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ORIGINAL ARTICLE

Prognostic Value of the Blood Urea Nitrogen-to-Albumin Ratio for ICU Mortality in Cardiogenic Shock Patients: Evidence from the MIMIC-IV Database

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SUMMARY

Background: **Cardiogenic shock (CS) is a life-threatening condition with high mortality. This study explored the association between the blood urea nitrogen-to-albumin ratio (BAR), a marker of renal function and nutritional status, and mortality in CS, aiming to evaluate its utility as a simple early risk stratification tool.**
Methods: **This study analyzed data from the Medical Information Mart for Intensive Care IV (MIMIC-IV) database, categorizing participants by BAR quartiles to examine 28-day intensive care unit (ICU) mortality. Least absolute shrinkage and selection operator (LASSO) regression was used to identify key variables associated with BAR and clinical outcomes. Logistic regression, Cox proportional hazards models, and restricted cubic splines were applied to assess the relationship between BAR and mortality. Kaplan–Meier curves illustrated cumulative mortality, while sensitivity and subgroup analyses were conducted to ensure the robustness of the findings. Causal mediation analysis (CMA) was conducted to investigate the indirect effects of BAR on prognosis.**
Results: **This study of 1,474 CS patients found that a higher BAR was linked to a greater risk of 28-day ICU mortality. After adjustments, those in the highest BAR quartile had a significantly increased mortality risk (HR 1.88, 95% CI: 1.30 - 2.71, p = 0.001) compared to those in the lowest quartile. Kaplan-Meier analysis demonstrated significantly reduced 28-day ICU survival probabilities in highest BAR quartile. Hemoglobin partially mediated this relationship, explaining 10.88% of the effect. The association between BAR and prognosis in patients with CS remained consistent across most subgroups, with significant interactions identified in the race and acute kidney injury (AKI) subgroups.**
Conclusions: **This study found that elevated BAR is closely associated with adverse ICU outcomes in patients with CS.**
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Supplementary Data

Table S1. Missing values proportions of variables.

Variable	Missing values, n (%)
BMI	163 (11.1)
Hemoglobin	14 (0.9)
Platelet	15 (1.0)
White blood cell	13 (0.9)
Calcium	4 (0.3)
Potassium	1 (0.1)
ALT	31 (2.1)
AST	17 (1.2)
LDH	114 (7.7)
Lactate	25 (1.7)
PCO_2	72 (4.9)
PH	56 (3.8)
PO_2	69 (4.7)
SBP	47 (3.2)
DBP	47 (3.2)
Temperature	64 (4.3)
GCS score	3 (0.2)
INR	29 (2.0)

BMI body mass index, ALT alanine aminotransferase, AST aspartate aminotransferase, LDH lactate dehydrogenase, PCO_2 partial pressure of carbon dioxide, PH potential of hydrogen, PO_2 partial pressure of oxygen, SBP systolic blood pressure, DBP diastolic blood pressure, GCS Glasgow coma scale score, INR prothrombin time international normalized ratio.

Table S2. VIF of model variables.

Variable	VIF
Age	1.46
BAR	1.17
Lactate	1.36
PH	1.45
OASIS	1.64
Charlson comorbidity index	1.56
APACHE II score	1.94
HF	1.16
CRRT	1.18
Vasopressor	1.02

BAR blood urea nitrogen-to-albumin ratio, PH potential of hydrogen, OASIS Oxford Acute Severity of Illness Score, APACHE II acute physiology and chronic health evaluation II, HF heart failure, CRRT continuous renal replacement therapy.

Table S3. Baseline characteristics between survivors and non-survivors.

Characteristic	Overall	Survivor	Non-survivor	p-value
	n = 1,474	n = 986	n = 488	
Demographics				
Age, years	71.00 (60.00, 80.00)	69.00 (58.00, 78.00)	74.00 (66.00, 82.00)	< 0.001
Gender, n (%)				
Male	890 (60.38)	604 (61.26)	286 (58.61)	0.327
Female	584 (39.62)	382 (38.74)	202 (41.39)	
Race, n (%)				
White	879 (59.63)	600 (60.85)	279 (57.17)	0.175
Non white	595 (40.37)	386 (39.15)	209 (42.83)	
BMI, kg/m2	27.90 (24.30, 32.50)	27.90 (24.40, 32.20)	27.85 (24.10, 33.30)	0.528
Vital sign				
Heart rate, beats/minute	90.00 (77.00, 106.00)	89.00 (76.00, 106.00)	90.00 (78.00, 108.00)	0.279
Respiratory rate, beats/minute	20.00 (16.00, 24.00)	20.00 (16.00, 24.00)	20.00 (17.00, 25.00)	0.002
SpO2, %	97.00 (94.00, 100.00)	97.00 (94.00, 100.00)	97.00 (93.00, 100.00)	0.534
Temperature, °F	98.00 (97.60, 98.60)	98.00 (97.60, 98.60)	97.90 (97.50, 98.60)	0.002
DBP, mmHg	66.00 (54.00, 79.00)	67.00 (55.00, 79.00)	65.00 (52.00, 78.00)	0.005
SBP, mmHg	110.50 (96.00, 126.00)	111.00 (98.00, 126.00)	108.00 (94.00, 123.00)	0.016
Laboratory				
Glucose, mg/dL	150.00 (117.00, 198.00)	146.00 (115.00, 192.00)	157.00 (121.00, 210.00)	0.009
WBC, × 109/L	12.70 (9.30, 17.50)	12.60 (9.10, 17.10)	13.20 (9.85, 18.30)	0.018
Platelet, × 109/L	195.00 (139.00, 260.00)	195.00 (141.00, 258.00)	195.00 (133.00, 265.00)	0.678
Hemoglobin, g/dL	10.70 (9.00, 12.50)	11.00 (9.20, 13.00)	10.30 (8.60, 11.90)	< 0.001
INR	1.40 (1.20, 1.90)	1.40 (1.20, 1.80)	1.50 (1.30, 2.00)	0.003
PH	7.35 (7.27, 7.41)	7.36 (7.29, 7.42)	7.33 (7.24, 7.39)	< 0.001
PCO2, mmHg	41.00 (35.00, 48.00)	41.00 (34.00, 47.00)	41.00 (35.00, 48.00)	0.335
PO2, mmHg	84.00 (43.00, 160.00)	84.00 (44.00, 161.00)	82.00 (40.00, 157.00)	0.245
Lactate, mmol/L	2.30 (1.50, 3.70)	2.10 (1.40, 3.40)	2.60 (1.60, 4.80)	< 0.001
Calcium total, mmol/L	8.40 (7.90, 8.90)	8.40 (8.00, 8.90)	8.40 (7.80, 8.80)	0.142
Potassium, mmol/L	4.30 (3.90, 4.90)	4.30 (3.90, 4.90)	4.40 (3.90, 5.00)	0.078
Sodium, mmol/L	137.00 (134.00, 140.00)	137.00 (134.00, 140.00)	137.00 (134.00, 141.00)	0.237
ALT, IU/L	52.00 (23.00, 173.00)	50.00 (22.00, 156.00)	59.00 (25.00, 191.00)	0.096
AST, IU/L	94.00 (38.00, 307.00)	88.00 (35.00, 305.00)	107.00 (42.00, 317.00)	0.136
LDH, IU/L	438.00 (300.00, 774.00)	414.00 (291.00, 706.00)	498.00 (327.00, 898.00)	< 0.001
Creatinine, mg/dL	1.50 (1.00, 2.20)	1.40 (1.00, 2.10)	1.70 (1.20, 2.70)	< 0.001
BUN, mg/dL	30.00 (19.00, 48.00)	28.00 (18.00, 45.00)	36.00 (23.00, 57.00)	< 0.001
Albumin, g/dL	3.10 (2.70, 3.50)	3.20 (2.80, 3.50)	3.00 (2.50, 3.40)	< 0.001
BAR	10.00 (6.29, 16.30)	8.63 (5.71, 14.69)	12.07 (7.89, 20.34)	< 0.001
Severity scores				
SOFA score	7.00 (5.00, 10.00)	7.00 (4.00, 9.00)	9.00 (6.00, 12.00)	< 0.001
SIRS score	3.00 (2.00, 3.00)	3.00 (2.00, 3.00)	3.00 (2.00, 4.00)	< 0.001
OASIS	36.00 (29.00, 42.00)	34.00 (28.00, 40.00)	39.00 (33.00, 46.00)	< 0.001
GCS score	15.00 (14.00, 15.00)	15.00 (14.00, 15.00)	15.00 (14.00, 15.00)	0.001
Charlson comorbidity index	6.00 (4.00, 8.00)	6.00 (4.00, 8.00)	7.00 (5.00, 9.00)	< 0.001
APACHE II score	22.00 (17.00, 28.00)	21.00 (16.00, 26.00)	25.00 (21.00, 31.00)	< 0.001

Table S3. Baseline characteristics between survivors and non-survivors (continued).

Characteristic	Overall	Survivor	Non-survivor	p-value
	n = 1,474	n = 986	n = 488	
Comorbidities, n (%)				
Hypertension	351 (23.81)	243 (24.65)	108 (22.13)	0.286
Acute kidney injury	1,002 (67.98)	624 (63.29)	378 (77.46)	< 0.001
Cerebral vascular accident	126 (8.55)	87 (8.82)	39 (7.99)	0.591
Chronic kidney disease	472 (32.02)	289 (29.31)	183 (37.50)	0.002
Type 2 diabetes mellitus	525 (35.62)	333 (33.77)	192 (39.34)	0.036
Heart failure	1,145 (77.68)	799 (81.03)	346 (70.90)	< 0.001
Myocardial infarct	521 (35.35)	350 (35.50)	171 (35.04)	0.863
Ischemic heart disease	994 (67.44)	668 (67.75)	326 (66.80)	0.716
Hyperlipidemia	670 (45.45)	471 (47.77)	199 (40.78)	0.011
Interventions, n (%)				
Mechanical ventilation	1,325 (89.89)	890 (90.26)	435 (89.14)	0.500
CRRT	290 (19.67)	138 (14.00)	152 (31.15)	< 0.001
Medications, n (%)				
Glucocorticoid	383 (25.98)	227 (23.02)	156 (31.97)	< 0.001
Vasopressor	1,344 (91.18)	864 (87.63)	480 (98.36)	< 0.001

BMI body mass index, DBP diastolic blood pressure, SBP systolic blood pressure, WBC white blood cell, INR prothrombin time international normalized ratio, PH potential of hydrogen, PCO_2 partial pressure of carbon dioxide, PO_2 partial pressure of oxygen, ALT alanine aminotransferase, AST aspartate aminotransferase, LDH lactate dehydrogenase, BUN blood urea nitrogen, BAR blood urea nitrogen to albumin ratio, SOFA sequential organ failure assessment, SIRS systemic inflammatory response syndrome, OASIS oxford acute severity of illness score, GCS Glasgow coma scale, APACHE II acute physiology and chronic health evaluation II, CRRT continuous renal replacement therapy.

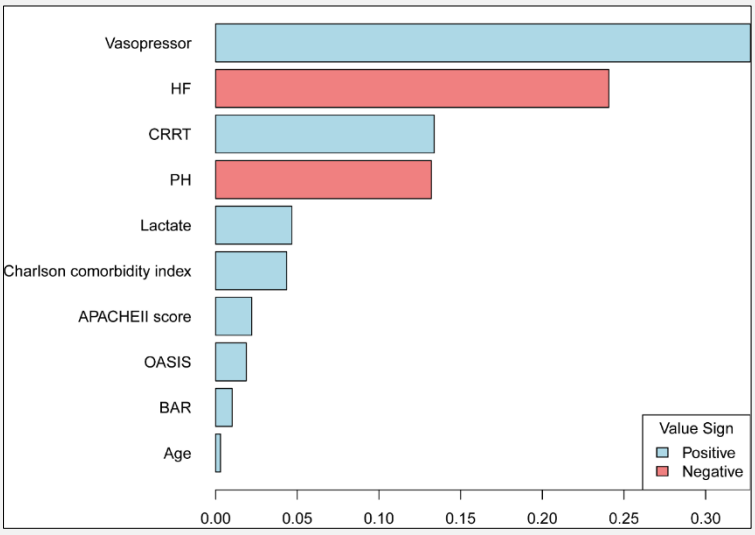

Figure S1. Feature importance ranking based on LASSO regression analysis. The x-axis represents the standardized coefficient values from LASSO regression.

HF heart failure, CRRT continuous renal replacement therapy. PH potential of hydrogen, APACHE II acute physiology and chronic health evaluation II, OASIS Oxford Acute Severity of Illness Score, BAR blood urea nitrogen-to-albumin ratio.

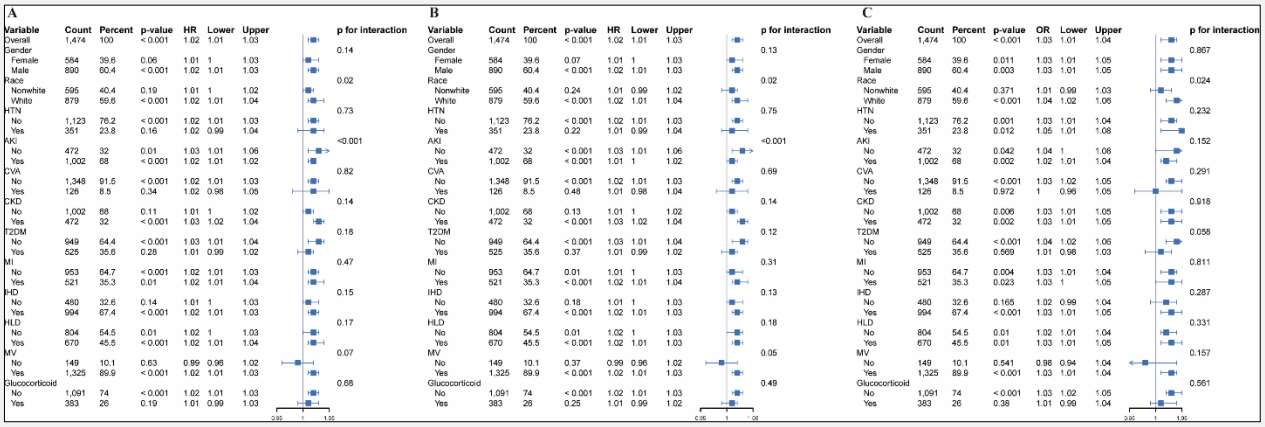

Figure S2. Subgroup analyses for the association of BAR with 90-day ICU all-cause mortality (A), 360-day ICU all-cause mortality (B) and ICU all-cause mortality (C), adjusted for age, OASIS, charlson comorbidity index, APACHE II score; lactate, pH, HF, CRRT and vasopressors use.

HR hazard ratio, OR odds ratio, HTN hypertension, AKI acute kidney injury, CVA cerebrovascular accident, CKD chronic kidney disease, T2DM Type 2 diabetes mellitus, MI myocardial infarction, IHD ischemic myocardial disease, HLD hyperlipidemia, MV mechanical ventilation.