Development of a Machine Learning Algorithm for Prediction of All-Cause Early Reoperation Following Lower Extremity Tumor Resection and Endoprosthetic Reconstruction: A Secondary Analysis from the PARITY Trial

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INTRODUCTION: Aggressive lower extremity bone tumors are typically treated with resection and endoprosthetic reconstruction. Given the significant morbidity associated with reoperation in systemically compromised patients, accurate preoperative risk stratification is critical to patient counseling and shared decision-making. Machine learning (ML) is powerful tool that has been increasingly utilized in predictive modeling for clinical outcomes in orthopaedic surgery. The goal of this study was to leverage data from the Prophylactic Antibiotic Regimens in Tumor Surgery (PARITY) trial to develop a ML model for prediction of early reoperation after lower extremity tumor excision and endoprosthetic reconstruction.

METHODS:

Fifty-seven patient demographics and clinical features across 604 lower extremity endoprosthetic reconstructions were evaluated as predictors of all-cause reoperation within one year. Traditional logistic regression (LR) and four additional standard ML benchmarks were used for model building. Standard metrics of area under receiver operating curve (AUROC), area under the precision-recall curve (AUPRC), and Brier scores were used to evaluate model performance. Important features for the top-performing model were determined.

RESULTS:

Of 604 lower extremity endoprosthetic reconstructions performed in the study period, 155 patients (25.7%) underwent at least one reoperation. The gradient boosting model had the highest discriminative power (AUROC=0.817, AUPRC=0.690) as shown in Figure 1. Table 1 shows comparative model performance. Development of surgical site infection (SSI), operative time, white race, length of stay, and female sex were the five most important performance features for model performance (Table 2).

DISCUSSION AND CONCLUSION:

We report a well-calibrated ML-driven algorithm with high discriminatory power for the prediction of all-cause early reoperation following lower extremity tumor resection and endoprosthetic reconstruction. Preventing SSI remains paramount to avoiding the morbidity of reoperation after complex oncologic limb salvage surgeries.

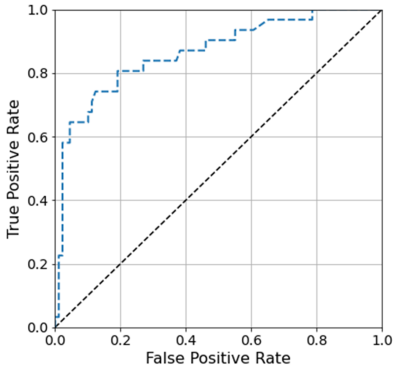

Table 1. Comparative model performance

Model	AUROC	AUPRC	Brier Score
Logistic Regression	0.783 ± 0.04	0.642 ± 0.10	0.138 ± 0.019
XGBoost	0.806 ± 0.03	0.674 ± 0.08	0.135 ± 0.016
Gradient Boosting	0.817 ± 0.04	0.690 ± 0.09	0.130 ± 0.020
AdaBoost	0.718 ± 0.04	0.523 ± 0.08	0.183 ± 0.02
Random Forest	0.815 ± 0.04	0.651 ± 0.08	0.137 ± 0.02

Table 2. Relative feature importance for Gradient Boosting

Binary Features	Rank in Gradient Boosting	Change to Risk Prediction
Surgical Site Infection	1	0.5755
White race	2	0.0535
Female sex	3	0.0479
NPWT use	4	0.0427
Opioid use	5	0.0286
Giant cell tumor of bone	6	0.0220
Osteosarcoma	7	0.0146
Open biopsy	8	0.0044
Continuous Features		
Operative length	1	0.1073
Length of stay	2	0.0499
Age	3	0.0463