Journal of Critical Care 30 (2015) 310–314

Contents lists available at ScienceDirect

Journal of Critical Care

journal homepage: www.jccjournal.org

A risk prediction model for mortality in the moribund general surgical patient☆,☆☆,★,★★,☆☆☆

Lindsay E. Kuo, MD *, Kristina D. Simmons, Ph.D, Daniel N. Holena, MD, Giorgos Karakousis, MD, Rachel R. Kelz, MD, MSCE

Department of Surgery, University of Pennsylvania, Philadelphia, PA

ARTICLE INFO

Keywords:
Mortality
Moribund
Risk prediction
Surgery

ABSTRACT

Introduction: Surgeons struggle to counsel families on the role of surgery and likelihood of survival in the moribund patient. We sought to develop a risk prediction model for postoperative inpatient death for the moribund surgical candidate.

Materials and methods: Using 2007-2012 American College of Surgeons National Surgical Quality Improvement Program data, we identified American Society of Anesthesiologists class 5 (moribund) patients. The sample was randomly divided into development and validation cohorts. In the development cohort, preoperative patient characteristics were evaluated. The primary outcome measure was in-hospital mortality. Factors significant in univariate analysis were entered into a multivariable model; points were assigned based on β coefficients. A scoring system was generated to predict inpatient mortality. Models were developed separately for operations performed within and after 24 hours of admission, and tested on the validation cohort.

Results: A total of 3120 patients were included. In-hospital mortality was 50.6%. In multivariable analysis, patient characteristics associated with in-hospital mortality were age, functional status, recent dialysis, recent myocardial infarction, ventilator dependence, body mass index, and procedure type. The scoring system generated from this model accurately predicted in-hospital mortality for patients undergoing surgery within and after 24 hours.

Conclusion: A simple risk prediction model using readily available preoperative patient characteristics accurately predicts postoperative mortality in the moribund surgical patient. This scoring system can assist in decision making.

1. Introduction

Surgical evaluation of the moribund patient is fraught with difficult decisions, perhaps the most important of which is the decision whether or not to offer an operation. The term *moribund* literally means "close to death's door" [1]. Because certain critical clinical situations exist where death is certain without surgery, the American Society of Anesthesiologists (ASA) Physical Status classification system includes ASA class 5 to describe patients who are "moribund [and] not expected to survive without the operation" [2]. Although death without operation is expected in this cohort of surgical patients, the likelihood of survival with operation is often unclear.

The ability to predict the survival of a moribund patient following an operation plays a critical role both in the surgeon's decision to offer an operation and in a patient's or surrogate decision maker's decision to consent to an operation. Recent literature demonstrates a nearly 50% 30-day postoperative survival rate in moribund surgical patients [3], but data on factors associated with survival are lacking. Therefore, it is difficult to provide patients and their family members with information on the best course of action for a specific patient.

Much of the difficulty in preoperative prognostication in moribund patients lies in the lack of high-quality data upon which to build predictive models. Available large administrative databases such as the National Inpatient Sample provide robust sample sizes but do not capture physiology or laboratory data, which are critically important in developing appropriate risk-adjusted models in this patient population. Single-center databases may capture physiologic and laboratory values but likely suffer from limited sample sizes and unclear generalizability.

☆ Author contributions: Dr Kuo: conception, design, data analysis and interpretation, manuscript composition.Dr Karakousis: critical revision of the article.Dr Simmons: data analysis.Dr Holena: critical revision of the article.Dr Kelz: conception, design, critical revision of the article.

☆☆ All authors have read and approved this article.

★ The authors declare no conflicts of interest.

★★ Dr Holena was supported by award number K12 HL 109009 from the National Heart, Lung, and Blood Institute. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Heart, Lung, and Blood Institute or the National Institutes of Health.

☆☆☆ Acknowledgement: The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in it are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

* Corresponding author at: Hospital of the University of Pennsylvania, 3400 Spruce St, 4 Maloney, DSE, Philadelphia, PA 19104. Tel.: +1 215 662 2071; fax: +1 215 662 7476.
E-mail address: Lindsay.Kuo@uphs.upenn.edu (L.E. Kuo).

http://dx.doi.org/10.1016/j.jcrc.2014.11.012
0883-9441/

The American College of Surgeons National Surgical Quality Improvement Project (ACS NSQIP) database is a national data set that captures preoperative and postoperative information on more than 500 000 patient cases yearly. We hypothesized that, using this data set, we could develop accurate mortality risk prediction models for moribund patients undergoing surgery. Furthermore, we hypothesized that risk factors for mortality would vary between those patients undergoing surgery on admission and those undergoing surgery greater than 1 day after admission. The goal of our efforts was to generate a clinical useful mortality risk prediction model to inform both surgeons and their patients.

2. Materials and methods

We conducted a retrospective cohort study using the ACS NSQIP Participant Use File (PUF) from 2007 to 2012. The PUF was obtained from the NSQIP Web site. The PUFs are compliant with the Health Insurance Portability and Accountability Act; and as such, no identifying patient information was included. Hospital and provider information is not included in the ACS NSQIP file. The validity of the ACS NSQIP PUF has been described elsewhere [4–6]. In 2007, 183 hospitals participated in the ACS NSQIP; and in 2012, 374 hospitals participated. Data were collected for 214 variables describing patient characteristics, preoperative and postoperative events, and mortality [7].

We identified all ASA class 5 patients undergoing surgery by a general surgeon for inclusion in the study. Patients were excluded from the study if a non–general surgeon performed the operation, as a proxy for eliminating patients who underwent non–general surgical procedures. Patients were also excluded if the index operation was reported as “elective,” as this may have represented a palliative intervention rather than a potentially curative one. No trauma patients were included in the study, as these patients are excluded from the ACS NSQIP PUF [7]. The remaining cases were then randomly divided into a development cohort and a validation cohort in a 3:1 ratio.

Only variables containing information that would have been known or readily available to the surgeon at the time of surgical decision making were evaluated for inclusion in the prediction model. These characteristics included patient demographics: age, sex, race, body mass index (BMI), admission source, and functional status. Age was grouped into 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 to 69, 70 to 79, and 80 years of age or greater. We categorized BMI (kg/m^2) into underweight (BMI < 18.5), normal (18.5-24.9), overweight (25.0-29.9), and obese (>30.0) using the World Health Organization classification system [8]. Admission source refers to the method of the patient’s admission to the hospital: transfer from an acute care hospital vs admission from home or a chronic care facility via the emergency room. Functional status was defined as fully dependent or partially dependent/fully independent. We also evaluated patient comorbidities (history of diabetes, history of chronic obstructive pulmonary disease, ventilator dependence, current pneumonia, history of congestive heart failure, history of myocardial infarction, need for dialysis within 30 days, acute renal failure, systemic sepsis) and laboratory values (sodium, creatinine, albumin, white blood cell count, hematocrit, platelet count, international normalized ratio of prothrombin time values, partial thromboplastin time). Because surgeons often know the general type of procedure that will be performed, we grouped the index operation into 1 of 4 categories by CPT code: skin and soft tissue, laparotomy, thoracotomy, and vascular (Table 1). Univariate analyses were then performed using these preoperative characteristics on the derivation cohort. The primary outcome measure was inpatient death. A P value of <.1 in univariate analysis was used as the threshold for including a variable in the multivariate model.

Multivariable logistic regression was performed to evaluate the relationship between inpatient death and patient characteristics found to be significantly associated with inpatient death in univariate analyses. Characteristics that remained significantly associated with death in the regression model were then used to generate a simple scoring system to predict inpatient death ($P < .05$). A weighted point system was developed using the β coefficients from the multivariable analysis. The reference groups in the regression, as well as variables with negative or nonsignificant β coefficients, were assigned 0 point. Variables were assigned a point value of 1 if the associated β coefficient was less than 0.5, a point value of 2 if the associated β coefficient was 0.5 to 1, and a point value of 3 if the associated β coefficient was greater than 1. Observed and predicted mortality rates for each point value were calculated. Model performance was then tested on the validation cohort. Discrimination and validation were tested using the C statistic and Hosmer-Lemeshow goodness-of-fit tests.

Table 1
Categorization of procedures by CPT code for univariate analysis

Category	CPT codes
Skin/soft tissue	10040-10999, 11000-11044, 12001-13160, 15570-15999, 19000-19240
Abdominal/laparotomy	38100-38780, 43280-45190, 45500-46320, 46700-47530, 47560-49999
Chest wall/thoracotomy	19260-19272, 31750-32999, 39000-39561, 43121
Vascular	34001-37799

CPT, Current Procedural Terminology.

Within the derivation cohort, models were developed separately for patients who received the index operation within 24 hours of admission and patients who received the index operation at least 1 day after admission. This was done to differentiate between patients who presented to the hospital in an acutely ill state and those whose condition deteriorated over the course of the hospital stay. All analyses were performed independently for these 2 groups.

All data were transferred into STATA format using Stat/Transfer Version 11.0 statistical program (Circle Systems Inc, Seattle, WA). All analyses were performed with STATA 12.0/IC statistical software (STATA Corp, College Station, TX). This study was reviewed and deemed exempt from approval by the University of Pennsylvania Institutional Review Board.

3. Results

3.1. Patient demographics

We identified 3120 patients in the ACS NSQIP PUF from 2007 to 2012 who were ASA class 5 and received an emergent or urgent operation from a general surgeon. Nearly half the patient population was female, at 1508 (48.3%). Almost three quarters of the group were white (2285 patients or 73.2%), 12.8% were black (399 patients), 2.5% were Asian (78), and 9.3% (290) had no race identified. The median age of the group was 67 years, with an interquartile range of 57 to 78 years. One fifth of the patients were older than 80 years (632 patients or 20.3%). A total of 1057 patients received the surgery of interest within 24 hours of admission, whereas 2063 received the surgery of interest after 1 day of admission. The overall mortality rate was 50.6% or 1579 patients.

The derivation and validation cohorts were similar in sex, median age, race, and mortality rate. Overall inpatient death was 50.1% (1169 patients) in the derivation cohort and 52.2% (410) in the validation cohort ($P = .29$). Analyses were then performed within the derivation cohort for patients who received operations within 24 hours of admission and for patients who received an operation at least 1 day after admission.

The overwhelming majority of procedures performed were laparotomies (2868 or 91.9%). Vascular procedures accounted for 3.1% (n = 96); thoracotomies, 0.8% (n = 26); and skin/soft tissue operations, 4.2% (n = 130). The procedure type distribution differed between the 2 groups: