Development and Validation of a Bariatric Surgery Mortality Risk Calculator

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BACKGROUND: While the epidemic of obesity continues to plague America, bariatric surgery is underused due to concerns for surgical risk among patients and referring physicians. A risk score estimating postoperative mortality (OS-MRS) exists, however, is limited by consideration of only 12 preoperative variables, failure to separate open and laparoscopic cases, a lack of robust statistical analyses, risk factors not being weighted, and being applicable to only gastric bypass surgery. The objective of this study was to develop a validated risk calculator for 30-day postoperative mortality after bariatric surgery.

STUDY DESIGN: The National Surgical Quality Improvement Program (NSQIP) dataset (2006 to 2008) was used. Patients undergoing bariatric surgery for morbid obesity (n = 32,889) were divided into training (n = 21,891) and validation (n = 10,998) datasets. Multiple logistic regression analysis was performed on the training dataset. The model fit from the training dataset was maintained and was used to estimate mortality probabilities for all patients in the validation dataset.

RESULTS: Thirty-day mortality was 0.14%. Seven independent predictors of mortality were identified: peripheral vascular disease, dyspnea, previous percutaneous coronary intervention, age, body mass index, chronic corticosteroid use, and type of bariatric surgery. This risk model was subsequently validated. The model performance was very similar between the training and the validation datasets (c-statistics, 0.80 and 0.82, respectively). The high c-statistics indicate excellent predictive performance. The risk model was used to develop an interactive risk calculator.

CONCLUSIONS: This risk calculator has excellent predictive ability for mortality after bariatric procedures. It is anticipated that it will aid in surgical decision-making, informed patient consent, and in helping patients and referring physicians to assess the true bariatric surgical risk. (J Am Coll Surg 2012;214:892–900. © 2012 by the American College of Surgeons)

The epidemic of obesity has become a major health problem in many countries. In 2010, globally, 1 billion adults were overweight (body mass index [BMI] between 25 and 29.9 kg/m^2) and more than 300 million were obese (BMI $\geq$ 30 kg/m^2). At least 2.6 million people die each year as a result of being overweight or obese.[1] In the United States, the prevalence of obesity in adults in 2010 was 46.3%[2] and was estimated to be 44.2% in men and 48.3% in women.[3] The annual attributable medical cost for obese adults has increased from approximately $78.5 billion in 1998 to $147 billion in 2008.[4] The risk of death increases by 20% to 40% in overweight persons and by 2 to 3 times in obese people.[5] Bariatric surgery has been shown to significantly reduce the risk of cardiovascular disease, cancer, and endocrine, infectious, psychiatric, and mental disorders.[6] There is also a reduction in the risk of 5-year mortality by 89%.[6] In spite of the benefits, bariatric surgery continues to remain underused due to a number of factors, one of which is concern for surgical risk among patients and referring physicians.

Over the last 5 years, 2 risk estimation tools have been developed to predict mortality after bariatric surgery.[7,8] These, however, have multiple limitations. The objective of this study was to develop and validate a risk calculator for

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ACS NSQIP Disclaimer: The ACS NSQIP and the hospitals participating in the ACS NSQIP 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. This study does not represent the views or plans of the ACS or the ACS NSQIP.

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Abbreviations and Acronyms

BMI = body mass index
IQR = interquartile range
NSQIP = National Surgical Quality Improvement Program
OS-MRS = obesity surgery mortality risk score
PCI = percutaneous coronary intervention
PVD = Peripheral vascular disease requiring revascularization or amputation

estimation of 30-day postoperative mortality after bariatric surgery. The risk calculator will aid in surgical decision-making, informed patient consent, and will help patients and referring physicians make a true risk assessment of surgery vs living with obesity and its medical risks.

METHODS

Dataset

Data were extracted from the 2006, 2007, and 2008 National Surgical Quality Improvement Program (NSQIP) Participant Use Data Files. These are multicenter, prospective databases with 121 (year 2006), 183 (year 2007), and 211(year 2008) participant academic and community US hospitals. NSQIP collects data on 136 variables (135 in 2008), including preoperative and intraoperative variables and postoperative 30-day mortality and morbidity outcomes for patients undergoing surgical procedures in both inpatient and outpatient settings. The design of NSQIP has been described in detail previously.[9-12] The Participant Use Data Files are Health Insurance Portability and Accountability Act (HIPAA)-compliant data files containing patient level and aggregate data, and they do not identify hospitals, health care providers, or patients.

Patients and outcomes

Patients undergoing procedures with the American Medical Association's Current Procedural Terminology (CPT) codes 43644, 43645, 43770, 43842, 43843, 43845, 43846, and 43847 for morbid obesity were included from the 2006, 2007, and 2008 NSQIP datasets. Sleeve gastrectomy did not have a CPT code at the time data were collected, and these patients were not included in the NSQIP dataset.

Multiple preoperative variables were analyzed, including demographic variables like age and sex. Lifestyle variables included smoking (within 1 year of operation) and alcohol consumption (more than 2 drinks a day within 2 weeks of operation). Comorbidities analyzed included presence or absence of renal disease (dialysis dependence), coronary artery disease (angina within 30 days of surgery, myocardial infarction within 6 months of surgery, percutaneous coronary intervention, and cardiac surgery), congestive heart failure, hypertension, peripheral vascular disease requiring revascularization or amputation, rest pain in lower extremity, history of COPD, neurologic event or disease (stroke with or without residual deficit, transient ischemic attack [TIA]), diabetes mellitus, chronic corticosteroid use, weight loss (more than 10% in last 6 months), bleeding disorders, and open wound. Other factors considered were American Society of Anesthesiologists' (ASA) class, preoperative functional status (partially dependent and totally dependent), dyspnea (none, moderate exertion, exertion at rest), BMI, race, previous operation within 30 days, neoadjuvant chemotherapy or radiotherapy, admission status, and type of bariatric surgery. Preoperative laboratory variables included blood urea nitrogen, creatinine, sodium, serum glutamate-oxaloacetate transaminase, alkaline phosphatase, albumin, bilirubin, hematocrit, platelet count, white blood cell count, partial thromboplastin time, and prothrombin time. The full definition of all variables has been previously described.[12]

The primary outcomes variable was surgical mortality. Major morbidity included 17 postoperative complications: deep wound infection, organ space infection, pneumonia, reintubation, on ventilator more than 48 hours, pulmonary embolus, deep venous thrombosis, renal insufficiency, acute renal failure, stroke, coma, cardiac arrest, myocardial infarction, transfusion of more than 4 units of packed red blood cells within 72 hours, sepsis, septic shock, and return to the operating room. Urinary tract infection and superficial infection were considered minor morbidities. Outcomes are tracked for 30 postoperative days in NSQIP except for hospital length of stay, which is tracked until discharge from hospital.

Statistical analysis

Patients were randomly divided into training (n = 21,891) and validation (n = 10,998) datasets in an approximate 2:1 ratio. Univariate exploratory analysis was performed on the training dataset to assess risk factors associated with postoperative mortality. Pearson chi-square test or Fisher's exact test was used for categorical variables, and 2-sided Student's *t* or F test for continuous variables. A p value < 0.05 was considered significant. Statistical analysis was performed using SAS (version 9.2; SAS Institute).

Forward stepwise multiple logistic regression analysis was performed to assess risk factors associated with postoperative mortality. Even though not initially significant, the type of bariatric surgery was forced into the multivariable analysis because previously published reports have shown different outcomes for each type of bariatric surgery.[13] To address the possibility that the type of bariatric surgery