Shaping Tomorrow's Nephrology: Insight-Driven Kidney Care
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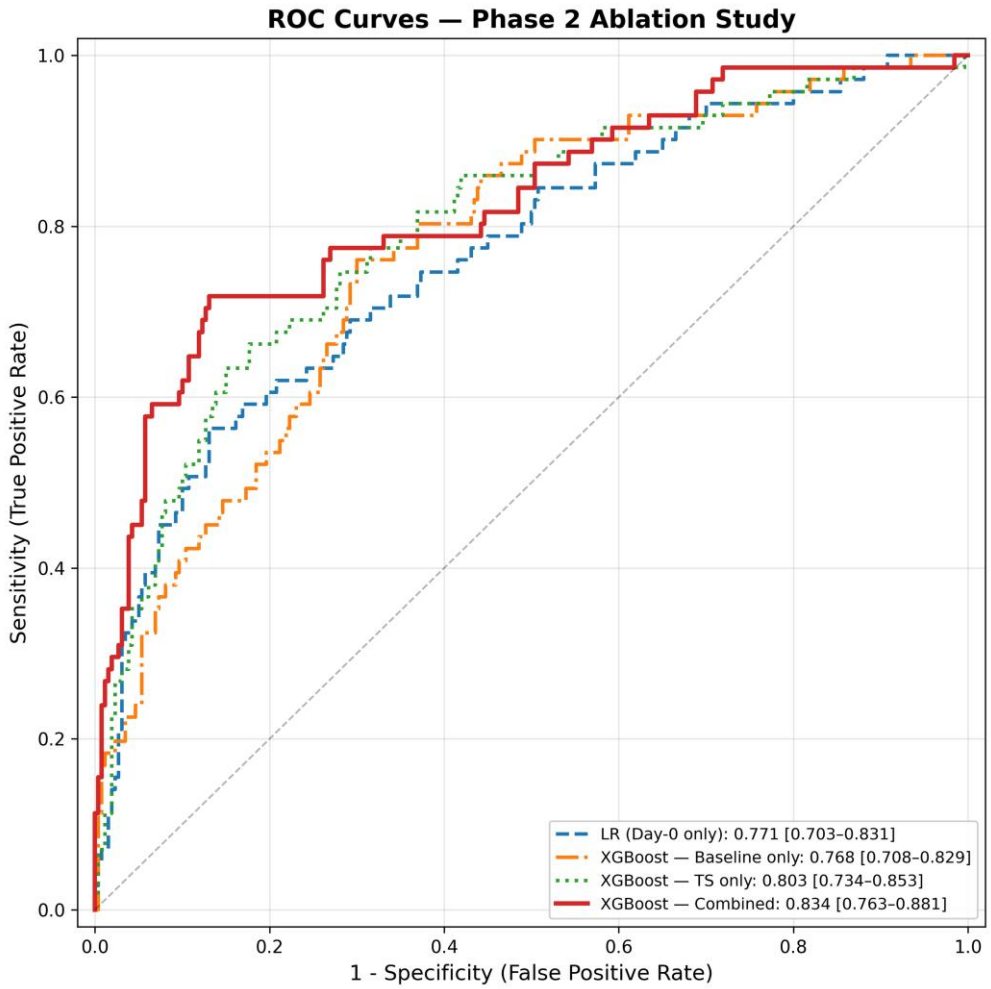
72-Hour Hemodynamic and Urine Output Trajectories Predict Renal Recovery in Continuous Kidney Replacement Therapy: A Machine Learning Approach

Daseul Huh, Juyeon Park, Youn Kyung Kee, Hee Jung Jeon, Jieun Oh, Dong Ho Shin
Department of Internal Medicine-Nephrology, Kangdong Sacred Heart Hospital, Korea, Republic of

Objectives : Predicting renal recovery in patients receiving continuous kidney replacement therapy (CKRT) remains challenging. Conventional single-time-point hemodynamic assessments at CKRT initiation have shown limited prognostic value. We investigated whether 72-hour hemodynamic and urine output (UO) trajectories, analyzed through machine learning, could improve prediction of 28-day renal recovery.
Methods : This single-center retrospective cohort study included 331 CKRT episodes (318 patients). Renal recovery was defined as successful CKRT discontinuation with no kidney replacement therapy for at least 72 hours within 28 days of initiation. Phase 1 employed Cox proportional hazards regression to evaluate day-0 variables. Phase 2 developed machine learning models (logistic regression, XGBoost, bidirectional LSTM) using 51 engineered features from 72-hour MAP, heart rate (HR), and UO time-series data. Model performance was assessed using 5-fold stratified cross-validation with bootstrap 95% confidence intervals. SHAP analysis was used for model interpretability.
Results : Of 331 episodes, 71 (21.5%) achieved renal recovery. In Phase 1, day-0 UO was non-significant in both univariable (HR=1.000; p=0.146) and multivariable Cox regression (HR=1.000; p=0.697), even when forced into a model with clinically important covariates. The multivariable model (C-index=0.769) identified CCI (HR=0.749; p<0.001) and SOFA (HR=0.804; p<0.001) as the strongest independent predictors. In Phase 2, incorporating 72-hour trajectories significantly improved prediction: XGBoost Combined (day-0 + 72h features) achieved an AUC of 0.834 (95% CI, 0.763–0.881), compared with 0.768 for baseline-only XGBoost (ΔAUC=+0.066, DeLong p=0.076). SHAP analysis revealed late-phase (36–72h) UO variability (UO_late_std) as the dominant predictor (mean SHAP=1.310), exceeding the second-ranked feature by four-fold. The 72-hour UO trajectory features occupied two of the top three positions in feature importance.
Conclusions : Day-0 hemodynamic variables fail to predict renal recovery in CKRT patients when assessed as single-time-point measurements. However, 72-hour trajectories—particularly late-phase UO variability—are powerful predictors when captured through machine learning. These findings support integrating temporal hemodynamic patterns into clinical decision-making for CKRT patients.

Figure2_ROC_curves.jpeg



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