Development of a Dynamic Risk Assessment Instrument to Assess Candidacy for Outpatient Hip or Knee Arthroplasty Based on Machine Learning Techniques

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INTRODUCTION:
Patient selection is critical to the safety of outpatient hip or knee arthroplasty. Those selected for outpatient arthroplasty should be at minimal risk of requiring a hospital-based intervention postoperatively. Using machine learning approaches, we developed a risk assessment instrument that identifies patients who are at higher risk of requiring inpatient postoperative care based on their preoperative characteristics.

METHODS: We reviewed 17,792 patients who underwent a primary total hip or total knee arthroplasty between 2016-2019 using an institutional electronic health record. These patients were divided into two groups: one group requiring a hospital-based intervention (HBI) during their postoperative admission (n=12,820) and one which did not (n=4,972). HBIs included abnormal vital signs, abnormal laboratory testing requiring monitoring or intervention, blood transfusion, urinary retention requiring catheterization, uncontrolled nausea, and uncontrolled pain requiring intravenous breakthrough medication. Using 64 patient characteristics, we applied supervised machine learning models to predict the risk for HBIs. This model was adapted into a risk assessment instrument using SHAP values, allowing for a determination of HBI risk using routinely obtained preoperative variables.
RESULTS: The area under the receiver operating characteristics (AUROC) for the best performing machine model, XGBoost, was 0.969 for predicting HBI (Figure 1). The predictive capability of this model far exceeds current clinical selection criteria, which carries an AUROC of 0.545. Clinical variables that are routinely available on preoperative examinations were adapted into a web-based risk assessment instrument that determines a patient's risk for HBI based on data from the computational model (Figure 2).
DISCUSSION AND CONCLUSION: A machine learning approach can be effective in predicting the need for a hospital-based intervention following THA or TKA. The use of machine learning combined with the development of a dynamic risk assessment instrument represents an objective, data-driven approach in identifying candidates who are safe for outpatient hip or knee arthroplasty.

Classifier	AUROC
Logistic Regression (LR)	0.8157 ± 0.0153
Linear Discriminant Analysis (LDA)	0.8147 ± 0.0178
Gaussian Naïve Bayes (GNB)	0.6612 ± 0.0145
Random Forest (RF)	0.9676 ± 0.0059
XG Boost (XGB)	0.9691 ± 0.0067
Multilayer Perceptron (MLP)	0.8705 ± 0.0172
Extra Trees (ET)	0.8857 ± 0.0144