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Therapeutic Effects of CRRT in Patients with Severe Acidosis Using Deep Learning-Based Causal Inference on MIMIC-III data

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Objectives : Continuous renal replacement therapy (CRRT) is an essential treatment for uncontrolled severe metabolic acidosis. However, CRRT is a relatively invasive treatment that requires the establishment of a new central line and may lead to complications. Therefore, selectively applying CRRT to patients with significant treatment benefits is crucial. This study aims to investigate the therapeutic effect of CRRT in patients with severe acidosis by utilizing a deep learning-based causal inference model to assess its potential impact on in-hospital mortality.
Methods : The MIMIC-III dataset was utilized, and subjects with data available within the first 48 hours after intensive care unit (ICU) admission were selected. Patients experiencing severe acidosis with a pH < 7.2 within the initial 48 hours were selected. Treatment was defined as the application of CRRT within 48 hours of ICU admission, and the outcome was defined as in-hospital mortality. The dataset was randomly divided into a 85:15 ratio for training and testing. The Generative Adversarial Nets for Inference of Individualized Treatment Effects (GANITE) model was trained using the training dataset, and the model's performance was evaluated using the test dataset.
Results : In the training set, the model demonstrated an accuracy and AUROC of 0.88 and 0.89, respectively, while in the test set, it showed 0.84 and 0.82. The probability change of average in-hospital mortality with CRRT treatment for all severe acidosis patients was +15% and +14% in the train and test sets, respectively. However, in the group that underwent CRRT, the application of CRRT resulted in an average reduction of in-hospital mortality probability by -13% in both the train and test sets. Age and creatinine levels in subjects experiencing a reduction in in-hospital mortality with CRRT were higher than the overall population data.
Conclusions : Developed model could be expected to aid decision-making in the future application of CRRT treatment.

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Table 1. Performance of model

	Train	Test
Accuracy	0.883	0.841
F1-score	0.811	0.776
AUROC	0.887	0.824

AUROC, Area Under Receiver Operating Characteristic Curve

Table 2. ATE and CATE according to treatment

	Train	Test
ATE	0.154 (0.151-0.158)	0.125 (0.117-0.133)
CATE for Treatment group*	-0.131 (-0.146--0.117)	-0.131 (-0.162--0.101)

ATE, average treatment effect; CATE, conditional average treatment effect

*For the subjects with CRRT treatment

Table 3. Characteristics of subjects with negative value of treatment effect

	Negative treatment effect in train set	Total train set	P-value*	Negative treatment effect in test set	Total test set	P-value*
Age	64.803 (64.296-65.310)	60.057 (59.790-60.324)	<0.001	62.444 (61.465-63.422)	60.427 (59.761-61.092)	0.001
pH	7.117 (7.115-7.120)	7.059 (7.058-7.061)	<0.001	7.119 (7.114-7.124)	7.065 (7.062-7.068)	<0.001
Creatinine	2.685 (2.603-2.768)	1.612 (1.581-1.643)	<0.001	2.848 (2.696-3.001)	1.865 (1.787-1.942)	<0.001

*Chi-square test for categorical variables and T-test for continuous variables

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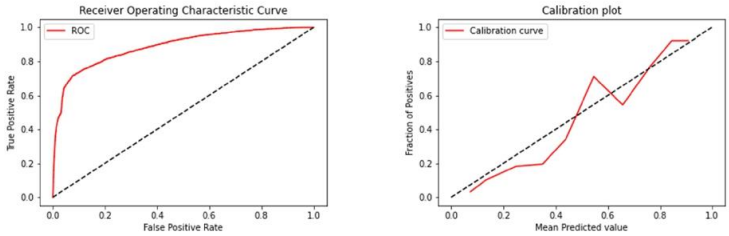
Figure 1. ROC and Calibration plot of train and test dataset

(A) Train dataset



(B) Test dataset

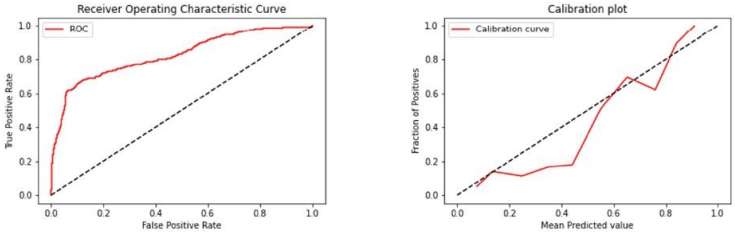
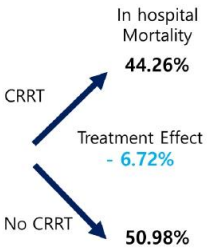


Figure 2. Examples of specific cases

SEX	AGE
1	86.3902

Anion gap	Bicarbonate	**Creatinine**	**Diastolic blood pressure**	Fraction inspired oxygen	Heart Rate	Hemoglobin	Mean blood pressure	Oxygen saturation	Platelets	**Potassium**	Prothrombin time	Respiratory rate	Sodium	**Systolic blood pressure**	**Urine output**	White blood cell count	**pH**
12	22	0.6	49	0.5	90	10.6	72	100	203	4.1	13.1	14	134	111	25	21.2	7.43
12	22	0.6	52	0.5	73	10.6	75	100	203	4.1	13.1	14	134	117	60	21.2	7.43
12	22	0.6	52	0.5	70	10.6	76	100	203	4.1	13.1	14	134	118	60	21.2	7.43
12	22	0.6	55	0.5	75	10.6	79	100	203	4.1	13.1	14	134	126	30	21.2	7



SEX	AGE
1	76.05397

Albumin	Anion gap	Bicarbonate	Bilirubin	**Creatinine**	**Diastolic blood pressure**	Fraction inspired oxygen	Heart Rate	Hemoglobin	Mean blood pressure	Oxygen saturation	Platelets	**Potassium**	Prothrombin time	Respiratory rate	Sodium	**Systolic blood pressure**	Temperature	**Urine output**	White blood cell count	**pH**
2.7	21	12	0.3	2.1	58	0	114	11.2	67	95	207	4.5	14.3	23	137	97	38.22222	40	18.4	7.18
2.7	21	12	0.3	2.1	58	0	114	11.2	70	95	207	4.5	14.3	27	137	90	38.22222	100	18.4	7.18
2.7	21	12	0.3	2.1	60	0	120	10.8	71	77	207	4.5	14.3	29	137	91	39.3889	30	18.4	7.18
2.7	21	12	0.3	2.1	50	0	115	10.8	60	100	207	4.5	14.3	29	137	81	38.5	8	18.4	7.18