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Machine Learning Enhances Diagnosis of Necrotizing Soft Tissue Infections (NSTI) with Superior Accuracy

Anita Gunaseelan Subbarao, MD[1]; Jane Hall, PhD[1]; Robert Doerning, MD, MBA, MS, FACEP[1]; Eileen Bulger, MD, FACS[2]; Erika Bisgaard, MD[2]; M. Kennedy Hall, MD, MHS[1]

1 University of Washington, Department of Emergency Medicine; Seattle, WA
2 University of Washington, Department of Surgery; Seattle, WA

Introduction

Necrotizing soft tissue infections (NSTI) are life-threatening conditions with mortality rates up to 30%, requiring timely diagnosis to improve outcomes[1]. Diagnosis is challenging, often relying on surgical exploration, leading to treatment delays. Existing risk stratification tools like the Laboratory Risk Indicator for Necrotizing Fasciitis (LRINEC) score perform poorly in external validation[2], highlighting the need for a reliable risk prediction tool. This study aimed to develop and validate a machine learning-based scoring system (N-FECT) to improve diagnostic accuracy and streamline decision-making.

Methods

This retrospective study included cases with diagnostic codes for "NSTI", "cellulitis", and "abscess" from two academic centers (April 2022–April 2024) with ESR or CRP results, suggesting high clinical suspicion. Baseline demographics, vitals, and lab values were extracted, and a surgical database served as the gold standard for confirmed NSTI cases. The dataset was split 70% for training and 30% for test validation. Random forest and logistic regression reduced 50 variables to 10, optimizing dimensionality handling and interpretability, generating a final model, N-FECT. Performance metrics, including AUC-ROC, assessed accuracy and feasibility, and were compared to LRINEC score performance.

Dataset Splitting

Initial dataset partitioned with a held back sample for testing.

Feature Selection

Random forest identifies and prioritizes influential predictors from 50 candidate variables for efficiency and interpretability.

Logistic Regression

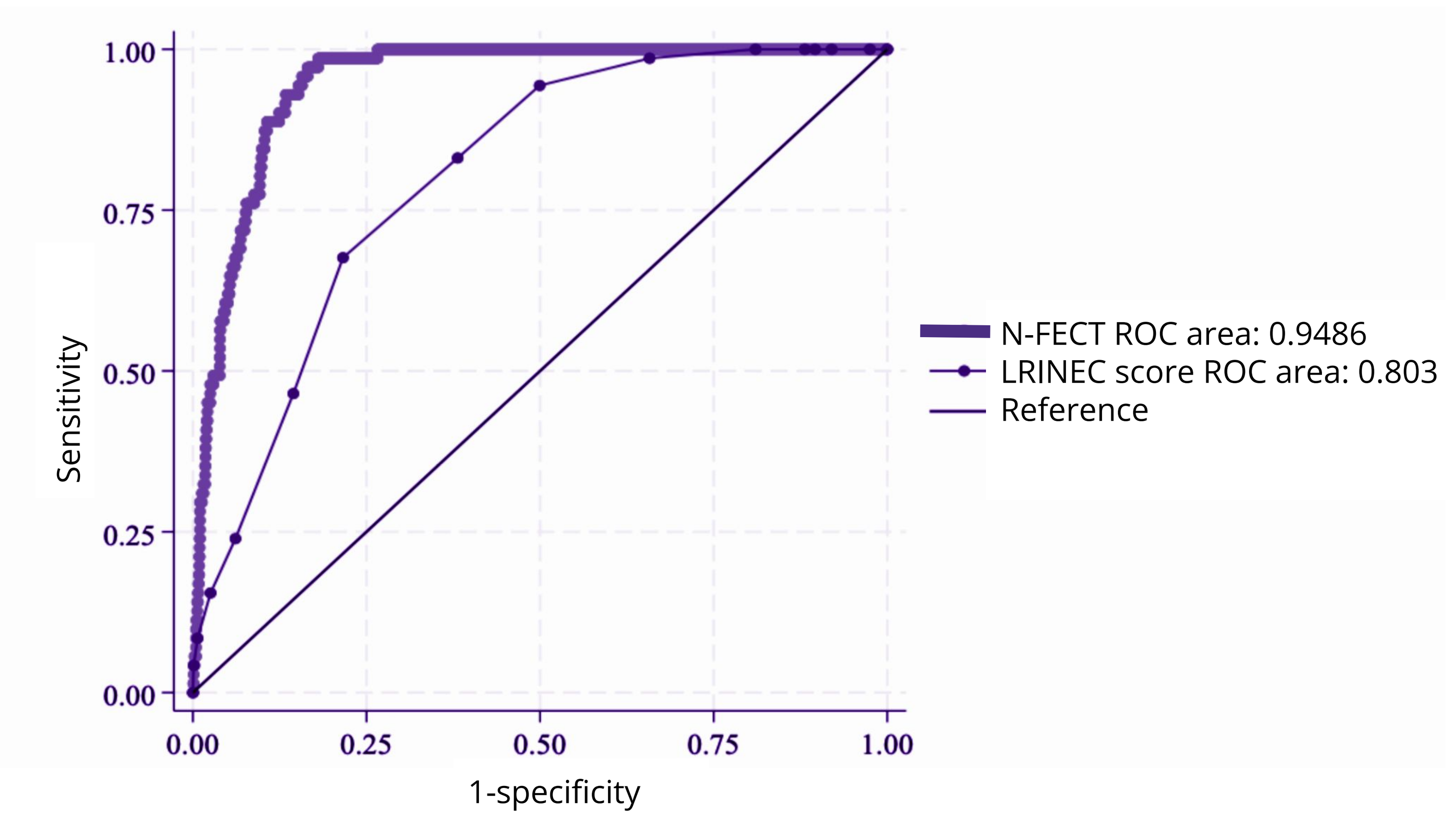
Selected features were used to train a logistic regression model, quantifying predictor magnitude and effect size on outcome.

Model Evaluation

Model's predictive power rigorously assessed using performance metrics, primarily AUC-ROC.

Results

The dataset included 8,288 patients, of which 193 had confirmed NSTIs from the gold standard surgical database. The N-FECT model achieved a cross-validated ROC-AUC of 0.949 (95% CI = 0.935–0.963) with sensitivity of 96.6% and specificity of 63.0% at a 1% predicted probability, indicating its strong ability to identify almost all true cases while maintaining reasonable exclusion of false positives. The corresponding positive predictive values (PPV) and negative predictive values (NPV) were 10.6% and 100.0%, respectively, versus LRINEC with PPV=4.0% and NPV=100.0%.



Applying model predictions to the test set demonstrated superior diagnostic accuracy compared to the LRINEC score (ROC-AUC = 0.803, 95% CI = 0.762–0.844). The difference in AUCs between the N-FECT model and the LRINEC score was statistically significant ($p < 0.001$), as determined by DeLong's test. Notably, the false positive rate among suspected NSTIs using the N-FECT model was 32.7% vs. 93.7% using the LRINEC model, highlighting its potential to significantly reduce unnecessary surgical interventions. The key lab predictors (albumin, total protein, WBC, CO2, BUN, CRP, sodium, creatinine, BMI, and potassium) exhibited strong alignment with clinical relevance, enhancing the model's interpretability and feasibility for integration into clinical workflows.

Key Lab Predictors

Albumin, Total Protein, WBC, CO2, BUN, CRP, Sodium, Creatinine, BMI and Potassium

Conclusions

This study demonstrates the utility of a machine learning-based NSTI risk prediction tool developed from routinely collected clinical and laboratory data. By incorporating 10 clinically relevant predictors and achieving high predictive accuracy, this model provides a practical and interpretable approach to support timely and accurate clinical decision-making and aligns with real-world workflows to identify patients at high risk for NSTI. The overarching aim is to improve early risk stratification and reduce the incidence of unnecessary surgical interventions in patients deemed to be at low risk. These findings provide a foundation for broader external validation to build a scalable framework for integrating predictive models into clinical practice. Future efforts will focus on engaging key stakeholders to assess the acceptability and perceived utility of a novel risk stratification tool, and on expanding model implementation across diverse healthcare settings, institutions, and patient populations.

References

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