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Real-time dual prediction of intradialytic hypotension and hypertension using an explainable deep learning model

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Objectives: Both intradialytic hypotension (IDH) and hypertension (IDHTN) correlate with poor outcomes in hemodialysis patients, but a model predicting dual outcomes in real-time has never been developed. We developed an explainable deep learning model with a sequence-to-sequence-based attention network to predict the above events simultaneously.

Methods: We retrieved 302,774 hemodialysis sessions from the electronic health records of 11,110 corresponding patients, and they were split into training (70%), validation (10%), and test (20%) datasets by patient randomization. The outcomes were defined when nadir systolic blood pressure (BP) <90 mmHg (termed IDH-1), a decrease in systolic BP ≥20 mmHg and/or a decrease in mean arterial pressure ≥10 mmHg (termed IDH-2), or an increase in systolic BP ≥10 mmHg (i.e., IDHTN) occurred within 1 hour.

Results: We developed the temporal fusion transformer (TFT)-based model, and its model performance, such as receiver operating characteristic curve (AUROC) and area under the precision-recall curves (AUPRC), was compared with those obtained using other machine learning models, such as recurrent neural network, light gradient boosting machine, random forest, and logistic regression. Among all models, the TFT-based model achieved the highest AUROCs of 0.953 (0.952–0 .954), 0.892 (0.891–0.893), and 0.889 (0.888–0.890) in predicting IDH-1, IDH-2, and IDHTN, respectively. The AUPRCs in the TFT-based model for outcomes were higher than those obtained from other models. The factors that contributed most to the prediction were age and previous session, which were time-invariant variables, and systolic BP and elapsed time, which were time-varying variables.

Conclusions: The present TFT-based model predicts both IDH and IDHTN in real time and provides explainable variable importance.

Figure 1. Plots of the model performance. (A), Area under the receiver operating curve (AUROC) in predicting outcomes. (B), Area under the precision-recall curve (AUPRC) in predicting outcomes. (C), AUROC and counts of outcomes according to the elapsed time. (D), AUPRC and counts of outcomes according to the elapsed time.

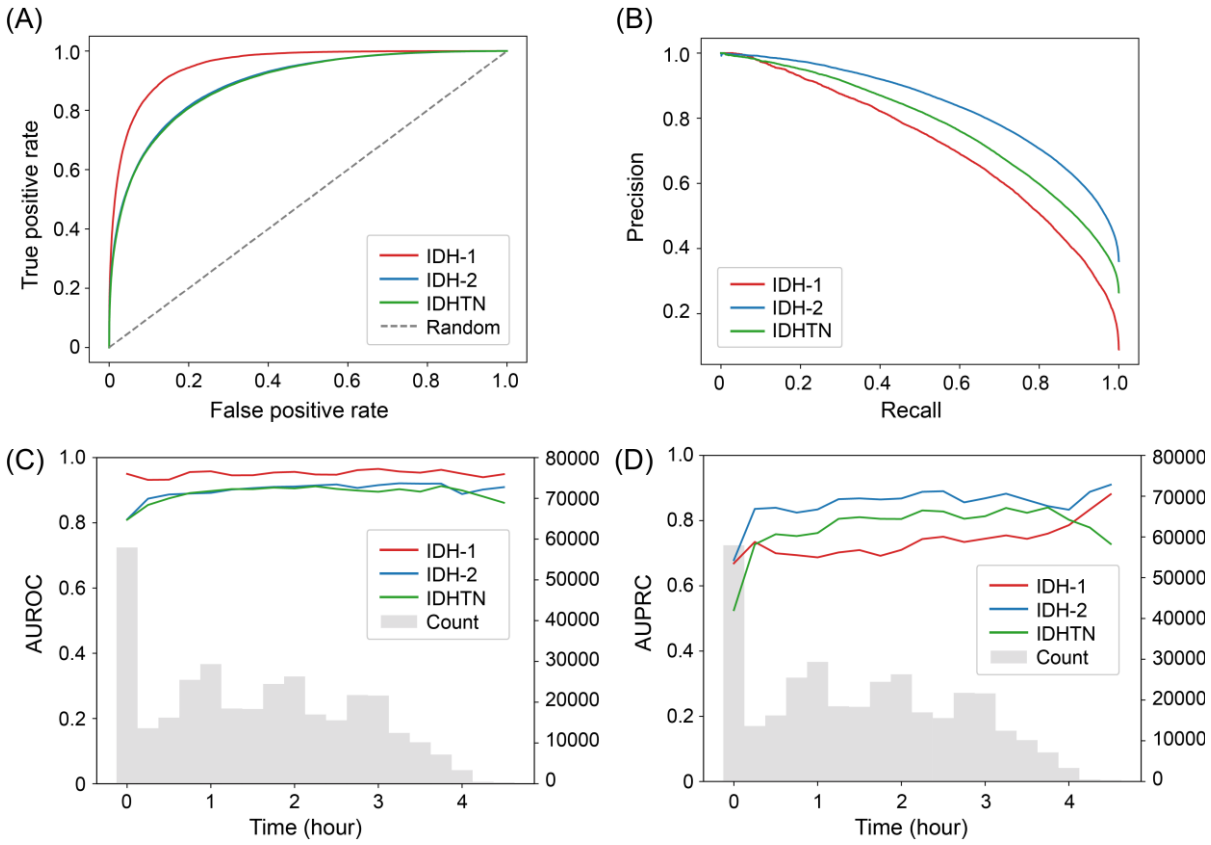

Figure 2. Mean weights of time-invariant and time-varying features from the attention module in the model. (A), Weights of time-invariant features. (B), Weights of time-varying features. BP, blood pressure.