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Focused Risk Analysis: Regression Model Based on 5,314 Total Hip and Knee Arthroplasty Patients from a Single Institution

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ABSTRACT

We aimed to identify significant demographic, preoperative comorbidity and surgical predictors for major complications for use in the development of a risk prediction tool for a well-defined population as Total Joint Arthroplasty (TJA) patients. Data on 5314 consecutive patients who underwent primary total hip or knee arthroplasty from October 1, 2008 through September 30, 2011 at a single institution were used in a multivariate regression analysis. The overall incidence of a primary endpoint (reoperation during same admission, extended length of stay, and 30-day readmission) was 3.8%. Significant predictors include certain preexisting genitourinary, circulatory and respiratory conditions; ASA >2; advanced age and prolonged operating time. Mental health conditions demonstrate a strong predictive effect for subsequent serious complication(s) in TJA patients and should be included in a risk-adjustment tool.

As evidence-based medicine has become a major driving force in the healthcare industry, policymakers and payors have increased the demand for objective outcome measures. This has led to efforts to evaluate the quality of care provided across healthcare providers and institutions. Risk adjustment plays an important role in the evaluation of quality of care. This has driven the development of generic risk assessment and adjustment techniques such as the Charlson-Comorbidity Index (CCI), and the Index of Coexistent Disease (ICED) to control for differences in patient characteristics and clinical factors associated with outcomes of interest and are used in comparative databases such as the National Surgical Quality Improvement Program (NSQIP) [1,2].

Comorbidities have been shown to be major determinants in treatment selection and survival for certain conditions [3]. As a result clinicians may be required to adjust for comorbid conditions when assessing their effects on patient outcome(s). The CCI which estimates 1-year mortality risk based on the influence of comorbidities is comprised of 19 comorbidities which have been selected and weighted based on their strength of associations with mortality [4,5]. The ICED on the other hand is used to control for comorbidities when the outcome of interest is functional ability [6]. NSQIP is designed to allow for a comprehensive evaluation of surgical outcomes based on the analysis of various factors that include preoperative, intraoperative, body structures and processes of care [7]. However, these generic measures may not be directly applicable to a well-defined and generally healthy population such as patients undergoing Total Joint Arthroplasty (TJA). Despite increasing attention to outcomes research in the field of joint arthroplasty, no single method of risk adjustment has been embraced by surgeons or payors. This prompts the need for a more appropriate predictive tool that is targeted at this population.

We aimed to identify significant demographic, preoperative comorbidity and surgical predictors that may be used in the development of a risk predictive tool for major complications or readmissions specific to total joint arthroplasty patients.

Data Source and Methods

Data Set

The data used in this study were from a hospital-based joint registry maintained by the Connecticut Joint Replacement Institute in Hartford, Connecticut. The focus of the registry is to facilitate the efficient collection, organization and presentation of data derived from primary and revision total joint procedures performed in a high volume arthroplasty center. The registry is linked to an Electronic Health Record (EHR) system and billing data warehouse (CareLink and McKesson's Horizon Performance Manager) within the hospital. *International Classification of Disease*, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes as well as Medicare severity diagnosis-related group (MS-DRG) codes were retrieved from the hospital's admission-discharge-transfer (ADT) database.

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The analysis was limited to primary total hip and knee arthroplasties (THAs and TKAs) (ICD-9-CM procedure codes 81.51 and 81.54 respectively). Demographic data, preoperative comorbidities, intraoperative surgical measures, hospital length of stay (LOS), postoperative complications and 30-day readmissions were queried on 5,314 consecutive patients who underwent total hip or knee arthroplasty from October 1, 2008 through September 30, 2011. Patients 18 years and older were included. Primary endpoints of interest to our analysis were incidence of reoperation during same admission, length of stay greater than 4 days, readmission within 30 days post surgery, and the incidence of postoperative orthopaedic, major non-orthopaedic or minor non-orthopaedic complication(s) as defined below.

Patient Demographic and Clinical Data

These included gender, age, height, weight, the American Society of Anesthesiologists (ASA) score [8] (categorized as ≤2 vs. >2; with 1 being healthy, 2 mild systemic disease, 3 severe systemic disease and 4 life threatening) [8], operating time (number of minutes from incision through closure), and type of anesthesia administered. Age was dichotomized as <80 vs. ≥80 years. Body Mass Index (BMI) was dichotomized as <40 vs. ≥40 kg/m^2. A signal modeling procedure [9] applied to determine the actual cut-off threshold at which age and BMI would be significant predictors for an outcome (in this cohort) revealed 88.33 years and 46.03 kg/m^2 respectively. However, we chose to go with the cut-offs presented above as these had no effect on the final results.

Intraoperative Surgical Measures

Patients were administered one of the following forms of anesthesia: general, spinal/epidural, peripheral nerve block (PNB) with laryngeal mask anesthesia (LMA) or a monitored anesthesia care (MAC) in one case. Operating time was analyzed as a continuous variable (5 minute increments) and a categorical variable (dichotomized as ≤74 minutes vs. >74 minutes based on the median operating time).

Preoperative Comorbidities

These were categorized into diseases affecting 9 major body systems and/or conditions: *Circulatory* (cerebrovascular accident [CVA]/transient ischemic attack [TIA], congestive heart failure [CHF], valvular disease, myocardial infarction [MI], peripheral vascular disease and coronary artery disease [CAD]), *Endocrine* (diabetes), *Digestive* (gastrointestinal problems [such as irritable bowel syndrome, constipation, paralysis agitans, chronic liver disease, chronic pancreatitis, paralytic ileus, pancreatic disease, diverticulosis, ulcerative colitis, gastroenteritis] and hepatitis), *Genitourinary* (urinary tract infection [UTI], urinary retention and chronic renal failure [CRF]), *Respiratory* (venous thromboembolism [VTE], pneumonia, chronic obstructive pulmonary disease [COPD] and sleep apnea), *Blood disease/Blood forming organs* (anemia, blood disease and clotting disorders), *Psychiatric* (delirium, dementia, depressive psychosis), *Central nervous system* (Parkinson's disease) and *Neoplasia*.

Postoperative Complications

An orthopaedic complication was defined as clinical or radiologic diagnosis of hemarthrosis or hematomas requiring surgical debridement, periprosthetic fracture, dislocation, deep infection, hemorrhage requiring transfusion, wound dehiscence, tendon rupture, and mechanical loosening. A major non-orthopaedic complication was defined as clinical or radiologic diagnosis of pulmonary embolism (PE), MI, CHF, cardiac arrest, unspecified heart failure, intracerebral hemorrhage, cerebral embolism, proximal deep venous thromboembolism (DVT), acute renal failure, stroke, subendocardial infarction or death. All other conditions including postoperative psychiatric conditions were considered minor non-orthopaedic complications.

Outcomes of Interest

These were defined as primary endpoints (reoperation on same admission, 30-day readmission and length of stay greater than 4 days); and postoperative complications (orthopaedic, major non-orthopaedic and minor non-orthopaedic).

To follow up and adjudicate complications, surgeons reported any known complications and patients were also contacted by phone within a 60–90 day window post-discharge by Institute staff to identify any late complications post surgery. Patient-reported complications were also confirmed through review of hospital and physician's office medical records or diagnostic test(s) where admission to outside hospitals occurred.

Statistical Analysis

Logistic univariate and stepwise multivariate regression analyses were conducted to serve as the basis for risk prediction. Age, BMI, Gender, Procedure, Operating Time, ASA score, preoperative comorbidities, reoperation on same admission, length of stay greater than 4 days, 30-day readmission, and postoperative orthopaedic, major non-orthopaedic or minor non-orthopaedic complication status were used in the model. None of the predictor variables were highly correlated with one another. In order to avoid overfitting that could potentially result in biased results, only statistically significant univariate variables were included in the final model. Also, given the multiple comparisons performed, statistical significance was set at 0.01 to minimize chance findings. Reference categories in the final model for which results are presented were <80 years for age, male gender, BMI <40, ASA ≤2, THA procedure, and absence of a specified comorbidity. Results are reported as adjusted risk ratios (RR) with corresponding 95% confidence interval (CI). Categorical variables are summarized as counts and percentages, while continuous variables are summarized as means and standard deviations or median and interquartile range depending on distribution of data. The statistical analysis was performed using IBM SPSS version 20.0 [10].

This study was approved by the Saint Francis Hospital and Medical Center Institutional Review Board.

Results

There were a total of 2170 (41%) and 3144 (59%) primary total hip and knee arthroplasties respectively during this period. Females accounted for 58% of this cohort. Mean age for the entire sample was 65.6 (±10.9) years with 64.1 (±11.9) and 66.7 (±9.9) years for THA and TKA patients respectively (Table 1). In the entire sample, approximately 50 percent of patients were overweight or obese with a mean BMI of 29.2 (±5.6) kg/m^2 in THA patients and 32.0 (±6.3) kg/m^2 in TKA patients (Table 1).

Greater than 80% of the population had at least one pre-existing medical comorbidity. The majority (85%) of patients had an ASA score of ≤2 (Table 1). The median operating time for all surgeries performed by the eleven surgeons was 74 (64–89) minutes. For THA and TKA, these times were 70 (61–85) minutes and 77 (67–91) minutes respectively (Table 2). Among THA patients, 24.5% were anesthetized with spinal anesthesia; the remainder (75.5%) received general anesthesia except for one MAC. 76.3% of TKA patients were anesthetized with peripheral nerve block with LMA (Table 2).

The overall incidence of a primary endpoint (reoperation during same admission, length of stay greater than 4 days, and 30-day readmission) was 3.8% (Table 3). The combined postoperative