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**Development of Machine Learning Models for Predicting CRRT in Bacteremia Patients Admitted to the ICU, with a Focus on the Impact of Vancomycin Administration using MIMIC-III data**

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**Objectives :** Bacteremia patients admitted to the intensive care unit(ICU) are at a high risk of developing septic acute kidney injury(AKI), often necessitating continuous renal replacement therapy(CRRT). Additionally, the use of nephrotoxic antibiotics, particularly vancomycin, may further elevate the risk of kidney injury. This study aims to develop a machine learning model, utilizing the MIMIC-III dataset, to predict the likelihood of CRRT initiation in ICU-admitted bacteremia patients. Specifically, we investigate how vancomycin usage influences the probability of requiring CRRT using a deep learning model.

**Methods :** We analyzed patients with positive blood cultures. The primary outcome was defined as the initiation of CRRT during the ICU stay. Machine learning and deep learning models were developed to predict the outcome, emphasizing the significance of vancomycin. The GANITE model was utilized to quantitatively demonstrate the impact of vancomycin on the probability of CRRT initiation.

**Results :** A total of 1,309 patients were included in the analysis, with 41 requiring CRRT. Vancomycin administration showed a significant association with an odds ratio of 2.62 (1.13-6.06,  $p=0.024$ ) for CRRT initiation. Among machine learning models, CatBoost and Random Forest exhibited the best performance, with Area Under Curve of Receiver Operating Characteristic Curve(AUROC) values of 0.880 and 0.901, respectively. SHapley Additive exPlanations(SHAP) values from both models indicated that vancomycin administration increased the probability of CRRT initiation. The GANITE model demonstrated an average 7% increase in the probability of CRRT occurrence in both train and test data. When comparing the ICU initial creatinine and norepinephrine levels between groups with a more than 10% increase in the probability of CRRT due to vancomycin administration and those without, both creatinine and norepinephrine requirements were significantly higher in the former group.

**Conclusions :** We developed machine learning and deep learning models to predict the likelihood of CRRT in bacteremia patients, highlighting the importance of vancomycin as a significant variable.

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Table 1. Performance of prediction models

	Train AUC	Train Accuracy	Train F1-score	Train Recall	Test AUC	Test Accuracy	Test F1-score	Test Recall
<b>Ensemble</b>	0.966	0.981	0.730	0.742	0.902	0.957	0.414	0.600
<b>Random Forest</b>	0.930	0.929	0.425	0.774	0.901	0.911	0.314	0.800
<b>CatBoost</b>	0.957	0.98	0.710	0.710	0.880	0.964	0.417	0.500
<b>TabTransformer</b>	0.876	0.966	0	0	0.782	0.975	0	0

Table 2. ATE, CATE, and evaluation index of GANITE model

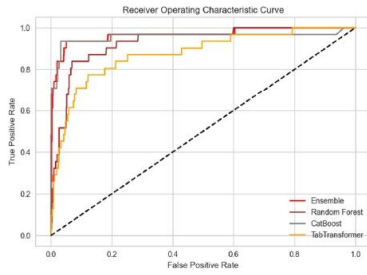
	Train	Test
<b>Accuracy</b>	0.783	0.789
<b>F1-score</b>	0.181	0.108
<b>AUROC</b>	0.84	0.732
<b>ATE</b>	0.067 (0.065-0.069)	0.066 (0.063-0.069)
<b>CATE for Treatment group</b>	0.071 (0.065-0.077)	0.065 (0.056-0.074)

Table 5. Comparing negative effect group and positive effect group

	Train TE < 0.1	Train TE > 0.1	P-value	Test TE < 0.1	Test TE > 0.1	P-value
<b>MRSA</b>	0.108	0.104	>0.999	0.096	0.017	0.084
<b>MSSA</b>	0.065	0.110	0.064	0.072	0.138	0.149
<b>ICU 1<sup>st</sup> Creatinine</b>	1.738 (1.617-1.86)	3.449 (3.015-3.883)	<0.001	2.028 (1.821-2.234)	3.767 (2.943-4.591)	<0.001
<b>Norepinephrine</b>	4.145 (4.086-4.204)	4.31 (4.171-4.45)	0.031	4.178 (4.099-4.257)	4.503 (4.234-4.773)	0.024

Figure 1. ROC curve of prediction models

(A) Train data



(B) Test data

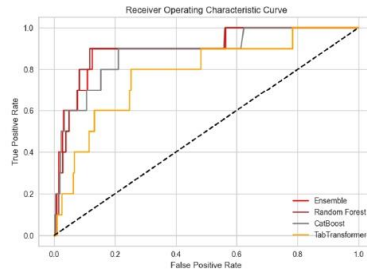
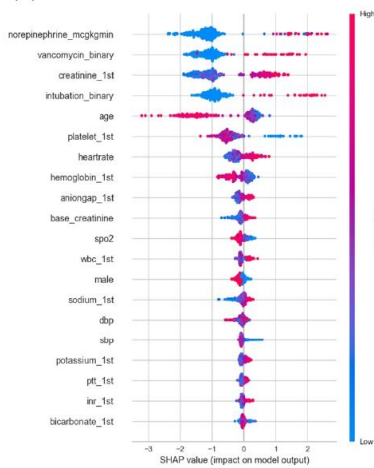


Figure 2. SHAP of CatBoost and LightGBM models

(A) CatBoost



(B) LightGBM

