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The American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator Has a Role in Predicting Discharge to Post-Acute Care in Total Joint Arthroplasty

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ABSTRACT

Background: Patient demand and increasing cost awareness have led to the creation of surgical risk calculators that attempt to predict the likelihood of adverse events and to facilitate risk mitigation. The American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator is an online tool available for a wide variety of surgical procedures, and has not yet been fully evaluated in total joint arthroplasty.

Methods: A single-center, retrospective review was performed on 909 patients receiving a unilateral primary total knee (496) or hip (413) arthroplasty between January 2012 and December 2014. Patient characteristics were entered into the risk calculator, and predicted outcomes were compared with observed results. Discrimination was evaluated using the receiver-operator area under the curve (AUC) for 90-day readmission, return to operating room (OR), discharge to skilled nursing facility (SNF)/rehab, deep venous thrombosis (DVT), and periprosthetic joint infection (PJI).

Results: The risk calculator demonstrated adequate performance in predicting discharge to SNF/rehab (AUC 0.72). Discrimination was relatively limited for DVT (AUC 0.70, $P = .2$), 90-day readmission (AUC 0.63), PJI (AUC 0.67), and return to OR (AUC 0.59). Risk score differences between those who did and did not experience discharge to SNF/rehab, 90-day readmission, and PJI reached significance ($P < .01$). Predicted length of stay performed adequately, only overestimating by 0.2 days on average (rho = 0.25, $P < .001$).

Conclusion: The American College of Surgeons National Surgical Quality Improvement Program Surgical Risk Calculator has fair utility in predicting discharge to SNF/rehab, but limited usefulness for 90-day readmission, return to OR, DVT, and PJI. Although length of stay predictions are similar to actual outcomes, statistical correlation remains relatively weak.

Improving patient satisfaction and outcomes while simultaneously delivering cost-effective care depends not just on surgical expertise intraoperatively, but also on the ability to anticipate postoperative complications. These two goals can be addressed through use of predictive tools that already exist in many surgical fields [1–3]. Surgical risk calculators generally assess preoperative factors and attempt to predict the likelihood of adverse events.

Despite being considered a surgical success story, patients undergoing total joint arthroplasty still experience complications, however infrequent [4]. With US volume expected to reach 3.5 million annually by 2030, even a low complication rate becomes a significant burden both to patients and a health system struggling to control costs [5]. Modern reimbursement models consider many of these to be avoidable—termed "zero-tolerance" complications—particularly those requiring early readmission, and focus has turned to identifying patients at risk for preventable

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complications prior to surgery and modulating their postoperative inpatient care appropriately [6].

The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) Universal Surgical Risk Calculator is an open-access online tool for predicting likelihood of adverse perioperative outcomes [7]. Available for a wide variety of surgical procedures, the risk calculator was modeled using nearly 1.5 million patients across 1557 Current Procedural Terminology (CPT) codes, and generates an estimated risk for 11 postoperative complications as well as discharge disposition and predicted length of hospital stay. This risk calculator has already undergone validation efforts across a number of surgical specialties [8–14]. To our knowledge, however, the ACS NSQIP risk calculator has only undergone 2 published attempts at validation within the orthopedics literature [15,16]. Of these, only one (Edelstein et al) examined all 11 postoperative complications as well as discharge disposition. Neither examined length of stay nor the more useful 90-day readmission window commonly used to assess hospital performance [17].

Our objective was to evaluate the predictive ability of the ACS NSQIP Surgical Risk Calculator within a total joint arthroplasty population for discharge to post-acute care, 90-day readmission, return to operating room (OR), periprosthetic joint infection (PJI), deep venous thrombosis (DVT), and length of hospital stay.

Materials and Methods

Data Collection

We performed a single-center, retrospective review of patients receiving a unilateral primary total knee arthroplasty (TKA) or total hip arthroplasty (THA) between January 2012 and December 2014. Approval was obtained from the Institutional Review Board before collecting patient information from their electronic medical record. Only patients with a minimum follow-up of 90 days were included. For each patient, 21 preoperative characteristics including demographics, case type, and medical comorbidities were gathered and manually entered into the ACS NSQIP Surgical Risk Calculator (http://riskcalculator.facs.org/). This interactive online tool generates a percent risk for a variety of postoperative variables of interest. Predicted postoperative outcomes were then recorded alongside actual patient results and adverse events, including discharge to skilled nursing facility (SNF) or rehabilitation center, 90-day readmission, return to OR, PJI, and length of stay. These outcomes were abstracted manually from patient electronic medical records. Readmissions were not counted for 7 patients who underwent a scheduled elective primary total joint replacement on the contralateral side within 90 days. PJI was recorded if diagnosed within 90 days, and return to OR was likewise included if occurring within 90 days (all risk calculator outcomes are actually based on 30 days after surgery). The risk calculator generates length of stay predictions in half-day units, and actual length of stay for each patient was rounded to the same degree of accuracy. CPT codes used were 27447 for primary total knee arthroplasty and 27130 for primary total hip arthroplasty. Joint replacement was assumed to be the only potential treatment option, and was indicated as such in the risk calculator. No adjustment based on surgeon judgment of risk was made to the model. Five surgeons were involved in this study, none of whom operated on more than 40% of our cohort. All used a posterior approach, and any differences in operative time, length of stay, and discharge disposition between surgeons did not reach statistical significance, making it statistically valid to pool patients from all surgeons for analysis.

Statistical Analysis

Risk scores generated by the ACS NSQIP calculator were compared with actual patient outcomes. The Wilcoxon rank-sum test was used to compare average risk scores for those who did and did not experience an adverse event. Associations between predicted risk and observed outcomes were evaluated using logistic regression and summarized using odds ratios and 95% confidence intervals. Receiver operating characteristic (ROC) curves were generated and area under the curve (AUC, or C-statistic) calculated to determine discriminatory ability of the regression models. Discrimination represents the likelihood that events have higher predicted risk scores and non-events have lower predicted risk scores [18]. AUC values range from 0.5 to 1.0, with 1.0 representing a perfect model and 0.5 being no better than a coin flip. Typically, a model is considered adequate when the AUC is <0.7, and strong when <0.8. Confidence intervals (95% CIs) for ROC curves were generated according to the methods described by DeLong [19]. Evaluation of continuous variables (length of stay) was done using Pearson's r and Spearman's rho coefficients. All statistical analyses were performed using R version 3.3.3 (The R Foundation, Vienna, Austria), including the pROC package.

Results

Demographic and comorbidity inputs for the ACS NSQIP risk calculator were collected for 909 patients undergoing unilateral primary TKA (496) or THA (413) between January 3, 2012 and December 30, 2014. Means and standard deviations were calculated for continuous data. TKAs made up the majority (54%) of the cohort, and mean age at surgery was 67.8 years (range 21-95). Fifty-seven percent of the patients were female, and mean body mass index was 30.2 kg/m^2 (range 14.3-58.6) (Table 1).

The risk calculator demonstrated adequate performance in predicting discharge to SNF/rehab, with an AUC of 0.72 (95% CI 0.68-0.75) (Fig. 1). Notably, further stratifying patients by joint showed THA to perform significantly better than TKA (AUC 0.75 vs 0.68). This occurred despite THA making up a smaller proportion of the cohort. Discharge disposition also had the most events in the cohort, with 353 patients (38.8%) discharged to SNF/rehab (Table 2). These patients also had significantly higher ACS NSQIP risk scores than those who were discharged home (42.3 ± 18.3% vs 28.8 ± 15.8%, $P < .001$) (Fig. 2).

Occurrence of DVT also showed fair discrimination (AUC 0.70), but the logistic regression model was not significant ($P = .182$), as DVT arose in a relatively small number of patients (n = 6, 0.66%) (Table 2). Differences in predicted risk scores between those who experienced a DVT and those who did not also failed to reach significance ($P = .082$).

Although logistic regression models were significant for each, discrimination was comparatively limited for PJI (AUC 0.67), 90-day readmission (AUC 0.63), and return to OR (AUC 0.59) (Table 2). Stratifying PJI by joint showed THA to perform substantially better than TKA (AUC 0.70 vs 0.53). THA also performed better than TKA in models for 90-day readmission (AUC 0.68 vs 0.58). Calculated risk scores were significantly higher in patients who experienced a PJI (1.11 ± 0.45% vs 0.86 ± 0.33%, $P = .006$) or a 90-day readmission (4.44 ± 1.84% vs 3.80 ± 1.54%, $P < .001$) than in those who did not (Fig. 2). Risk score differences did not reach significance for patients experiencing a return to OR ($P = .056$).

The risk calculator performed fair in predicting hospital length of stay, only overestimating by 0.2 days on average (median 0.5), although this difference was statistically significant ($P < .001$). Actual mean hospital stay was 3.14 ± 1.28 days versus a predicted stay of 3.36 ± 0.81 days (Table 2). Predicted length of hospital stay