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Thirty-Day Readmission Following Total Hip and Knee Arthroplasty – A Preliminary Single Institution Predictive Model

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ABSTRACT

We sought to identify demographic or care process variables associated with increased 30-day readmission within the total hip and knee arthroplasty patient population. Using this information, we generated a model to predict 30-day readmission risk following total hip and knee arthroplasty procedures. Longer index length of stay, discharge disposition to a nursing facility, blood transfusion, general anesthesia, anemia, anticoagulation status prior to index admission, and Charlson Comorbidity Index greater than 2 were identified as independent risk factors for readmission. Care process factors during the hospital stay appear to have a large predictive value for 30-day readmission. Specific comorbidities and patient demographic factors showed less significance. The predictive nomogram constructed for primary total joint readmission had a bootstrap-corrected concordance statistic of 0.76.

As increasing interest is turned toward reforming our health care system into a more efficient and affordable model, one area of resource consumption targeted is the large incidence of unplanned hospital readmissions. As many as 20% of hospitalized Medicare patients are readmitted within 30 days of hospital discharge, accounting for an estimated 17 billion US Dollars annually of unanticipated cost for the federal government [1]. With the recent inception of the *Affordable Care Act* (*ACA*), the concept of value-based purchasing has emerged as a tool to drive reduction in healthcare spending by rewarding or penalizing specific measures of hospital performance. Foundational to this approach is the mandate to publicly report a variety of measures, including compliance with core process measures and such avoidable complications as hospital-associated infections and readmissions. Hospitals with 30-day readmission rates that are greater than a benchmark are at risk of incurring a financial penalty proportioned from their total Medicare payments for a specified time period. While initially this was directed toward targeted medical patient populations [2], the program has expanded to common orthopaedic diagnoses and readmissions – specifically total hip and knee arthroplasty. As part of this mandate, evidence based medicine (EBM) guidelines focused on decreasing so-called "preventable" readmissions within "targeted" medical populations (heart failure [3], acute myocardial infarction [4], pneumonia [5]) have been created. Likewise, some common post surgical complications are now counted as relevant patient safety indicators, including post-operative deep vein thrombosis (DVT) and surgical site infections (SSI). It is expected that readmissions related to these events may not be reimbursed if occurring within the 30-day post-discharge window.

One concern in creating a generalized financial penalty for all readmissions is the danger of accepting all patient risk as equal. Recent literature has described various risk factors associated with readmission in the general orthopaedic and primary arthroplasty populations [6,7]. Despite a general knowledge of specific risk factors and their association with early readmission, no pragmatic risk stratification models exist for those institutions where the patient census is comprised largely of complex medical patients, associated with multiple comorbidities. With this in mind, our primary goal was to utilize our newly formed readmission database in order to understand specified comorbidity, care process, and demographic variables within the primary total joint population that harbored associated increased risk for 30-day readmission. We then aimed to develop a preliminary predictive model for readmission risk within our institution, using these identified variables.

Materials and Methods

Study Design

This study was a retrospective case–control comparison analysis, composed of orthopaedic admissions and readmissions, over a 12-

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month period (May 1, 2010 to April 30, 2011). Institutional Review Board approval was obtained.

Data Sources

Data for all orthopaedic inpatient encounters was obtained from a readmission database, which was implemented in April 2010. Primary total hip and knee arthroplasty patients (1,291 admissions/1,236 patients) were identified using DRG Codes 469 and 470. Exclusion criteria included patients less than 18 years of age, observational (<23 h) admissions, outpatient procedures, patients that underwent a post-operative visit to the emergency department but were discharged home without re-admission to the hospital, and those patients who were seen as consults by the orthopaedic service during their index admission. In addition, those patients with documented evidence for a planned readmission were excluded, as they were thought to represent a different cohort whose disease required multiple admissions and for whom payment decisions related to the readmission will likely be viewed differently by insurance carriers [8,9]. Patients with multiple inpatient encounters during the study period had only the first chronological index admission/readmission included for analysis, in an effort to limit statistical bias.

Using similar exclusion criteria, the control (non readmission) group data was identified after separating those patients undergoing readmission from the 1,291 total hip and knee arthroplasty inpatient admissions over the same 12-month period. The Anesthesia Record Keeping System (ARKS) was used to ascertain anesthesia type and procedure length. In both populations, a combination of DataMart and EpicCare® (Epic Systems; Verona, WI) were used to obtain all patient demographic, co-morbidity, laboratory, and disposition data. The Charlson Comorbidity Index (CCI) was retrospectively calculated (using comorbidity diagnoses established in the medical record prior to index admission) to risk stratify both groups base on medical comorbidities using the previously accepted vessel of I*CD-9* diagnosis codes [10–13]. A similar methodology described by Higuera et al. was utlized [14]. Anemia was defined by the widely accepted WHO standards (males <13g/100 mL, females <12g/100 mL) [15].

Variables

Variables of interest were selected to include patient clinical variables, care process events (i.e. length of operation, operative time, discharge disposition, anesthesia type, hospital unit, blood transfusion status, etc.), and socioeconomic factors. A local primary residency address was defined as being within the surrounding seven-county metropolitan region.

Statistical Analysis

Comparisons of continuous variables between index admissions leading and not leading to readmissions were made using either Welch's two sample t-tests or Wilcoxon rank-sum tests, as appropriate. Comparisons of categorical variables between index admission leading and not leading to readmission were made using either Pearson's chi-squared tests or Fisher's exact tests, with the latter used in the case of small cell sizes. Continuous variables were described using means, standard deviations, and 5-number summaries (minimum, 1st quartile, median, 3rd quartile, and maximum). Categorical variables were described using counts and percentages.

Logistic regression in the primary total joint population was used to predict the probability of readmission following joint replacement surgery, utilizing those variables identified as significant in univariate analysis. Because of the scarcity of the readmission events (46 episodes/44 patients), known sample rules suggest that the maximal number of predictors within any model being considered specific to our study should be 4–5 [16]. Variables having poor distributional qualities (e.g. small cell sizes) were eliminated. From the remaining variables, a subset of important variables was chosen using stepwise selection based on Akaike's Information Criteria (AIC). All model fitting was done using complete cases. The final model was internally validated by using one thousand bootstrapped samples to form a bias-corrected concordance statistic (area under the curve). Predicted probabilities were compared with observed probabilities using a bias-corrected calibration plot, produced by bootstrapping (B=1000), to determine the extent to which the model over- or under-predicts probability of readmission. A visual representation of the model was then generated.

A significance level of 0.05 was used for all analyses.

Source of Funding

No external sources of funding were used for this study.

Results

After exclusion criteria, 2,368 adult admissions to the orthopaedic service were identified during the one-year study period, including 159 (144 patients, 6.7%) unplanned readmission episodes – 117 of which were unique, unplanned patient readmissions in the general orthopaedic population. Concerning the 1,291 (1,236 patients) primary total hip and knee arthroplasty index admissions, 46 (44 patients, 3.6%) underwent early readmission within 30 days of index admission discharge. Of the total 159 unplanned orthopaedic readmissions, 28.9% were comprised of primary total joint index admissions.

The only demographic factor showing independent association with readmission was insurance payor, with government insured (Medicare/Medicaid) patients comprising the highest proportion of patients readmitted. Age, race, gender, smoking history, BMI, and local address showed no association with readmission tendency. Care process factors showing significant independent association with readmission tendency included increased index length of stay, discharge disposition, receiving a blood transfusion, and general anesthesia. Operative time and post-operative admission to a designated orthopaedic hospital floor did not show association with readmission. Table 1 summarizes these findings.

Table 2 describes several pre-operative comorbidities that showed significant prevalence associations with readmission. Patients identified as using anti-coagulation or pre-operative narcotics prior to admission, those patients with a Charlson Comorbidity Index greater than 2, and those patients with pre-operative diagnoses of anemia or chronic heart failure were readmitted at significantly higher percentages. History of coronary artery disease (CAD) or AMI, dementia, peripheral vascular disease (PVD), and having a diagnosed DVT during index admission all showed statistical associations with increased readmission as well, but notably were characterized by small count sizes.

Fig. 1 depicts the nomogram for the final model containing the four predictors we identified as having the highest predictive value for future readmission – anticoagulation status prior to admission, anesthesia type, CCI, and blood transfusion status. Fig. 2 shows the corrected ROC curve created using a random sub-sampling procedure, resulting in a corrected C-statistic of 0.76 (bootstrapped 95% CI [0.69–0.87]). Fig. 3 shows a calibration plot comparing predicted probabilities of readmission to actual probabilities, based on 1,000 bootstrapped samples.

Discussion

One high priority issue being addressed in the move toward value-based care is a relatively high incidence of early readmission following hospital discharge. To our knowledge, this is the first study to develop and define a predictive model for early readmission within the