Wound complication after instrumented spinal fusion: a random forest-driven algorithm

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INTRODUCTION:

Wound complications after spinal surgery are a source of increased cost, hospitalization length, and morbidity. Additionally, post-operative infection of instrumentation risks mechanical instability, pseudarthrosis, deep infection, and neurologic deterioration. Pre-operative prediction of wound complication risk would thus be of significant utility. Dedicated algorithms for wound complication after instrumented spinal fusion remain scarce. We aim to develop a machine learning model for prediction of wound complication after instrumented spinal fusion. We additionally aim to identify novel features important for model performance.

METHODS:

We included all adult patients who underwent instrumented spinal fusion at a tertiary care academic medical center between 2013-2020. The primary outcome was post-operative wound complication defined as superficial surgical site infection, deep infection, seroma formation, or dehiscence. We generated logistic regression and machine learning models representing different modeling techniques: XGBoost, gradient boosting, AdaBoost, random forest. Discrimination was determined using the area under the receiver operating characteristic curve (AUROC) and area under the precision-recall curve (AUPRC). We assessed calibration with the calibration slope, calibration intercept, and Brier score. With the use of a partial dependence function, we ranked the importance of patient features for the best-performing model.

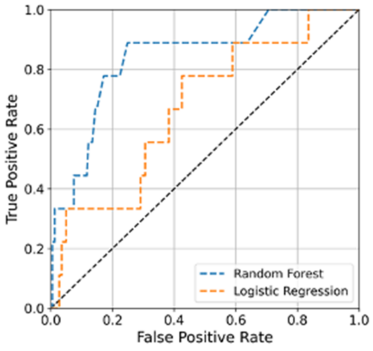
RESULTS:

A total of 2,053 patients met inclusion criteria, with 42 cases of wound complication (2.0%).

The random forest model had the best performance of all tested models, with an AUROC of 0.713 and AUPRC of 0.080. The receiver-operating characteristic curve and precision-recall curve are shown in Figures 1 and 2, respectively. With a calibration slope of 1.15, calibration intercept of -0.006, and Brier score of 0.02, this model was well-calibrated. The following features were the most important for random forest performance: spinal infection as surgical indication, hemodialysis-dependence, spinopelvic fixation, fusion spanning $\geq$2 spinal junctions, HIV positive status, positive smoking history, depression/anxiety, and revision surgery (Table 1). Of these, only two – smoking history and depression/anxiety – were important features for logistic regression. The most important continuous features for the random forest model were body mass index and pre-operative hemoglobin.

DISCUSSION AND CONCLUSION:

We report a well-calibrated random forest algorithm that predicts wound complication after instrumented spinal fusion. With an AUROC of 0.713, this model has moderate-to-high discrimination. Additionally, we identify novel patient features important for model performance; these features are distinct from those identified by logistic regression. Prediction of risk of wound infection after instrumented fusion may facilitate improved pre-operative risk stratification and patient counseling. Furthermore, we identify potentially modifiable risk factors such as depression/anxiety and positive smoking history that can be addressed to minimize the risk of developing a wound complication after instrumented fusion.



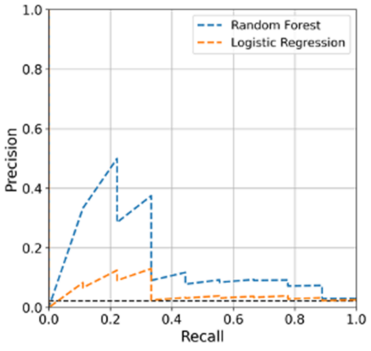


Table 1. Relative feature importance for wound complication after instrumented spinal fusion

Feature	Rank in random forest model	Change to risk prediction
Binary features		
Indication: infection	1	0.0419
Dialysis-dependent	2	0.0308
Spinopelvic fixation	3	0.0221
Transforaminal lumbar interbody fusion	4	0.0121
Indication: other	5	0.0115
Fusion across ≥3 levels	6	0.0106
HIV positive	7	0.0103
Smoking history	8	0.0089
Depression and/or anxiety	9	0.0087
Revision surgery	10	0.0082
Continuous features		
Body mass index	1	0.0185
Pre-operative hemoglobin	2	-0.0144
Pre-operative WBC count	3	-0.0063
Charlson comorbidity index	4	0.0050
Number of levels fused	5	0.0018

WBC: white blood cell; HIV: human immunodeficiency virus