Title: Transfer Status Predicts Extended Operation Time in Pediatric Femur Fracture Fixation: A Machine Learning Analysis

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INTRODUCTION: Pediatric femur fractures are common injuries requiring surgical intervention. With increased scrutiny into quality of care for pediatric subspecialties, including orthopedics, timely surgery has emerged as a key quality indicator, with extended operation time (eOT) linked to postoperative complications. Transfer status may delay time to the operating room and contribute to eOT, yet its role as a predictor of eOT has not been characterized. Using the National Surgical Quality Improvement Program-Pediatric (NSQIP-P) database, this study applied machine learning (ML) to predict eOT, with particular focus on transfer status as a preoperative predictor.

METHODS: Patients ≤18 years undergoing femur fracture fixation were identified in NSQIP-P (2016-2022) using Current Procedure Terminology (CPT) codes. eOT was defined as operation duration exceeding one standard deviation above the mean. Models were trained on demographics, comorbidities, procedural factors, and institutional variables, then evaluated using AUC, precision, accuracy, recall, and F1 score. Feature importance was quantified using SHapley Additive exPlanations (SHAP) analysis, with predictors ranked by mean absolute SHAP (MAS) values.

RESULTS: Among 7838 patients (mean age 10.3 ± 3.85 years, 27.5% female), 12.1% had eOT (1084 cases). CatBoost demonstrated the best predictive performance (AUC = 0.727, accuracy = 75.2%, precision = 24.1%, recall = 48.6%, F1 score = 0.322). Transfer status was a top predictor of eOT (MAS = 0.106), with transfer from an acute care hospital or from a clinic or doctor's office contributing most. Other influential factors included higher weight, lower work RVU, higher ASA class, and younger age.

DISCUSSION AND CONCLUSION: Transfer status is a key system-level factor contributing to eOT, impacting both time to OR and operation duration. These findings represent a modifiable target for improving quality benchmarks and suggest that referring providers should prioritize direct transfer to pediatric trauma centers or facilities with pediatric orthopedic expertise.

Figure 1. SHapley Additive exPlanations (SHAP) summary plot demonstrating feature importance in predicting extended operation time in pediatric patients undergoing surgical fixation of femur fractures, using the CatBoost classification model.