

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Editorial

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Risk-prediction models play a pivotal role in informing clinical decisions both in ensuring and measuring quality of care and in helping payers determine payments to healthcare institutions. The CathPCI registry is a national surveillance system, designed to assess characteristics and outcomes of patients undergoing coronary angiography and percutaneous intervention (PCI) in the United States.[1] The CathPCI registry collects data from >1,600 hospitals in the United States. In 2013, Brennan et al. performed an analysis of the CathPCI registry and reported an overall in-hospital mortality of 1.4% and developed three scoring models (pre cath, full model, and a simplified bedside model) to predict mortality in these patients.[2] However, given concerns that this existing model does not perform well in extremes of risk as well as for lower-volume hospitals, a newer, more contemporary model was needed.[3] An additional driver for more accurate risk prediction is the public reporting of PCI outcomes and use of these models to determine payment to hospitals. Several reports have indicated that while, theoretically, this may allow for improved standardization of care and appropriate patient selection, there is an increasing concern that these drive risk-averse behavior among interventional cardiologists, wherein patients who are appropriate for coronary angiography and revascularization may not undergo these procedures.[4,5] For example, in an analysis of the SHOCK registry, patients with acute myocardial infarction and cardiogenic shock from New York (a state that has mandated public reporting of PCI outcomes) had a higher adjusted mortality and were less likely to undergo angiography and PCI. They also were likely to wait significantly longer to undergo coronary artery bypass grafting than their non-New York counterparts.[5]

Given these concerns, Castro-Dominguez et al. studied 706,263 PCIs between July 2018 and June 2019 using the CathPCI registry.[3] They used version five of the data collection form (launched in 2018), which included new variables such as frailty, cardiovascular instability, level of consciousness after cardiac arrest, and decision for PCI with surgical consult. The study population was allocated randomly into a model-development cohort (70% of total) and a validation cohort (30% of total). The authors created a new ordinal variable to reflect clinical severity. This included six mutually exclusive categories: (1) salvage PCI or refractory shock, (2) cardiogenic shock (not refractory) without salvage, (3) cardiovascular instability (CVI) (includes hemodynamic instability, acute heart failure symptoms, and ventricular arrhythmia in the absence of shock) without salvage, (4) emergency PCI without shock or CVI, (5) urgent PCI without shock or CVI, and (6) elective PCI without shock or CVI. The National Cardiovascular Database Registry established a work group of volunteers to oversee model development and to provide input on variable selection. Candidate variables were screened and selected based on clinical relevance and association with mortality based on prior research. Final variable selection was based on persistence of statistical significance in more than 700 permutations of the 1,000 bootstrap samples randomly created in the derivation set.[6] Thereafter, a multivariate linear regression model was created linking mortality to the selected variables. Three models were created (similar to the 2013 risk assessment score).[2] These included (1) a full model that included all the candidate variable, (2) a pre-cath model that excluded angiographic data, and (3) a simplified bedside risk score (which included variables that explained >90% of the model).

The mean age of patients in the study was 66 years; 31% were women, and 85% of patients were white. Elective procedures represented 39% of the population. The overall mortality was 1.9% (similar in both development and validation cohorts). The mortality ranged from 0.2% for elective procedures without CVI or shock to 62% in salvage PCI or refractory shock cases. The full model included 21 unique variables of which the following are new to the 2021 model: unresponsiveness after cardiac arrest, severe frailty (in patients without cardiac arrest, shock, or salvage), moderate or more severe aortic stenosis, and surgery not recommended. The bedside risk score model contains the variables (age, chronic kidney disease, clinical instability, cardiac arrest) that had the strongest association with mortality and that in combination explained >90% of the risk model (Fig 1).[3] This has changed significantly from the prior bedside model (2013), which included ST-elevation myocardial infarction, age, body mass

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The Bedside Risk Score (adapted from *Castro-Dominguez et al*)

Variable	Total Points
Age	1-10 points *(1 point for decade above age 10)*
CKD stage	
GFR >60 ml/min/1.73 m²	0
GFR 45-60 ml/min/1.73 m²	1
GFR 30-44 ml/min/1.73 m²	2
GFR 0-29 ml/min/1.73 m²	3
Clinical Instability	
Salvage PCI or refractory shock	13
Cardiogenic shock without salvage	11
CVI without shock/salvage	7
Emergent PCI without shock/CVI	6
Urgent PCI without shock/CVI	3
Elective PCI without shock/CVI	0
Cardiac Arrest	
Responsive	1
Non responsive	5

A 50-year-old man with refractory cardiogenic shock secondary to anterior STEMI and no other comorbidities undergoing PCI of the LAD.
2021 bedside model: Total points [5 (age) +13 (refractory shock)] = 18 (~23% risk of mortality)
2013 bedside model: Total points [6 (STEMI) + 0(<60 y of age) + 3 (no prior PCI) + 43 (sustained shock)]=52 (~4% risk of mortality)

A 64 year-old man with heart failure (LVEF of 25%), prior stroke, known CAD with prior PCI to the LAD, DM (on insulin) who is undergoing elective PCI to the RCA for angina.
2021 bedside model: Total points= 6 (age) (0.07% risk of mortality)
2013 bedside model: Total points [4 (age) + 2(CVD) + 3 (DM) + 9 (LVEF)]=18 (~0.2% risk of mortality)

Fig 1. The bedside risk score. CKD, chronic kidney disease; CVI, cardiovascular instability; DM, diabetes mellitus; LAD, left anterior descending; LVEF, left ventricular ejection fraction; PCI, percutaneous intervention; RCA, right coronary artery; STEMI, ST-segment elevation myocardial infarction.

index, cerebrovascular disease, peripheral arterial disease, chronic lung disease, prior PCI, diabetes, glomerular filtration rate, ejection fraction, cardiogenic shock/PCI status, New York Heart Association class, and cardiac arrest.[2] Traditional predictors of risk, such as ejection fraction, and comorbidities, such as diabetes, lung disease and peripheral arterial disease, have lost their place in the new model. It is possible that this is due to the technical and technologic advancements over the years. However, as the overall mortality following PCI remains unchanged, it is more likely that it reflects the higher discriminatory power of variables such as clinical instability. For example, for a relatively young patient with clinical instability (50-year-old with cardiogenic shock following ST-segment elevation myocardial infarction), the model reclassifies the patient to a higher-risk subgroup (Fig 1). This is important for quality control, payments to hospitals, and public reporting of data, as it appropriately reflects the risk profile of patients with a high degree of clinical instability. To conclude, new variables that were associated with higher in-hospital mortality included pre-PCI clinical instability, unresponsiveness after cardiac arrest, moderate aortic stenosis, inoperable patients, and patients with high frailty scores. Also, for the first time, emphasis on a multidisciplinary heart team approach was noted and will be included in the overall risk modeling. One of the key limitations of this dataset was that participation in the registry was voluntary and although data were included from >90% of US hospitals, it may not be reflective of smaller hospitals or non-US practices.[3] Regardless, the new model does have excellent discrimination in the derivation and validation cohorts and, therefore, is one that likely will be used routinely in estimating risk for patients undergoing PCI and will aid in standardizing risk assessment for payers, hospitals, and physicians.

Conflict of Interest

None

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