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A Risk Score Calculator for Short Term Morbidity Following Hip Fracture Surgery

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ABSTRACT

Hip fractures are a common source of morbidity and mortality amongst the elderly. While multiple prior studies have identified risk factors for poor outcomes, few studies have presented a validated method for stratifying patient risk. The purpose of this study was to develop a simple risk score calculator tool predictive of 30-day morbidity after hip fracture. To achieve this, we queried a database prospectively maintained by The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) to identify all cases of hip fracture between 2005 and 2010, based on primary Current Procedural Terminology (CPT) codes. Patient demographics, comorbidities, laboratory values, and operative characteristics were compared in a univariate analysis, and a multivariate logistic regression analysis was then used to identify independent predictors of 30 day morbidity. Weighted values were assigned to each independent risk factor, and used to create predictive models of 30 day complication risk. The models were internally validated with randomly partitioned 80% / 20% cohort groups. We hypothesized that significant predictors of morbidity could be identified and used in a predictive model for a simple risk score calculator. All analyses are performed via SAS® software.

INTRODUCTION

Risk stratification is a widespread practice. Commonly cited examples include Ranson's criteria for acute pancreatitis,[1] the Framingham calculator for cardiovascular risk,[2] the Model for End Stage Liver Disease (MELD),[3] and the American Society of Anesthesia (ASA) class system.[4] These scores are useful for identifying patients in need of medical optimization, for counseling patients about outcome risks specific to their medical status, and for comparing outcomes across institutions. However, few condition specific orthopaedic risk calculators exist.

Hip fractures are an extremely common orthopaedic problem, with more than 1.6 million occurring each year world-wide.[5,6] Numerous previous studies have reported on risk factors for mortality following a hip fracture.[7-14] However, to the best of our knowledge, only one prior study has attempted to create a risk stratification tool predictive of mortality after hip fracture,[14] and no prior study has developed a tool predictive of morbidity. The development of a validated simple risk score for morbidity data could thus be useful for obtaining informed consent for identifying high risk patients who require medical optimization prior to surgery, and for comparing morbidity and mortality data between different institutions or different surgeons.

The purpose of this study was to develop a simple risk stratification tool predictive of 30-day morbidity after hip fracture. We queried a database prospectively maintained by The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP)[15] to identify all cases of hip fracture between 2005 and 2010. We hypothesized that significant predictors of morbidity could be identified and used in a predictive model for a simple risk score calculator.

METHODS

(1) DATA ACQUISITION:

The ACS NSQIP prospectively collects surgical pre-operative, operative, and 30-day post-operative outcomes data for participating institutions, and now over 258 hospitals around the United States now participate in such data collection as patient demographics, pre-operative comorbidities, laboratory values, and operative variables. Post-operative 30-day outcomes across 21 categories of morbidity and mortality are recorded. High quality data is ensured by routine auditing, with a disagreement rate of less than 1.8%.[15] Strict variable definitions minimize ambiguity. The use of the ACS NSQIP database has been widely accepted for use in short term surgical outcomes in a variety of surgical specialties, including general surgery, vascular surgery, and orthopaedic surgery.[16-19]

Our inclusion criteria were based on a previous study using the Veterans Health Administration NSQIP database in hip fractures[20]. Four-thousand three-hundred and thirty-one (4,331) patients undergoing surgical treatment of a hip fracture between 2005 and 2010 were selected based on Current Procedural Terminology (CPT) codes.

(2) COMORBIDITY VARIABLES

The demographic data included age, sex, and race (white, black, other). Included pre-operative health variables were body mass index (BMI kg/m^2), recent weight loss (10% of total body weight in 6 months), diabetes mellitus, smoking, alcohol use, pre-operative blood transfusion, recent operation (within 30 days), and corticosteroid use. Pre-operative comorbidities included coronary artery disease, peripheral vascular disease, previous transient ischemic attack (TIA), dialysis use, bleeding disorder such as hemophelia, an open wound, chemotherapy (within 30 days of surgery), radiation therapy (within 90 days of surgery), pre-operative sepsis and chronic obstructive pulmonary disease (COPD). The pre-operative laboratory values included: serum sodium (Na), white blood cell count (WBC), hematocrit (HCT), platelet count, creatinine, BUN, albumin, and international normalized ratio (INR). The operative variables included: wound class, American Society of Anesthesiologists (ASA) class, number of blood transfusions, length of operation dichotomized at 2 hours, and resident involvement.

(3) OUTCOMES

Short term, 30-day, complications after hip fracture surgery were divided into mortality and complications. Mortality was defined as death within 30 days, while the 30-day complications include the following categories: infectious, pulmonary, hematologic complication, cardiac complication, renal complication, neurologic complication, hardware failure, return to the operating room within 30 days, and mortality within 30 days. Complication was defined by the presence of one or more of the above positive outcomes.

(4) STATISTICAL ANALYSIS AND SAS PROCEDURES

All analyses were performed via SAS (Version 9.3, SAS Institute Inc., Cary, NC). Several statistical models were created to calculate complication frequencies, independent predictors of complication, and risk stratification. All regression and risk score stratification were calculated from a randomly generated 80% development data set while a 20% sample was used to validate the model. The following SAS codes are used for doing this. Here, the number 12456 is arbitrarily chosen. Of course, you may use another one and just keep it unchanged for consistent result.

```
data data80 data20;
        set alldata;
        if RANUNI(12456)<=0.80 then output data80;
        else output data20;
run;
```

Receiver Operator Curves (ROCs), reported as a C index, were used to judge the predictive fit of the multivariate logistic regression model to the developmental dataset and validation set. A C index greater than 0.6 is considered a predictive fit (ranges from 0 to 1, 1=perfect fit, 0.5=no fit). The Hosmer-Lemeshow test was also used to secondarily assess model calibration[21].

For outcome complications, all pre-operative characteristics were separately compared in univariate method. For example, characteristics between all those patients that had that morbidity within 30 days were compared against those who did not. Some continuous variables were converted to categorical groups based on generally accepted cutoffs. These were done using SAS proc freq or proc ttest. A $p < 0.05$ was set to establish inclusion into a multivariate logistic regression model. Adjusted odds ratios and 95% confidence intervals were calculated. The multivariate logistic regression model for complications is

```
proc logistic data=data80 descending;
        class  sex new_race age cpt dyspnea PrSepis bun wbc  HCT ASACLAS optime;
        model complication= sex race age2 cpt dyspnea PrSepis bun wbc  HCT ASACLAS optime/lackfit risklimits;
run;
quit;
```

Next, the 20% validation set was used to test the multivariate logistic regression model. Once verified, all pre-operative variables identified by the multivariate logistic regression analysis were introduced into a risk score stratification model. A 200-cycle bootstrapped simulation sample was used to generate median Beta coefficients of each risk factor included in the logistic regression model for the development data set. The code to generate simulation samples is:

```
proc surveyselect data=data80 out=outboot
        seed=30459584
```

```
        method=urs
        samprate=1
        outhits
        rep=200;
run;
```

The following codes are used to generate median Beta coefficients of each risk factor:

```
%global i;
%macro myboot;
        %do i=1 %to 200;
                data b&i;
                    set outboot(where=(Replicate=&i));
                run;

                ODS OUTPUT ParameterEstimates=beta;
                proc logistic data=b&i descending;
                        class  sex race age cpt dyspnea PrSepis bun  wbc HCT ASACLAS optime;
                        model complication= sex race age cpt  dyspnea  PrSepis bun wbc HCT ASACLAS
                                        optime /lackfit risklimits;
               run;
               quit;
                ODS OUTPUT CLOSE;

                data beta2;
                        set beta;
                        IdVariable=variable||ClassVal0;
                        BetaID=compress(IdVariable,' -/');
                run;

                proc transpose data=beta2  out=beta3(drop=_NAME_);
                        id BetaID;
                        var estimate;
                run;

                title "b&i";
                proc append base=allbeta data=beta3;
                run;

        %end;

%mend myboot;

%myboot;

proc contents data=allbeta out=all2;
run;

proc sql;
        select name into:NameID separated by ' ' from all2;
run;

%put &NameID;

title 'Medians distributions of each variable';
proc means data=allbeta n mean median std range maxdec=2;
        var &NameID;
run;
```

Using a previous scoring scheme[22], the medians for the beta coefficients from the logistic regression model were then used to develop an integer-based weighted point system for stratifying in-hospital morbidity risk. The referent for each variable was assigned a value of zero. For the remaining values of the variables, the lowest beta coefficient was

given a value of 1, and the coefficients for the others were adjusted proportionally, rounding to the nearest integer. Individual scores were assigned by summing the individual risk factor points. The risk scores were further stratified as follows: (1) low, 0 to 10; (2) low-moderate, 11 to 15; (3) moderate-high, 16 to 20; and (4) high, 21+. Within the development set, the risk score was calculated for each patient record, and discrimination was assessed using the area under the receiver operating characteristic (ROC) curve. For the validation of the risk score, the previously isolated 20% random sample was applied, and discrimination was assessed in a similar way.

RESULTS

The 30-day morbidity (MB) rate was 30.0% for hip fracture surgery patients. Patient age, especially age greater than 80 years old, (OR 1.43 95% CI: 1.05-1.94)) and male sex (OR 1.26 95% CI: 1.03-1.54)) were associated with both increased mortality and morbidity. An increased ASA Class had the highest negative impact on total complication incidence in the scoring models. Additionally, complete functional dependence, active malignancy, patient race, cardio-pulmonary disease, laboratory derangements, prolonged operating time, and open versus percutaneous surgery independently influenced outcomes. Risk scores, based on weighted models which included the aforementioned variables, predicted morbidity after hip fracture surgery. For detailed results, see Pugely[23].

CONCLUSIONS

Overall, our study has established a unique model for quantifying the impact of patient risk factors on outcomes after the surgical treatment of hip fractures. In addition, we have presented unique risk factors for morbidity. The risk score calculators presented here were internally validated, and we feel they would be useful in informing patient discussions about operative risk, for identifying patients in need of medical optimization pre-operatively, and for comparing risk adjusted outcomes between surgeons or institutions.

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