Comparison of Prospective Risk Estimates for Postoperative Complications: Human vs Computer Model

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BACKGROUND: Surgical quality improvement tools such as NSQIP are limited in their ability to prospectively affect individual patient care by the retrospective audit and feedback nature of their design. We hypothesized that statistical models using patient preoperative characteristics could prospectively provide risk estimates of postoperative adverse events comparable to risk estimates provided by experienced surgeons, and could be useful for stratifying preoperative assessment of patient risk.

STUDY DESIGN: This was a prospective observational cohort. Using previously developed models for 30-day postoperative mortality, overall morbidity, cardiac, thromboembolic, pulmonary, renal, and surgical site infection (SSI) complications, model and surgeon estimates of risk were compared with each other and with actual 30-day outcomes.

RESULTS: The study cohort included 1,791 general surgery patients operated on between June 2010 and January 2012. Observed outcomes were mortality (0.2%), overall morbidity (8.2%), and pulmonary (1.3%), cardiac (0.3%), thromboembolism (0.2%), renal (0.4%), and SSI (3.8%) complications. Model and surgeon risk estimates showed significant correlation ($p < 0.0001$) for each outcome category. When surgeons perceived patient risk for overall morbidity to be low, the model-predicted risk and observed morbidity rates were 2.8% and 4.1%, respectively, compared with 10% and 18% in perceived high risk patients. Patients in the highest quartile of model-predicted risk accounted for 75% of observed mortality and 52% of morbidity.

CONCLUSIONS: Across a broad range of general surgical operations, we confirmed that the model risk estimates are in fairly good agreement with risk estimates of experienced surgeons. Using these models prospectively can identify patients at high risk for morbidity and mortality, who could then be targeted for intervention to reduce postoperative complications. (J Am Coll Surg 2014;218:237–245. © 2014 by the American College of Surgeons)

Current quality assessment programs for surgery, such as the voluntary American College of Surgeons National Surgical Quality Improvement Program (NSQIP), have led to improvement in surgical outcomes.[1-4] These programs are limited in their ability to affect individual patient care by the retrospective audit and feedback nature of their design. A more optimal strategy for patient perioperative risk mitigation might be to prospectively identify risk at the

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Members of the DS3 Study Group are listed online in Appendix 1.

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Abbreviations and Acronyms

ACS = American College of Surgeons
ASA = American Society of Anesthesiologists
BMI = body mass index
DS3 = Decision Support for Safer Surgery
RVU = relative value units
SSI = surgical site infection

individual patient level preoperatively to allow enough time to engage in strategies to prevent specific surgical complications. Although there is abundant literature on the risk factors for adverse perioperative events,[5-8] few available decision aid tools assess the patient and procedure risk variables for a broad group of operative procedures and surgical outcomes. Furthermore, minimal knowledge is available on the accuracy or precision of surgeon risk assessment with or without decision aid tools.

The purpose of this study was to compare risk estimates from statistical models previously developed and evaluated[9] with risk estimates from the patients' surgeons for 30-day postoperative mortality, overall morbidity, and cardiac, pulmonary, thromboembolic, renal, and surgical site infection (SSI) complications in a diverse group of elective general surgical patients. In so doing, we sought to evaluate the predictive validity of the DS3 model in predicting perioperative risk for specific complications and the face validity of this model by correlating the model risk predictions to those of experienced surgeons. We hypothesized that the statistical models using patient preoperative characteristics could provide risk estimates of postoperative adverse events comparable to risk estimates provided by experienced surgeons and that the models could be useful for prospective, preoperative assessment of patient risk.

METHODS

Approvals

The study was approved by the Institutional Review Boards at the University of Colorado Denver, the University of Utah, the University of Alabama at Birmingham, and the New England IRB for QCMetrix, Inc.

Statistical prediction models

Development of the statistical prediction models is described in detail elsewhere,[9] and will only briefly be described here. We used NSQIP data on 60,411 patients undergoing elective general and vascular surgical operations from the Michigan Surgical Quality Collaborative[10] between 2003 and 2008 to develop prediction models for 30-day postoperative mortality, overall morbidity, cardiac, thromboembolic, pulmonary, renal, and SSI complications using logistic regression analysis. Only data that would routinely be available before the surgical procedure, such as patient demographics, selected patient preoperative comorbidities, and operative variables for the planned procedure, were considered in the model development. The models were developed using a random sample of 80% of the surgical cases and were tested on the remaining 20% of the sample. The c-indices for the models were generally good to excellent, ranging from 0.763 for SSI to 0.893 for mortality. There was very little change in the c-indices from the development to the test datasets, ranging from a decrease of 0.058 for thromboembolic events to an increase of 0.015 for renal events. The most important predictor variables across all of the models included some operative variables—work relative value units (RVU) of the operation, inpatient operation, Current Procedural Terminology (CPT) category of the operation, and some patient characteristics: age, American Society of Anesthesiologists (ASA) class, chronic steroid use, race, functional status, wound classification, on dialysis, history of congestive heart failure, body mass index (BMI), and current smoker.

Study variables for model prediction

As part of this grant, we developed a software system called Decision Support for Safer Surgery (DS3), which involves entry of patient level data about demographics, general medical condition, comorbidities, and operative variables, and which outputs risk calculations for individual patients regarding selected postoperative adverse events. Demographic variables included patient age, sex, ethnicity, and race. General medical condition variables included functional status, weight, height, BMI, and ASA class. Operative variables included whether or not the surgery was inpatient or outpatient, wound classification, CPT codes of the primary and secondary operations, and the work RVU of the primary operation. Patient preoperative comorbidities included on dialysis, disseminated cancer, peripheral vascular disease, hypertension, history of congestive heart failure, history of COPD, open wound, chronic steroid use, history of percutaneous coronary intervention, previous cardiac surgery, bleeding disorder, and current smoker. The DS3 data entry form is shown in Appendix 2.

Study cohort

To compare risk estimates from the statistical models and surgeons, we prospectively collected model- and surgeon-predicted risk scores as well as actual 30-day morbidity and mortality outcomes on patients undergoing elective general surgical operations at the University of Utah and the University of Alabama Birmingham from June 2010 to January 2012. Only patients being seen in an outpatient clinic who were being scheduled for elective