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Real Time Intradialytic Hypotension Forecasting Leveraging Modern Deep Learning Method with Fusion of Physiological Data and Electronic Health Record

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Background

- Intradialysis hypotension (IDH) poses a significant challenge in the clinical management of dialysis patients, necessitating real-time forecasting to enhance treatment outcomes. This work introduces a novel approach leveraging modern deep learning techniques to construct a predictive system capable of identifying and preempting hypotensive events during dialysis sessions. Both real time physiological data within the dialysis sessions and electronic health records are considered during modeling with multimodal fusion method. Furthermore, the model is trained under multitask learning manner that considered various definitions of IDH from the literature. Drawing from extensive data across multiple facilities covering more than 1.4k patients and 0.2M dialysis sessions, our method demonstrates promising results.

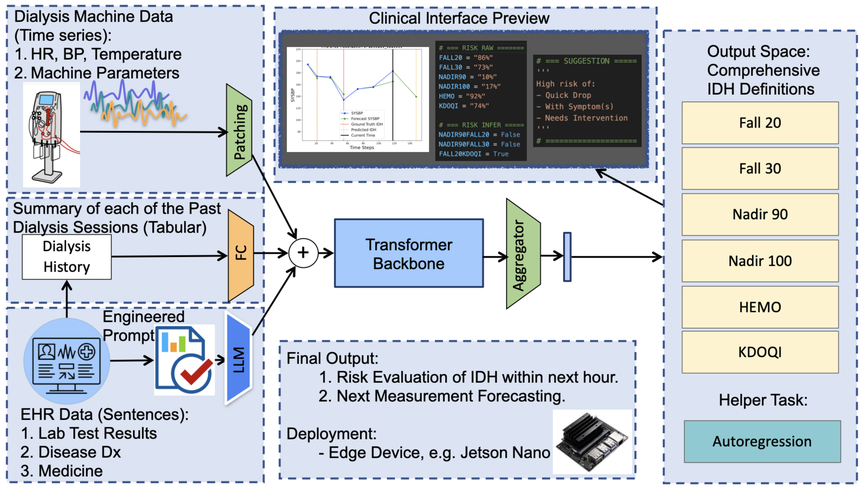
Data Statistics

Table 1. Basic information of the dataset

Factors	Domain	Statistics
Age (years), mean (SD)		65 (15)
Gender, (% out of 1452)	Male	58.2
	Female	41.8
Race, (% out of 1452)	WHITE	54.34
	ASIAN	1.72
	AMERICAN	8.2
	HISPANIC	11.98
	BLACK	16.74
	OTHER	7.02
Dialysis Vintage (years), mean (SD)		2.29 (1.61)
Number of Dialysis, mean (SD)		145.59 (203.07)
Dialysis Session Duration (hours:mins), mean (SD)		3:38 (0:41)
Measurement Frequency (minutes), mean (SD)		26 (15)
Number of BP Measurements /session, mean (SD)		9.3 (1.91)
Presence at session and patient levels	Fall20	12.5%, 79.27%
	Fall30	5.25%, 66.53%
	Nadir90	0.62%, 23.35%
	Nadir100	2.5%, 46.83%
	HEMO	0.37%, 25.76%
	KDOQI	0.02%, 1.72%
Lab Test Results	WBC	7.64 (98.23)
	Platelets	210.84 (84.43)
	Hematocrit	32.35 (5.52)
	Albumin (Serum)	3.76 (0.42)
	Ferritin	722.94 (651.99)
	Iron	68.62 (33.65)
	Lymphocytes	20.13 (8.25)
	HGB	10.4 (1.94)
	Neutrophils	65.32 (11.02)
	Urea reduction ratio	71.14 (9.15)
	TSAT%	30.44 (15.27)
Comorbidity, (% out of 1452)	Diabetes	41.8
	Lung Disease	20.01
	Coronary Artery Disease	9.16
	Heart Failure	18.52
	Cancer	2.2

Methods

Figure 1. Overview of the modeling framework



Results

Table 2. The best performance achieved on data from 17 facilities covering 1452 patients and 211298 dialysis session, conducting 5-fold cross validation. Performance on various definition stated in the literature are presented.

Definitions	ROC AUC	Spe	Sen	Bal Acc
Fall 20	0.849±0.003	0.737±0.048	0.785±0.037	0.761±0.006
Fall 30	0.873±0.004	0.810±0.029	0.764±0.032	0.787±0.003
Nadir 90	0.944±0.006	0.917±0.006	0.795±0.017	0.856±0.011
Nadir 100	0.933±0.006	0.867±0.010	0.846±0.006	0.857±0.007
HEMO	0.814±0.002	0.709±0.025	0.759±0.023	0.734±0.002
KDOQI	0.812±0.004	0.933±0.016	0.341±0.067	0.637±0.026
Nadir 90 Fall 20	0.913±0.004	0.971±0.004	0.502±0.022	0.737±0.010
Nadir 90 Fall 30	0.912±0.002	0.975±0.004	0.493±0.031	0.734±0.014
Fall 20 KDOQI	0.912±0.004	0.964±0.013	0.438±0.124	0.701±0.056

Table 3. Ablation study: Balanced accuracy of models with with various configurations

Definitions	Final	w/o EHR	Late Fuse	w/o Multitask
Fall 20	0.761±0.006	**0.765±0.003**	0.751±0.015	0.675±0.010
Fall 30	**0.787±0.003**	0.783±0.007	0.738±0.083	0.701±0.011
Nadir 90	**0.856±0.011**	0.852±0.004	0.847±0.018	0.829±0.001
Nadir 100	**0.857±0.007**	0.855±0.004	0.848±0.010	0.799±0.013
HEMO	0.734±0.002	**0.739±0.001**	0.725±0.012	0.734±0.005
KDOQI	**0.637±0.026**	0.622±0.023	0.597±0.037	0.610±0.011
Nadir 90 Fall 20	0.737±0.010	0.736±0.012	0.734±0.016	**0.761±0.002**
Nadir 90 Fall 30	0.734±0.014	0.734±0.016	0.708±0.070	**0.750±0.003**
Fall 20 KDOQI	**0.701±0.056**	0.676±0.041	0.641±0.067	0.557±0.014

Analysis and Visualization

Figure 2.Real time visualization of model predictions

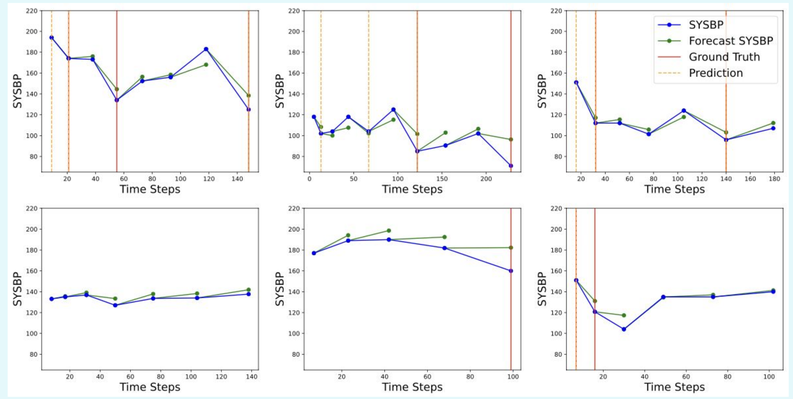
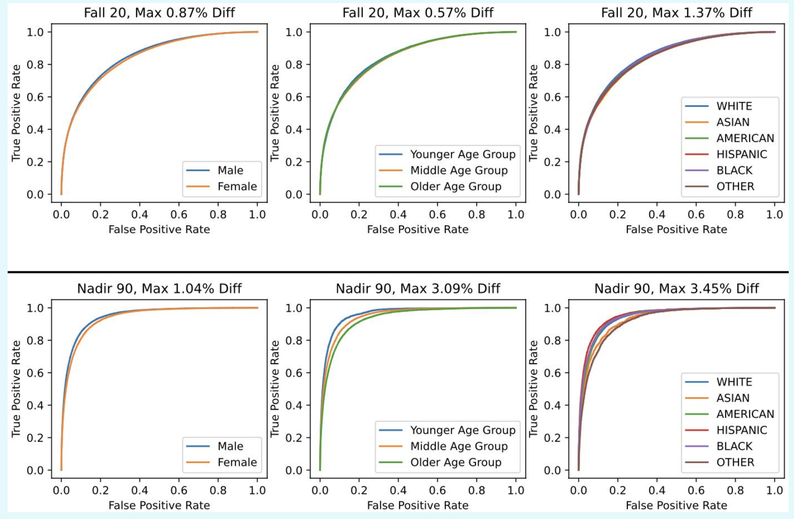


Figure 3. ROC curves across different demographic groups



Summary and Conclusions

- Our method achieve performance with the highest ROC AUC and balanced accuracy of 0.944 and 0.856 respectively in forecasting IDH 1 hour ahead. We present both qualitative and quantitative results, offering a valuable tool for improving patient care and outcomes in dialysis settings.

Acknowledgements

TBD
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