Predicting Hospital Length of Stay After Total Knee Arthroplasty Using Machine Learning: Insights from the UC Irvine MOVER Dataset

Jawaad Javaid[1], Zuhyr Khan[1], Abdullah Uddin[2]

Introduction: Predicting hospital length of stay (LoS) after total knee arthroplasty (TKA) plays a critical role in the allocation of healthcare resources and surgical planning. While traditional regression methods can identify basic associations, they may fail to capture complex nonlinear relationships between clinical variables and LoS. Machine learning (ML) approaches may enhance prediction accuracy using both categorical and continuous predictors.

Methods: We analyzed 693 patients who underwent total knee arthroplasty (TKA) in the UC Irvine MOVER dataset between 2015 and 2022. Predictive variables included age, sex, BMI, ASA rating, anesthesia type, and anesthesia duration. Univariate analysis was performed using Pearson correlation, one-way ANOVA, and post-hoc pairwise analysis where appropriate. Four regression models were tested which included Random Forest, Lasso, and Linear Regression. In addition, gradient boosting was applied using the CatBoost model to enhance regression performance. Four classification models were also trained to predict LoS < 2 days and LoS < 4 days. An 80/20 train/test split with 5-fold cross-validation was used in training each model.

Results : Univariate analysis identified total anesthesia time ($r = .357$, $p < .001$) and ASA rating ($r=.196$, $p < .001$) to have a significant impact on hospital LoS. One way ANOVA identified sex ($f = 5.75$, $p < .017$) and primary anesthesia type ($f = 4.03$, $p < .002$) as categorical variables with significant impacts on LoS. Of the four multivariate regression models, CatBoost performed the best by using the predictive variables to account for 29.7% (MAE < 1.332) of variance in LoS. CatBoost's feature importance values identified total anesthesia time, BMI,, and age as being the top three most impactful variables, respectively. Machine learning models are also trained using these predictors to estimate both LoS < 2 days (AUC = 0.75) and LoS < 4 days (AUC = 0.74) with accuracy highest for CatBoost LoS < 2 days (0.81) and LoS < 4 days (0.75).

Conclusion: Our findings demonstrate that machine learning methods, particularly gradient boosting with CatBoost, outperform traditional regression techniques in predicting LoS following TKA. Total anesthesia time, BMI, and age were the most influential predictors across the models. Classification models achieved moderate accuracy (AUC up to .75) in stratifying patients between LoS categories. These results suggest that machine learning could be a supplemental datapoint for risk stratification to guide discharge planning and improve allocation of hospital resources. Future studies with larger and more diverse datasets are warranted to further refine predictive accuracy and assess generalizability across institutions.

Significance/Clinical Relevance: Predicting hospital length of stay (LoS) after total knee arthroplasty (TKA) plays a critical role in the allocation of healthcare resources and surgical planning. Supplemental data points like those provided by machine learning models can help clinicians predict which patients might need to stay longer and optimize their care plans.

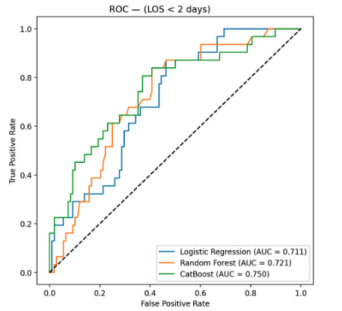

Fig 1. ROC for ML and logistic regression models trained using predictive variables to classify patients with expected LoS < 2 days.

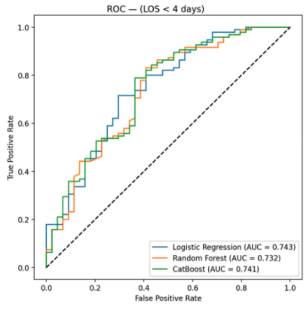

Fig 2. ROC for ML and logistic regression models trained using predictive variables to classify patients with expected LoS < 4 days.

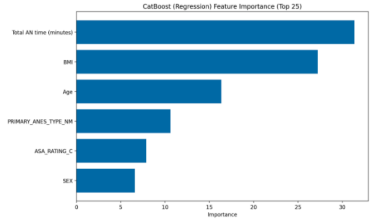

Fig 3. Feature importance plot from the CatBoost regression model predicting hospital length of stay (LoS). Importance values are normalized and reflect each variable's contribution to the model's predictive performance.

1. Chicago Medical School, Rosalind Franklin University, North Chicago, IL
2. SUNY Downstate College of Medicine, Brooklyn, NY