Predicting Length of Stay Following Radical Nephrectomy Using the National Surgical Quality Improvement Program Database

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Purpose: Length of stay is frequently used to measure the quality of health care, although its predictors are not well studied in urology. We created a predictive model of length of stay after nephrectomy, focusing on preoperative variables.

Materials and Methods: We used the NSQIP database to evaluate patients older than 18 years who underwent nephrectomy without concomitant procedures from 2007 to 2011. Preoperative factors analyzed for univariate significance in relation to actual length of stay were then included in a multivariable linear regression model. Backward elimination of nonsignificant variables resulted in a final model that was validated in an institutional external patient cohort.

Results: Of the 1,527 patients in the NSQIP database 864 were included in the training cohort after exclusions for concomitant procedures or lack of data. Median length of stay was 3 days in the training and validation sets. Univariate analysis revealed 27 significant variables. Backward selection left a final model including the variables age, laparoscopic vs open approach, and preoperative hematocrit and albumin. For every additional year in age, point decrease in hematocrit and point decrease in albumin the length of stay lengthened by a factor of 0.7%, 2.5% and 17.7%, respectively. If an open approach was performed, length of stay increased by 61%. The R^2 value was 0.256. The model was validated in a 427 patient external cohort, which yielded an R^2 value of 0.214.

Conclusions: Age, preoperative hematocrit, preoperative albumin and approach have significant effects on length of stay for patients undergoing nephrectomy. Similar predictive models could prove useful in patient education as well as quality assessment.

Key Words: kidney, nephrectomy, length of stay, hypoalbuminemia, risk

Abbreviations and Acronyms

ACS = American College of Surgeons

ASA = American Society of Anesthesiologists®

CHF = congestive heart failure

DRG = Diagnosis-Related Group

HCT = hematocrit

LoS = length of stay

NSQIP = National Surgical Quality Improvement Program

SIRS = systemic inflammatory response syndrome

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Study received institutional review board approval.

ACS NSQIP and participating hospitals have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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In efforts to curb the rising cost of health care in the United States payers have developed systems such as managed care and accountable care organizations. This highlights the longtime focus on quality as a measure to drive resource conservation. LoS is a common indicator in quality assessment and improvement constructs.[1–4] LoS can also contribute to decisions on pre-authorization and reimbursement as it is one of the primary output elements of the various DRG classification systems and used widely by payers to stratify diagnoses and procedures for reimbursement.

Prolonged LoS has been associated with increased resource consumption and complications.[5,6] The cost of an inpatient stay from 2009 to 2010 grew by 5.1%, nearly twice the rate of inflation.[7] The cost of an inpatient

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surgical admission grew by 6.4% during the same period.[7] Inpatient services account for 21% of national health care expenditures.[7] As spending continues to increase, LoS bears greater and greater importance. Furthermore, increased LoS places patients at greater risk for complications, leading to worse outcomes and increased system costs.[8,9]

Preoperative risk factors have an important role in predicting LoS and have been shown to be meaningful for overall hospital costs.[6,10] Elucidating the most significant factors presents an opportunity to mitigate modifiable variables, and improve clinical decision making and quality assessment. Previous studies have explored variables associated with prolonged LoS.[11–15] Such factors in common urological cases such as nephrectomy, prostatectomy and cystectomy include advanced patient age, dependent functional status, low serum albumin, low HCT and high creatinine.[12,15]

Some of these prior studies used the NSQIP database to study LoS determinants.[11,15] The NSQIP is a robust multi-institutional database including hundreds of variables and a variety of procedures that was designed and validated for use in quality improvement and outcomes data analysis.[16]

The primary objective of this study was to identify preoperative risk factors that significantly contribute to prolonged LoS after radical nephrectomy. Our aim was to examine the predictive ability of preoperative factors, assess use of the NSQIP database for urological procedures and create a predictive model to elucidate the intrinsic variability in the LoS measure. Such models have become important in the shift toward a pay for performance reimbursement structure in which physicians will be expected to meet benchmark quality measurements.

METHODS

American College of Surgeons NSQIP

The ACS NSQIP and participating hospitals are the source of the data used in this study. The NSQIP is a prospective, multi-institutional database with cases representing a sample of operations at each institution.[5] For each patient more than 150 variables are captured, including comorbidities, laboratory values and LoS. Data are audited annually for accuracy and completeness.

Training Set Patient Population

The primary cohort consisted of 1,527 patients identified from the NSQIP PUF (Participant Use Data File) who were older than 18 years and underwent radical nephrectomy between 2007 and 2011 via a laparoscopic approach (CPT code 50545/50546) or an open approach (CPT code 50220/50225). Patients treated with regional lymphadenectomy and/or vena caval thrombectomy were not included in study. Subsequent analysis and modeling were performed on 864 patients after excluding those who underwent concomitant procedures or had incomplete data.

Variables Measured

This study assessed more than 50 variables regarding patient demographics, medical comorbidities and preoperative laboratory variables collected within 90 days of surgery. The complete list includes gender, age, body mass index, ASA® score, various comorbidities and preoperative laboratory values (table 1).

Outcome Measures

The primary outcome measure was absolute LoS among patients discharged from the hospital. The predictive models used the log-transformed value of LoS due to the large amount of skew in the nontransformed LoS variable.

External Validation Set Patient Population

Results were validated in an external cohort of 427 patients at Emory University Hospital, Atlanta, Georgia, who underwent laparoscopic or open nephrectomy between November 2006 and January 2012. All participants provided written informed consent. Patients with nodal or metastatic disease were excluded from study as were those with concomitant procedures. Notably, these patients were not in the NSQIP cohort since urological patients are not generally abstracted at our institution.

Statistical Analysis

All available variables were evaluated using univariate analysis (linear regression models) to assess the correlation with LoS. Variables found to be significantly associated with LoS using an α level of 0.05 on univariate analysis were included in an initial multivariable linear model. Backward selection was then used to sequentially exclude nonsignificant variables from the model when controlling for other variables.

At each step the variable with the largest p value of the variables with $p > 0.05$ was excluded. All 2-way interactions between variables in the final model were tested. However, because none had a substantial influence (more than 1%) on R^2, none of them were kept in the model. This model is presented as model 1. A smaller model constructed using a subset of variables from model 1 is presented as model 2.

The validation aspect of this study is an important element to demonstrate the applicability of NSQIP derived data to individual institutions. Elements in model 1 that were not sufficiently common or adequately documented in institutional records were eliminated to create model 2. The validity of the final models was checked using model diagnostics, including the distribution of residuals, the Cook distance and leverage values.

The final linear regression model was then assessed in the external validation cohort. Using the parameter estimates from the final predictive model the predicted LoS was calculated for each patient in the validation cohort with data in all relevant fields. The correlation between this predicted value and the actual patient LoS was assessed using the Pearson correlation coefficient and R^2 was calculated. All statistical analyses were performed with SAS®, version 9.2.