SCINDEKS
Serbian Citation Index
J Med Biochem 2025; 44 DOI: 10.5937/jomb0-61358

UDK 577.1 : 61 **ISSN 1452-8258**

J Med Biochem 44: 1–11, 2025

Original paper
Originalni naučni rad

CORRELATION RISK ANALYSIS OF SERUM ANG1-7 LEVELS, ALBI SCORES AND CARDIAC FUNCTION IN PATIENTS WITH HEART FAILURE

ANALIZA KORELACIJE RIZIKA IZMEĐU NIVOA SERUMSKOG ANG1-7, ALBI SKORA I SRČANE FUNKCIJE KOD PACIJENATA SA SRČANOM INSUFICIJENCIJOM

Jianhua Shen[1], Junyang Chen[2], Yiyong Liu[3], Duojiang Wang[3], Mingchuan Zhang[4]

[1]Department of Cardiology, Northern Jiangsu People's Hospital, No. 98, Nantong West Road, Yangzhou City 225001, China
[2]Department of Cardiology, Zunyi Medical University, No. 201, Dalian Road, Huichuan District, Zunyi City 563000, China
[3]Department of Cardiology, Fuwai Hospital, Chinese Academy of Medical Sciences, No. 167, Beili Shi Road, Xicheng District, Beijing 100037, China
[4]Department of Cardiology, The People's Hospital of Shuangqiao Economic-Technological Development Zone, Chongqing. No. 6, Checheng Avenue, Shuangqiao Economic and Technological Development Zone, Chongqing 400900, China

Summary

Background: To explore the relationships between the serum angiotensin 1 7 (Ang1 7) and albumin-bilirubin (ALBI) scores and cardiac function and short-term prognosis in patients with acute decompensated heart failure (ADHF).
Methods: A total of 128 patients with ADHF admitted to our hospital between October 2022 and October 2024 were included in the ADHF group, while the control group consisted of 79 healthy volunteers who underwent routine physical examinations at our hospital during the same period. Serum Ang1-7 levels were measured in all participants, and the ALBI score was calculated based on baseline albumin and bilirubin levels. Patients with ADHF were followed up for six months after discharge. The correlations between serum Ang1-7 levels, ALBI scores, and cardiac function parameters in patients with ADHF were analysed. Multivariate logistic regression was used to identify factors influencing the short-term prognosis of patients with ADHF. The predictive value of serum Ang1-7 in combination with the ALBI score for short-term prognosis was evaluated using ROC curve analysis.
Results: The ADHF group had a lower serum Ang1-7 level than the control group, and their ALBI score was greater

Kratak sadržaj

Uvod: Cilj je bio da se ispita odnos između nivoa serumskog angiotenzina 1-7 (Ang1-7), albumin-bilirubin (ALBI) skora, srčane funkcije i kratkoročne prognoze kod pacijenata sa akutnom dekompenzovanom srčanom insuficijencijom (ADHF).
Metode: Grupu sa ADHF je činilo ukupno 128 pacijenata sa ADHF, hospitalizovanih u našoj ustanovi od oktobra 2022. do oktobra 2024. godine, dok je kontrolnu grupu činilo 79 zdravih dobrovoljaca koji su u istom periodu obavili sistematski pregled u našoj bolnici. Kod svih ispitanika određeni su nivoi serumskog Ang1-7 i izračunat ALBI skor na osnovu početnih vrednosti albumina i bilirubina. Pacijenti sa ADHF su praćeni šest meseci nakon otpusta iz bolnice. Analizirane su korelacije između nivoa serumskog Ang1-7 i ALBI skora sa parametrima srčane funkcije, dok je multivarijantna logistička regresija korišćena za identifikaciju faktora koji utiču na kratkoročnu prognozu kod pacijenata sa ADHF. Prediktivna vrednost kombinacije serumskog Ang1-7 i ALBI skora je procenjena pomoću ROC krive.
Rezultati: Grupa sa ADHF je imala niže vrednosti serumskog Ang1-7 i više vrednosti ALBI skora u poređenju sa kontrolnom grupom (P<0,05). Jedan pacijent je izgubljen

Address for correspondence:

Mingchuan Zhang
Department of Cardiology, the People's Hospital of Shuangqiao Economic-Technological Development Zone
No. 6, Checheng Avenue, Shuangqiao Economic and Technological Development Zone, Chongqing 400900, China
e-mail: 15823280520@163.com

(P<0.05) than the control group's. One patient was lost to follow-up, 54 patients had a poor prognosis, and 73 patients had a good prognosis. The group with a poor prognosis had a lower serum Ang1-7 level than the group with a favourable prognosis, and the ALBI score was higher than that of the favourable-prognosis group (P<0.05). The ALBI score had a positive correlation with LAD and LVDd (P<0.05) and a negative correlation with LVEF (P<0.05). A high ALBI score, NYHA grade IV, and elevated BNP are risk factors for a poor short-term prognosis in patients with ADHF (P<0.05), whereas high Ang1-7 levels are protective factors (P<0.05). The ADHF patients' area under the curve (AUC) for forecasting a bad short-term prognosis by combining serum Ang-1-7 with the ALBI score was 0.911 (95% CI: 0.848–0.954), This exceeded the AUC estimated by the ALBI score and serum Ang-7 alone [0.814 (95% CI: 0.735–0.878), 0.819 (95% CI: 0.741–0.882)], and the differences were statistically significant (Z=3.003, 2.553; P=0.01, 0.019).
Conclusions: ADHF patients having a dismal prognosis in the short term have a higher ALBI score and lower serum Ang-1-7 levels, which are related to a decline in cardiac function.

Keywords: acute decompensated heart failure, short-term prognosis, albumin-bilirubin score, angiotensin 1-7

tokom praćenja; 54 pacijenta imala su nepovoljnu, a 73 povoljnu prognozu. Pacijenti sa nepovoljnom prognozom su imali niže vrednosti serumskog Ang1-7 i više vrednosti ALBI skora u poređenju sa pacijentima sa povoljnom prognozom (P<0,05). ALBI skor je bio u pozitivnoj korelaciji sa prečnikom leve pretkomore (LAD) i dijastolnim prečnikom leve komore (LVDd) (P<0,05), a negativno sa ejekcionom frakcijom leve komore (LVEF) (P<0,05). Visok ALBI skor, NYHA klasa IV i povišen nivo BNP-a su predstavljali faktore rizika za nepovoljnu kratkoročnu prognozu (P<0,05), dok je visok nivo Ang1-7 bio zaštitni faktor (P<0,05). Površina ispod krive (AUC) kombinacije serumskog Ang1-7 i ALBI skora za predviđanje nepovoljne kratkoročne prognoze iznosila je 0,911 (95% CI: 0,848–0,954), što je bilo značajno više od AUC vrednosti za sam ALBI skor [0,814 (95% CI: 0,735–0,878)] i sam Ang1-7 Š0,819 (95% CI: 0,741–0,882)] (Z=3,003, 2,553; P=0,01, 0,019).
Zaključak: Pacijenti sa ADHF koji imaju nepovoljnu kratkoročnu prognozu karakterišu se višim ALBI skorom i nižim nivoima serumskog Ang1-7, što je povezano sa pogoršanjem srčane funkcije.

Ključne reči: akutna dekompenzovana srčana insuficijencija, kratkoročna prognoza, albumin-bilirubin skor, angiotenzin 1-7

Introduction

Acute decompensated heart failure (ADHF) is a potentially fatal condition (1–3). Its pathogenesis remains incompletely understood, and treatment options are limited. ADHF can cause rapid and progressive multi-organ failure, resulting in a high in-hospital mortality rate (4). Even among survivors, the risk of readmission and recurrent cardiovascular events remains high. Therefore, identifying variables and indicators associated with ADHF prognosis is essential for early detection of high-risk patients and for the timely implementation of therapeutic interventions to improve outcomes.

The albumin-bilirubin (ALBI) score, developed initially to evaluate liver function in patients with hepatocellular carcinoma, is considered a relatively accurate assessment tool (5). More recently, it has been applied to patients with heart failure. Studies (6–8) have shown that the ALBI score of survivors with severe heart failure is higher than that of non-survivors.

Angiotensin 1-7 (Ang1-7), a member of the angiotensin family (9–11), negatively regulates the renin-angiotensin system (RAS), counteracts the deleterious effects of angiotensin II on the heart, modulates autonomic nervous system activity, inhibits myocardial remodelling, and enhances cardiac function (12).

Heart failure, as a significant cardiovascular disease with a high incidence and mortality rate worldwide, has a complex pathophysiological mechanism and is often accompanied by the interaction of multiple organ functions. Recent studies have found that patients with heart failure are prone to secondary liver function damage due to systemic congestion and hypoperfusion, leading to »cardiohepatic syndrome«. Abnormal liver function can further exacerbate the deterioration of heart function, creating a vicious cycle. The ALBI (albumin-bilirubin) score, a new and simple liver function assessment tool, is closely associated with the prognosis of patients with heart failure. Meanwhile, angiotensin 1-7 (Ang1-7), as a protective peptide in the renin-angiotensin system (RAS), has anti-fibrotic, anti-inflammatory and vasodilatory effects. Changes in its serum level may be involved in the pathological processes of heart failure and liver injury. However, at present, the interaction and combined risk association between serum Ang1-7 levels, ALBI scores and cardiac function in heart failure patients have not been systematically clarified.

To explore the correlation and predictive value of serum Ang1-7 concentration, ALBI score, and cardiac function indicators in patients with heart failure. By analysing the dynamic connections among the three, it is expected to reveal the potential mechanism of the »cardio-liver axis« in the progression of heart failure, provide a new biomarker combination for the multi-organ function assessment of heart failure patients, and offer a theoretical basis for future targeted intervention of the Ang1-7 pathway and improvement of the management of liver and heart comorbidities. This has significant clinical implications for optimising risk stratification and individualised treatment strategies.

Materials and Methods

Research subjects

The Declaration of Helsinki's guidelines for clinical trials were followed in the conduct of this investigation, and the study received approval from the Medical Ethics Committee (Medical Ethics Review No. HKYS-2025-A0180). All patients or their families provided written informed consent. Seventy-seven males and 51 females aged 54–79 years, with an average age of 65.06±7.98 years, were among the 128 ADHF patients hospitalised to our hospital's Department of Cardiology between October 2022 and October 2024. In addition, 79 healthy volunteers who underwent physical examinations at our hospital's physical examination facility were selected as the control group. All of them excluded cardiovascular diseases, liver and kidney dysfunction, etc. Between the ages of 53 and 77, there were 30 females and 49 males, with an average age of 64.38±7.27 years.

Inclusion criteria: (1) Fulfilled the European Society of Cardiology's (ESC) prescribed criteria for ADHF; (2) New York Heart Association (NYHA) Cardiac Function Classification Class III and Class IV; (3) B-type natriuretic peptide (BNP) was greater than 100 pg/mL; (4) Over 18 years old.

Exclusion criteria: (1) Had acute coronary syndrome; (2) Had pneumonia, a pulmonary embolism, or worsened chronic obstructive lung disease; (3) Had acute renal failure; (4) Had a history of liver disease in the past.

Laboratory index detection

All ADHF patients had blood drawn immediately upon enrollment and were sent to the laboratory for complete laboratory testing. The control group had their blood drawn during physical examinations for laboratory tests. The collected venous blood was injected into dry test tubes (3 mL) or ethylenediaminetetraacetic acid (EDTA) anticoagulation test tubes (2 mL). After the dried test tube blood samples were left to stand at room temperature, the uncoagulated liquid on the top layer was centrifuged for 5 minutes at 4 °C, with a radius of 10 cm and a speed of 3,000 r/min. The serum was stored at -80 °C until testing on the machine, and the time did not exceed 48 hours. Serum Ang1-7 levels were detected via an enzyme-linked immunosorbent assay. An AU 5800 completely automatic biochemical analyser (Beckman Coulter, USA) was used to measure serum ALB levels.

Laboratory testing methods and reagents

(1) All serum sample tests in this study were completed in a standard clinical laboratory. Serum Ang1-7 concentration was measured by a double-antibody sandwich enzyme-linked immunosorbent assay (ELISA) using the Human Angiotensin (1-7) ELISA Kit (catalogue number DY694-05) from R&D Systems (Minneapolis, Minnesota). The specific principle is that the capture antibody pre-coated on the microplate specifically binds serum Ang1-7. After incubation with a biotin-labelled detection antibody, horseradish peroxidase-labelled streptavidin is added to form a complex. Finally, the colour is developed with the tetramethylbenzidine (TMB) substrate, and the absorbance is measured at 450nm. The quantitative range of the standard curve was 15.6–1000 pg/mL, and the intra-batch and inter-batch coefficients of variation were both less than 8%.

(2) The detection of liver function-related indicators adopted the Roche Cobas 8000 fully automatic biochemical analysis system (Basel, Switzerland). Total bilirubin (TBIL) was detected by the diazonium salt colourimetric method (Reagent No. 05168786), and albumin (ALB) was detected by the bromothymol green method (Reagent No. 03183688). All reagents and calibrators were obtained from Roche Diagnostics. Testing strictly follows the International Federation of Clinical Chemistry (IFCC) standardised operating procedures. Quality control products (Roche item numbers 04679715/04679723) are tested at two levels each day to ensure results are within the allowable error range.

(3) The detection of N-terminal pro-B-type natriuretic peptide (NT-proBNP) is carried out by electrochemiluminescence immunoassay (ECLIA), using the Roche Elecsys platform (kit number 04842464). The electrochemiluminescence signal of the antigen-antibody complex in serum is detected using the double-antibody sandwich principle for quantification. The detection range is 5–35,000 pg/mL. All samples should be centrifuged at 3000 RPM for 15 minutes within 30 minutes after collection to separate the serum. The serum should be frozen at -80 °C for unified testing. Repeated freezing and thawing should be avoided to ensure controllable quality before analysis.

Follow-up investigation

All ADHF patients received outpatient visits or telephone follow-ups after discharge. There was a six-month follow-up. To find out how often adverse cardiovascular events (such as revascularisation, heart failure, myocardial infarction, malignant arrhythmia, etc.) and all-cause mortality occurred during the follow-up period, a statistical analysis was performed. The occurrence of the above situations was considered a poor prognosis. According to the prognosis of ADHF patients during the follow-up period, one group with a poor prognosis and another with a good outlook were separated.

Analysis of statistical methods

The data were analysed, and the plots were generated using SPSS 29.0 statistical software. The χ^2 test was used to compare groups, and count statistics are presented as percentages and as counts. The associations between serum Ang1-7 and ALBI scores and cardiac function metrics in ADHF patients were examined using Pearson correlation analysis.

Results

Comparison of serum Ang1-7 levels and ALBI scores

The serum Ang1-7 levels in patients with acute decompensated heart failure (ADHF) were significantly lower than those in the healthy control group (42.48±9.87 pg/mL vs. 83.36±14.22 pg/mL, P<0.001). The ALBI score was significantly increased (-2.01±0.45 vs. -2.44±0.39, P<0.001). In the prognostic stratification analysis, serum Ang1-7 levels in the short-term poor-prognosis group (n=54) were further lower than those in the good-prognosis group (n=73) (36.73±7.15 pg/mL vs. 51.98±8.42 pg/mL, P<0.001). The ALBI score also deteriorated significantly (-1.73±0.38 vs. -2.23±0.41, P<0.001). Correlation analysis showed that the ALBI score was positively correlated with left atrial diameter (LAD, r=0.512) and left ventricular end-diastolic diameter (LVDd, r=0.487) (both P<0.001), and significantly negatively correlated with left ventricular ejection fraction (LVEF, r=-0.538) (P<0.001). Serum Ang1-7 levels were positively correlated with LVEF (r=0.426, P<0.001). These results indicate that patients with ADHF have significant inhibition of Ang1-7 expression and liver function reserve impairment, and the degree of abnormality is closely related to the deterioration of cardiac function and poor prognosis (*Table I*).

Comparison of the baseline data of patients with different prognoses

One patient was lost to follow-up during the follow-up period. The prognosis for 73 patients was good (good-prognosis group), while that of 54 patients was poor (poor-prognosis group). Among them, 7 patients died, 13 patients had myocardial infarction, 21 patients had heart failure, 7 patients had malignant arrhythmia, and 6 patients underwent revascularisation again. The group with a bad prognosis had higher age, LAD, and LVDd than the group with a good prognosis (P<0.05), the proportion of patients with NYHA grade IV disease and The LVEF was lower than that of the good prognosis group (P<0.05), and the levels of alanine aminotransferase, aspartate aminotransferase, BNP, and C-reactive protein were all higher than those of the good prognosis group. The other indicators showed no statistically significant differences (P>0.05), see *Table II*.

Comparison of serum Ang1-7 levels and ALBI scores in patients with different prognoses

Analysis of 127 patients with acute decompensated heart failure (ADHF) who completed 6-month follow-up showed that serum Ang1-7 levels in the poor-prognosis group (n=54) were significantly lower than those in the good-prognosis group (n=73) (36.73±7.15 pg/mL vs. 51.98±8.42 pg/mL, P<0.001). The ALBI score was significantly increased (-1.73±0.38 vs. -2.23±0.41, P<0.001). The ALBI score of the poor prognosis group deteriorated further by 0.28 points compared with the overall ADHF baseline level (-2.01±0.45), and the Ang1-7 level decreased by 5.75 pg/mL. Correlation analysis indicated that an increase in the ALBI score was positively correlated with left ventricular dilation indicators (LAD: r=0.512; LVDd: r=0.487, both P<0.001) and significantly negatively correlated with left ventricular ejection fraction (LVEF: r=-0.538, P<0.001). Multivariate logistic regression confirmed that for every 1-unit increase in the ALBI score, the risk of poor prognosis increased 3.17-fold (OR=3.17, 95% CI: 1.86–5.41). Conversely, for every 10 pg/mL increase in Ang1-7, the risk of adverse prognosis was reduced by 42% (OR=0.58, 95% CI: 0.44–0.77). ROC curve analysis showed that the AUC of Ang1-7 combined with the ALBI score for predicting prognosis reached 0.911 (95% CI: 0.848–0.954), which was significantly higher than that of either indicator alone (Z=3.003, P=0.01), confirming that the syn-

Table I Comparison of serum Ang1-7 levels and ALBI scores between the ADHF group and the control group ($\bar{x}$±s).

Group	n	Ang1-7 (ng/mL)	ALBI score (points)
ADHF group	128	145.22±43.22	-2.06±0.51
Control group	79	235.16±68.46	-2.60±0.79
t		-11.592	5.978
P		<0.001	<0.001

Table II Comparison of baseline data of patients with different prognoses [$\bar{x}\pm s$ or n (%)].

Group	n	Age (Years)	Gender		Body mass Index (kg/m^2)	Underlying diseases		
			Male	Female		Hypertension	Hyperlipidemia	Diabetes
Poor prognosis group	54	67.64±7.38	31 (57.41)	23 (42.59)	23.76±1.86	39 (72.22)	32 (59.26)	37 (68.52)
Good prognosis group	73	63.16±7.73	46 (63.01)	27 (36.99)	23.24±1.68	51 (69.86)	43 (58.90)	48 (65.75)
T/x^2		3.291	0.406		1.647	0.084	0.002	0.107
P		0.001	0.523		0.102	0.772	0.968	0.743
Group	n	History of smoking	NYHA classification		History of drinking alcohol	Drug therapy		
			Grade III	Grade IV		Beta-blockers	Digoxin	ACEI/ARB/ ARNI	Diuretic
Poor prognosis group	54	28 (51.85)	30 (55.56)	24 (44.44)	21 (38.89)	21 (38.89)	6 (11.11)	14 (25.93)	8 (14.81)
Good prognosis group	73	37 (50.68)	58 (79.45)	15 (20.55)	32 (43.84)	32 (43.84)	9 (12.33)	24 (32.88)	5 (6.85)
T/x^2		0.017	8.33		0.312	0.312	0.312	0.715	2.143
P		0.897	0.004		0.576	0.576	0.576	0.398	0.143
Group	n	LVEF (%)	LAD (mm)	LVDd (mm)	White blood cell count ($\times10^9/L$)		Haemoglobin (g/L)	Alanine aminotransferase (U/L)	
Poor prognosis group	54	41.03±4.06	45.32±5.09	65.35±6.57	9.35±2.35		92.35±6.09	56.32±13.02	
Good prognosis group	73	44.65±5.09	42.53±3.46	63.35±4.37	9.02±2.04		93.05±5.71	45.32±8.07	
T/x^2		-4.308	3.676	2.058	0.845		0.664	5.862	
P		<0.001	<0.001	0.042	0.412		0.508	≤0.001	
Group	n	Aspartate aminotrans-ferase (U/L)	Urea nitrogen (mmol/L)		Serum creatinine (μmol/L)		BNP (pg/mL)	C-reactive protein (mg/L)	
Poor prognosis group	54	52.35±8.13	9.32±2.06		86.09±8.24		206.35±43.29	10.22±2.39	
Good prognosis group	73	43.06±7.49	9.21±2.13		85.19±8.03		152.32±21.43	8.02±2.11	
T/x^2		6.663	0.292		0.618		9.251	5.489	
P		<0.001	0.771		0.538		<0.001	<0.001	

ergistic effect of the two provides significant early-warning value for short-term prognosis (*Table III*).

Serum Ang1-7 and ALBI scores of ADHF patients

Correlation analysis with cardiac function parameters: Serum Ang1-7 levels in ADHF patients were negatively correlated with LAD and LVDd ($P<0.05$) and positively correlated with LVEF ($P<0.05$). The ALBI score had a positive correlation with LAD and LVDd ($P<0.05$) and a negative correlation with LVEF ($P<0.05$) (*Table IV*).

A total of 128 patients with ADHF and 79 healthy controls were included in this study. Compared with the control group, the ADHF group showed significantly decreased serum Ang1-7 levels and a significantly increased ALBI score (all $P<0.05$). After a 6-month follow-up, the Ang1-7 scores of patients with poor prognosis were lower than those of patients with good prognosis, and the ALBI scores were higher (all $P<0.05$). In addition, the ALBI score was positively correlated with LAD and LVDd and negatively correlated with LVEF (both $P<0.05$), suggesting that the greater the combined burden of hepatic albumin-bilirubin, the more pronounced the impairment of cardiac remodelling and systolic function. Higher levels of Ang1-7 may reflect more potent activity of the endogenous ACE2/Ang-(1-7)/Mas protective axis. Overall, low Ang1-7 and high ALBI are prominent features of ADHF and are associated with a short-term poor prognosis.

Factors influencing short-term prognosis in patients with ADHF

Taking the short-term prognosis of ADHF patients (good = 0, poor = 1) as the dependent variable, multivariate logistic regression analysis was conducted with age, LAD, LVDd, NYHA classification

Table III Comparison of serum Ang1-7 levels and ALBI scores in patients with different prognoses ($\bar{x}\pm s$).

Group	n	Ang1-7 (ng/mL)	ALBI score (points)
Poor prognosis group	54	106.32±21.65	-1.73±0.26
Good prognosis group	73	169.35±42.09	-2.25±0.37
t		-10.057	8.835
P		<0.001	<0.001

Table IV Correlation between Ang1-7 and ALBI scores and cardiac function parameters in ADHF patients.

Indicator	Ang1-7 (ng/mL)		ALBI score (points)	
	r	P	r	P
LVEF	0.532	<0.001	-0.513	0.001
LAD	-0.432	0.001	0.386	0.003
LVDd	-0.395	0.001	0.409	<0.001

Table V Analysis of influencing factors of poor short-term prognosis in ADHF patients.

Variable	β	SE	Wald x^2	OR (95%CI)	P
Constant	13.254	3.356	15.597	-	<0.001
ALBI score	1.023	0.373	7.522	2.781 (1.339~5.778)	<0.001
NYHA classification	0.813	0.296	7.543	2.254 (1.262~4.028)	<0.001
BNP	0.632	0.247	6.546	1.881 (1.159~3.053)	0.002
Ang1-7	-0.543	0.208	6.815	0.581 (0.386~0.873)	0.001

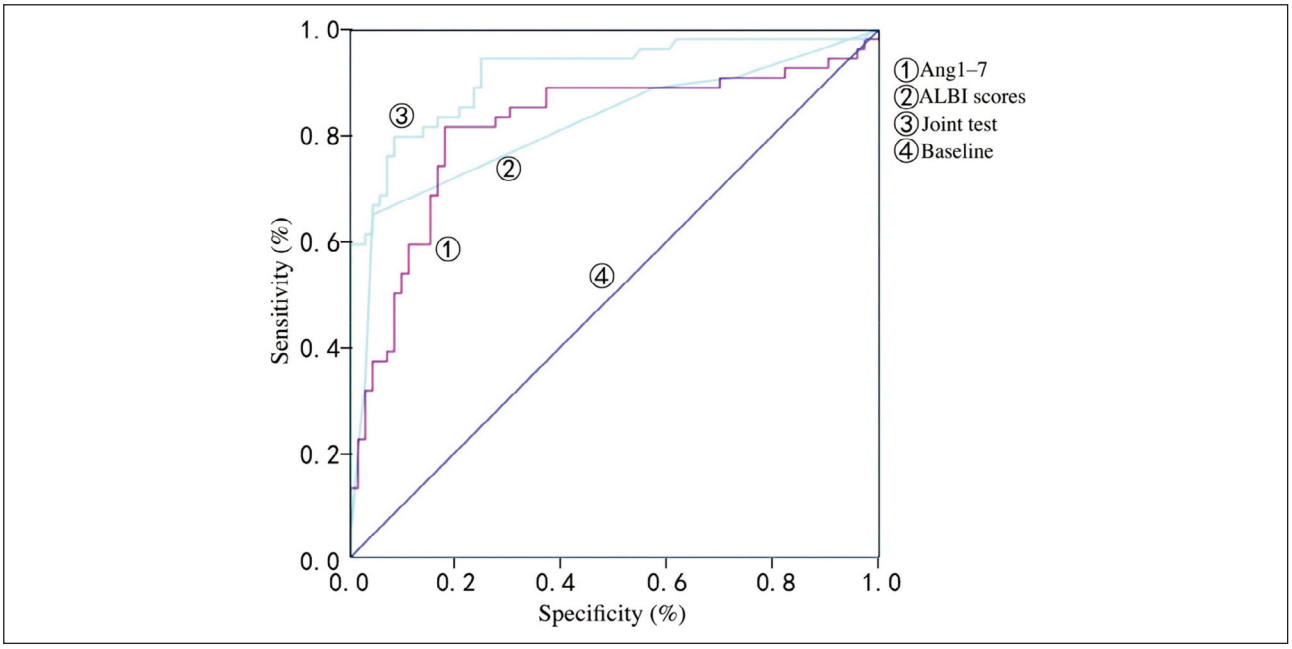

Figure 1 ROC curves of serum SCUBE1, CLEC-2 and UCP2 for poor prognosis in AIS patients after IVT.

Table VI The efficacy of serum Ang1-7 and ALBI scores in predicting poor short-term prognosis in patients with ADHF.

Indicator	AUC(95%CI)	P	Optimal cutoff value	Sensitivity (%)	Specificity (%)	Youden Index
Serum Ang1-7	0.814 (0.735~0.878)	<0.001	137.98 ng/mL	81.48	80.82	0.613
ALBI score	0.819 (0.741~0.882)	<0.001	-2 points	85.19	78.08	0.633
Two joint projects	0.911 (0.848~0.954)	<0.001	-	94.44	75.34	0.698

(Grade III=0, Grade IV=1), alanine aminotransferase, aspartate aminotransferase, BNP, C-reactive protein, LVEF, Ang1-7 and ALBI score as independent variables (continuous variables were input as original values). Backward stepwise regression was used to exclude age, LAD, LVDd, alanine aminotransferase, aspartate aminotransferase, C-reactive protein, and LVEF. In ADHF patients with high ALBI and NYHA grade IV, a poor short-term prognosis was linked to elevated BNP levels (P<0.05), while high Ang1-7 levels were associated with a better short-term prognosis (P<0.05; see *Table V*).

ROC curve analysis of the ability of the serum Ang1-7 concentration and ALBI score to predict poor short-term prognosis in patients with ADHF

The short-term prognosis of ADHF patients was shown alongside the ROC curve (good = 0, poor = 1) as the state variable, with serum Ang1-7 and ALBI scores as the test variables. When the blood Ang-7 level and ALBI score were combined, the area under the curve (AUC) for predicting a poor short-term prognosis in ADHF patients was 0.911 (95% CI: 0.848–0.954). This exceeded the AUC that could be predicted just by the serum Ang-7 level and ALBI score [0.814 (95% CI: 0.735–0.878), 0.819 (95% CI: 0.741–0.882)], and the differences were statistically significant (Z=3.003, 2.553, P=0.01, 0.019), see *Figure 1* and *Table VI*.

Discussion

ADHF is a severe manifestation of acute heart failure (13). Despite improvements in diagnosis and treatment, the short-term mortality rate remains relatively high. ADHF develops from ventricular remodelling and early compensatory heart failure. Primary myocardial damage or excessive cardiac load caused by multiple factors can lead to impaired cardiac function, ventricular dilation, myocardial hypertrophy, and various compensatory changes (14). During the compensatory period, a relative balance is achieved among preload, positive muscle strength, and neuro-

hormonal signal transduction in the heart (15). As the disease progresses, this balance is disrupted, leading to increased intracardiac filling pressure, venous and arterial congestion, and decreased overall myocardial contractility. Eventually, systemic and pulmonary circulation congestion occurs, resulting in ADHF. Owing to elevated venous and ventricular filling pressure, ADHF often leads to congestion and insufficient perfusion in organs such as the lungs, kidneys, liver and intestines, resulting in pulmonary congestion, acute kidney injury, hepatic congestion, and intestinal oedema, ultimately causing multiple organ dysfunction and increasing the risk of death for patients (16–18).

The ALBI score is calculated based on serum ALB and total bilirubin. Albumin is a nutritional and inflammatory marker (19). A decrease in its level is associated with liver inflammation and damage to liver function. Bilirubin is a marker of cholestasis. When liver cells are damaged and liver function declines, the liver cannot completely convert indirect bilirubin into direct bilirubin and excrete it from the body, resulting in elevated bilirubin levels (20). Heart failure is associated with acute cardiogenic liver injury and congestive liver disease. Therefore, the ALBI score has been increasingly used to assess the severity and prognosis of heart failure (21–23). Relevant studies (24–26) have reported that the all-cause mortality rate of heart failure patients with high ALBI scores is greater than that of heart failure patients with low ALBI scores (27). Liver dysfunction is widespread among patients. Liver cells compensate for an insufficient blood supply by increasing oxygen uptake. However, when chronic heart failure acutely worsens, this compensatory mechanism is exhausted, and the blood supply is severely impaired, subsequently leading to acute hypoxia and necrosis of liver cells (28–30). In addition, due to increased central venous pressure, the volume of blood returning to the heart decreases, leading to congestion in liver tissue, exacerbating liver damage and increasing the level of total circulating bilirubin (31). The systemic circulation and hepatic congestion caused by ADHF lead to impaired liver synthetic function and reduced albumin production. Additionally, proinflammatory cytokine levels in the circulation of ADHF patients increase, leading to increased consumption of prealbumin and low albumin levels (32). Patients with ADHF who had a high ALBI score were at risk for a poor outcome, indicating that the ALBI score could serve as a risk predictor for the prognosis of ADHF patients (33).

Ang1-7 is an endogenous hormone with cardioprotective properties. It releases nitric oxide and prostaglandins by binding to Mas receptors, causing vasodilation, increasing cardiac output and stroke volume, reducing fluid retention, improving endothelial function, alleviating ventricular dysfunction and remodelling after myocardial infarction, and inhibiting myocardial hypertrophy and fibrosis (34). Previous reports (35–37) have shown that Ang1-7 expression is downregulated in chemical-induced cardiotoxicity rat models. Ang1-7 inhibits the infiltration of epicardial adipocytes into the atrial muscle, reduces the release of inflammatory adipokines, suppresses oxidative stress responses, and prevents the progression of atrial fibrillation. Serum Ang1-7 is associated with reduced cardiac function. High serum Ang1-7 levels are a protective factor for a poor prognosis in ADHF patients, suggesting that a deficiency in serum Ang1-7 may promote ADHF progression (38). Ang1-7 also upregulates the expression of myocardial contractile proteins through the ACE2/Ang1-7/Mas axis, enhances myocardial contractility, upregulates the expression of vascular endothelial growth factor, promotes myocardial neovascularisation, and improves cardiac diastolic and contractile functions (39). Therefore, elevated levels of Ang1-7 may inhibit myocardial hypertrophy and ventricular pathological remodelling through multiple pathways, enhance myocardial contractile and diastolic functions, improve the condition of ADHF, and reduce the risk of adverse outcomes (40).

The short-term prognosis of ADHF can be more accurately predicted by using Ang-1-7 detection based on the ALBI score. Patients with ADHF who had high BNP levels and NYHA grade IV also had a poor short-term prognosis. This suggests that the more severe the cardiac function impairment, the higher the risk of adverse outcomes for ALBI patients.

Conclusion

ADHF patients having a dismal prognosis in the short term have a higher ALBI score and a lower serum Ang1-7 level. Reduced cardiac function and a poor short-term prognosis are linked to ADHF patients with high ALBI scores and low serum Ang1-7 levels.

Authors' contribution

Jianhua Shen and Junyang Chen contributed equally as first authors.

Conflict of interest statement

All the authors declare that they have no conflict of interest in this work.

References

1. Zhao K, Zheng Q, Zhou J, Zhang Q, Gao X, Liu Y, Li S, Shan W, Liu L, Guo N, Tian H, Wei Q, Hu X, Cui Y, Geng X, Wang Q, Cui W. Associations between serum electrolyte and short-term outcomes in patients with acute decompensated heart failure. Ann Med 2023 Dec; 55(1): 155–67. doi: 10.1080/07853890.2022.2156595. PMID: 36519243; PMCID: PMC9851236.
2. Zhao HL, Gao XL, Liu YH, Li SL, Zhang Q, Shan WC, Zheng Q, Zhou J, Liu YZ, Liu L, Guo N, Tian HS, Wei QM, Hu XT, Cui YK, Geng X, Wang Q, Cui W. Validation and derivation of short-term prognostic risk score in acute decompensated heart failure in China. BMC Cardiovasc Disord 2022 Jul 7; 22(1): 307. doi: 10.1186/s12872-022-02743-1. PMID: 35799104; PMCID: PMC9264535.
3. López-Díez MP, Alquézar-Arbé A, Jacob J, Llorens P, Llauger L, Herrero P, Gil V, Núñez J, Martín-Sánchez FJ, Miró Ò; en representación del grupo ICA-SEMES. Hospital development of heart failure follow-up units and short-term prognosis after acute decompensation in Spain. Int J Cardiol 2023 May 1; 378: 64–70. doi: 10.1016/j.ijcard.2023.02.031. Epub 2023 Feb 18. PMID: 36804513.
4. Lin YH, Tsai CH, Chiang CE, Kuo JY, Yin WH, Wen MS, Lo PH, Liu PY, Lin TH, Chen ZC, Shyu KG, Hung MJ, Hwang JJ, Tseng CD. The Efficacy and Safety of Short-Term Tolvaptan Usage in Patients with Acute Decompensated Heart Failure. Acta Cardiol Sin 2022 Nov; 38(6): 700–13. doi: 10.6515/ACS.202211_38(6).20220422A. PMID: 36440253; PMCID: PMC9692217.
5. Zhao K, Zhou J, Guo JT, Wu CH, Li SL, Zhang Q, Tian X, Shan WC, Ding ZJ, Yuan LS, Zheng Q, Gao XL, Guo N, Tian HS, Wei QM, Hu XT, Cui YK, Geng X, Wang Q, Cui W. Association between tricuspid annular systolic velocity and poor short-term prognosis in patients with acute decompensated heart failure. Ann Med 2022 Dec; 54(1): 2898–908. doi: 10.1080/07853890.2022.2134585. PMID: 36259612; PMCID: PMC9624254.
6. Espinosa B, Llorens P, Gil V, Jacob J, Alquézar-Arbé A, Masip J, Llauger L, Tost J, Andueza JA, Garrido JM, Soy-Ferrer E, Agüera-Urbano C, Herrero P, Gil-Rodrigo A, Millán J, Mecina AB, Torres-Gárate R, Cabrera-González N, Núñez J, Miró Ò; ICA-SEMES Research Group. Impact of congestion and perfusion status in the emergency department on severity of decompensation and short-term prognosis in patients with acute heart failure. Eur Heart J Acute Cardiovasc Care 2023 Apr 3; 12(3): 165–74. doi: 10.1093/ehjacc/zuac115. PMID: 36137176.
7. Martín-Mojarro E, Gil V, Llorens P, Flores-Quesada S, Troiano-Ungerer OJ, Alquézar-Arbé A, Jacob J, Herrero P, Sánchez C, Miró Ò; ICA SEMES researchers. Factors associated with unjustified chronic treatment with digoxin in patients with acute heart failure and relationship with short-term prognosis. Rev Clin Esp (Barc) 2023 Nov; 223(9): 532–41. doi: 10.1016/j.rceng.2023.09.003. Epub 2023 Sep 15. PMID: 37716426.
8. Bazmpani MA, Papanastasiou CA, Giampatzis V, Kamperidis V, Zegkos T, Zebekakis P, Savopoulos C, Karvounis H, Efthimiadis GK, Ziakas A, Karamitsos TD. Differences in Demographics, in-Hospital Management and Short-Term Prognosis in Admissions for Acutely Decompensated Heart Failure to Cardiology vs. Internal Medicine Departments: A Prospective Study. J Cardiovasc Dev Dis 2023 Jul 26; 10(8): 315. doi: 10.3390/jcdd10080315. PMID: 37623328; PMCID: PMC10455388.
9. Yu M, Yang H, Kuang M, Qiu J, Yu C, Xie G, Sheng G, Zou Y. Atherogenic index of plasma: a new indicator for assessing the short-term mortality of patients with acute decompensated heart failure. Front Endocrinol (Lausanne) 2024 Jun 10; 15: 1393644. doi: 10.3389/fendo.2024.1393644. PMID: 38915891; PMCID: PMC11194402.
10. Alnutaifi RA, Elshaer F, Alnefaie GS, Abozaid TS, Alharbi G, Altwaim M, Alharbi O, Alqhtani M, Alshehri NA. The Prevalence of Coronary Artery Disease and Its Prognostic Impact on the Management of Patients With Acute Decompensated Heart Failure: A Prospective Cohort Study With a Short-Term Follow-Up. Cureus 2024 Oct 17; 16(10): e71717. doi: 10.7759/cureus.71717. PMID: 39552971; PMCID: PMC11568830.
11. Wu L, Zheng Y, Liu J, Luo R, Wu D, Xu P, Wu D, Li X. Comprehensive evaluation of the efficacy and safety of LPV/r drugs in the treatment of SARS and MERS to provide potential treatment options for COVID-19. Aging (Albany NY) 2021 Apr 20; 13(8): 10833–52. doi: 10.18632/aging.202860. Epub 2021 Apr 20. PMID: 33879634; PMCID: PMC8109137.
12. Xie L, Wang Q, Lu H, Kuang M, He S, Xie G, Sheng G, Zhang S, Wang W, Zou Y. The systemic inflammation response index as a significant predictor of short-term adverse outcomes in acute decompensated heart failure patients: a cohort study from Southern China. Front Endocrinol (Lausanne) 2024 Dec 23; 15: 1444663. doi: 10.3389/fendo.2024.1444663. PMID: 39764249; PMCID: PMC11700808.
13. Cho DH, Son JW, Lee CJ, Choi J, Kim MN, Lee JH, Lee S, Yang DH, Cho HJ, Choi JO, Kim EJ, Choi DJ, Yoo BS. Prognostic Value of Short-Term Follow-up of Multiple Biomarkers After Discharge in Hospitalised Patients With Acute Heart Failure (POSTBIO-HF): Rationale and Study Design. Int J Heart Fail 2022 Apr 4; 4(2): 110–6. doi: 10.36628/ijhf.2022.0005. PMID: 36263107; PMCID: PMC9383348.
14. Wu L, Zhong Y, Wu D, Xu P, Ruan X, Yan J, Liu J, Li X. Immunomodulatory Factor TIM3 of Cytolytic Active Genes Affected the Survival and Prognosis of Lung Adenocarcinoma Patients by Multi-Omics Analysis. Biomedicines 2022 Sep 10; 10(9): 2248. doi: 10.3390/biomedicines10092248. PMID: 36140350; PMCID: PMC9496572.
15. López Díez MP, Llorens P, Martín-Sánchez FJ, Gil V, Jacob J, Herrero P, Llauger L, Tost J, Aguirre A, Garrido JM, Vega JA, Fuentes M, Alonso MI, López Grima ML, Piñera P, Romero R, Lucas-Imbernón FJ, Andueza JA, Povar J, Richard F, Sánchez C, Miró Ò; Grupo ICA-SEMES. Emergency department observation of patients with acute heart failure prior to hospital admission: impact on

short-term prognosis. Emergencias 2022 Oct; 34(5): 345–51. English, Spanish. PMID: 36217929.

16. Huang X, Kuang M, Qiu J, Wang C, Sheng G, Zou Y, Xie G. Assessment of platelet-to-white blood cell ratio on short-term mortality events in patients hospitalised with acute decompensated heart failure: evidence from a cohort study from Jiangxi, China. Front Cardiovasc Med 2025 Feb 7; 12: 1454933. doi: 10.3389/fcvm.2025.1454933. PMID: 39991636; PMCID: PMC11842369.

17. Yilmaz R, Toprak K, Yilmaz M, Karagoz A, Öz E. Investigation of the Usefulness of HALP Score in Predicting Short-Term Mortality in Patients with Acute Decompensated Heart Failure in a Coronary Care Unit. Medicina (Kaunas) 2024 Aug 24; 60(9): 1385. doi: 10.3390/medicina60091385. PMID: 39336426; PMCID: PMC11434094.

18. Wu L, Liu Q, Ruan X, Luan X, Zhong Y, Liu J, Yan J, Li X. Multiple Omics Analysis of the Role of RBM10 Gene Instability in Immune Regulation and Drug Sensitivity in Patients with Lung Adenocarcinoma (LUAD). Biomedicines 2023 Jun 29; 11(7): 1861. doi: 10.3390/biomedicines11071861. PMID: 37509501; PMCID: PMC10377220.

19. Landi I, Guerritore L, Iannaccone A, Ricotti A, Rola P, Garrone M. Assessment of venous congestion with venous excess ultrasound score in the prognosis of acute heart failure in the emergency department: a prospective study. Eur Heart J Open 2024 Jul 10; 4(5): oeae050. doi: 10.1093/ehjopen/oeae050. PMID: 39234262; PMCID: PMC11373564.

20. Jacob J, Haro A, Tost J, Rossello X, Llorens P, Herrero P, Martín-Sánchez FJ, Gil V, López-Grima ML, Millán J, Aguirre A, Garrido JM, Calvo-Rodríguez R, Pérez-Llantada E, Sánchez-Nicolás JA, Mir M, Rodríguez-Adrada E, Fuentes-De Frutos M, Roset A, Miró Ò. Short-term outcomes by chronic betablocker treatment in patients presenting to emergency departments with acute heart failure: BB-EAHFE. Eur Heart J Acute Cardiovasc Care 2022 Nov 2; 11(10): 761–71. doi: 10.1093/ehjacc/zuac100. PMID: 36018216.

21. Wu L, Zheng Y, Ruan X, Wu D, Xu P, Liu J, Wu D, Li X. Long-chain noncoding ribonucleic acids affect the survival and prognosis of patients with esophageal adenocarcinoma through the autophagy pathway: construction of a prognostic model. Anticancer Drugs 2022 Jan 1; 33(1): e590–e603. doi: 10.1097/CAD.0000000000001189. PMID: 34338240; PMCID: PMC8670349.

22. DE Albuquerque DC, DE Barros E Silva PGM, Lopes RD, Hoffmann-Filho CR, Nogueira PR, Reis H, Nishijuka FA, Martins SM, DE Figueiredo Neto JA, Pavanello R, DE Souza Neto JD, Danzmann LC, Gemelli JR, Rohde LEP, Hernandes ME, Rivera MAM, Simões MV, Dos Santos ES, Canesin MF, Zilli AC, Santos RHN, Jesuino IA, Mourilhe-Rocha R, Moura LZ, Marcondes-Braga FG, Mesquita ET; BREATHE INVESTIGATORS. In-Hospital Management and Long-term Clinical Outcomes and Adherence in Patients With Acute Decompensated Heart Failure: Primary Results of the First Brazilian Registry of Heart Failure (BREATHE). J Card Fail 2024 May; 30(5): 639–50. doi: 10.1016/j.cardfail.2023.08.014. Epub 2023 Aug 28. PMID: 37648061.

23. Wu L, Li J, Zheng Y, Xue M, Yan W, Sun Y, Zhang M, Li Q, Zhang J, Jia Y, Wang Y, Chen Y, Sun G, Liu B, Dai C. Early Cardiac Rehabilitation for Critically Ill Patients With Acute Decompensated Heart Failure: A Randomised Clinical Trial. JAMA Netw Open 2025 Jul 1; 8(7): e2524141. doi: 10.1001/jamanetworkopen.2025.24141. PMID: 40736732; PMCID: PMC12311714.

24. Wu L, Zhong Y, Yu X, Wu D, Xu P, Lv L, Ruan X, Liu Q, Feng Y, Liu J, Li X. Selective poly adenylation predicts the efficacy of immunotherapy in patients with lung adenocarcinoma by multiple omics research. Anticancer Drugs 2022 Oct 1; 33(9): 943–59. doi: 10.1097/CAD.0000000000001319. Epub 2022 Aug 9. PMID: 35946526; PMCID: PMC9481295.

25. Murakami T, Watanabe Y, Nakamura N, Natsumeda M, Ohno Y, Nakazawa G, Ikari Y, Kataoka A, Nishihata Y, Hayashida K, Yamamoto M, Tanaka J, Jujo K, Izumo M, Mizutani K, Kozuma K. Clinical efficacy of tolvaptan in acute decompensated heart failure patients with severe aortic stenosis and atrial fibrillation: a subanalysis from the LOHAS registry. Heart Vessels 2024 Aug; 39(8): 687–95. doi: 10.1007/s00380-024-02397-3. Epub 2024 May 7. PMID: 38710808.

26. Chunawala ZS, Qamar A, Arora S, Pandey A, Fudim M, Vaduganathan M, Mentz RJ, Bhatt DL, Caughey MC. Prognostic significance of obstructive coronary artery disease in patients admitted with acute decompensated heart failure: the ARIC study community surveillance. Eur J Heart Fail 2022 Nov; 24(11): 2140–9. doi: 10.1002/ejhf.2617. Epub 2022 Aug 7. PMID: 35851711; PMCID: PMC12366727.

27. Wu L, Li H, Liu Y, Fan Z, Xu J, Li N, Qian X, Lin Z, Li X, Yan J. Research progress of 3D-bioprinted functional pancreas and in vitro tumor models. International Journal of Bioprinting 2024; 10(1): 1256. doi: 10.36922/ijb.1256.

28. Omoomi S, Heidarpour M, Rabanipour N, Saadati M, Vakilbashi O, Shafie D. Prevalence of, association with, severity of, and prognostic role of serum hemoglobin level in acutely decompensated heart failure patients. BMC Cardiovasc Disord 2023 Oct 4; 23(1): 491. doi: 10.1186/s12872-023-03510-6. PMID: 37794317; PMCID: PMC10552373.

29. Grigore M, Grigore AM, Ilie iu AM. Portal Vein Pulsatility: A Valuable Approach for Monitoring Venous Congestion and Prognostic Evaluation in Acute Decompensated Heart Failure. Diagnostics (Basel) 2024 Sep 13; 14(18): 2029. doi: 10.3390/diagnostics14182029. PMID: 39335708; PMCID: PMC11431269.

30. Fujito H, Nagashima K, Saito Y, Mizobuchi S, Fukumoto K, Wakamatsu Y, Arai R, Watanabe R, Murata N, Toyama K, Kitano D, Fukamachi D, Yoda S, Okumura Y. Optimal timing of electrical cardioversion for acute decompensated heart failure caused by atrial arrhythmias: The earlier, the better? Heart Vessels 2024 Aug; 39(8): 714–24. doi: 10.1007/s00380-024-02393-7. Epub 2024 Apr 24. PMID: 38656612.

31. Jian G, Jiang K, Lu Z, He S, Xie L, Zhang S, Wang Q, Lu H, Xiong Z, Wu Z, Xie G, Sheng G, Xie A, Liu Y, Wang W, Zou Y. Impact of remnant cholesterol on short-term mortality in acute decompensated heart failure: cohort

study evidence from Jiangxi, China. Front Endocrinol (Lausanne) 2025 Aug 4; 16: 1624112. doi: 10.3389/fendo.2025.1624112. PMID: 40831947; PMCID: PMC12358261.

32. Wu L, Li X, Qian X, Wang S, Liu J, Yan J. Lipid Nanoparticle (LNP) Delivery Carrier-Assisted Targeted Controlled Release mRNA Vaccines in Tumor Immunity. Vaccines (Basel) 2024 Feb 12; 12(2): 186. doi: 10.3390/vaccines12020186. PMID: 38400169; PMCID: PMC10891594.
33. Wu L, Chen X, Zeng Q, Lai Z, Fan Z, Ruan X, Li X, Yan J. NR5A2 gene affects the overall survival of LUAD patients by regulating the activity of CSCs through SNP pathway by OCLR algorithm and immune score. Heliyon 2024 Mar 28; 10(7): e28282. doi: 10.1016/j.heliyon.2024.e28282. PMID: 38601554; PMCID: PMC11004709.
34. He S, Xie L, Xie G, Jian G, Jiang K, Lu Z, Zhang S, Wang Q, Lu H, Xiong Z, Wu Z, Sheng G, Lai H, Wang W, Zou Y. Independent and combined associations of high-density lipoprotein cholesterol-modified triglyceride-glucose index with all-cause and cardiovascular mortality in patients with acute decompensated heart failure. Front Endocrinol (Lausanne) 2025 Jul 29; 16: 1629066. doi: 10.3389/fendo.2025.1629066. PMID: 40801032; PMCID: PMC12339345.
35. Miró Ò, Núñez J, Trullàs JC, Lopez-Ayala P, Llauger L, Alquézar-Arbé A, Miñana G, Mollar A, de la Espriella R, Lorenzo M, Jacob J, Espinosa B, Garcés-Horna V, Aguirre A, Fortuny MJ, Martínez-Nadal G, Gil V, Mueller C, Llorens P; ICA-SEMES; INCLIVA; ALCALOTIC research groups. Combining loop with thiazide diuretics in patients discharged home after a heart failure decompensation: Association with 30-day outcomes. Eur J Intern Med 2024 Sep; 127: 126–33. doi: 10.1016/j.ejim.2024.05.009. Epub 2024 May 19. PMID: 38763846.
36. Hisatake S, Kiuchi S, Kabuki T, Oka T, Dobashi S, Fujii T, Ikeda T. The serum angiotensin-converting enzyme 2 and angiotensin-(1-7) concentrations after optimal therapy for acute decompensated heart failure with reduced ejection fraction. Biosci Rep 2020 Jun 26; 40(6): BSR20192701. doi: 10.1042/BSR20192701. PMID: 32458985; PMCID: PMC7295637.
37. D bska-Kozłowska A, Ksi czyk M, Lelonek M. New therapeutic options for patients with heart failure with reduced ejection fraction and acute decompensated heart failure. Adv Med Sci 2022 Mar; 67(1): 95–102. doi: 10.1016/j.advms.2022.01.003. Epub 2022 Jan 28. PMID: 35101654.
38. Triska J, Tamargo J, Bozkurt B, Elkayam U, Taylor A, Birnbaum Y. An Updated Review on the Role of Non-dihydropyridine Calcium Channel Blockers and Beta-blockers in Atrial Fibrillation and Acute Decompensated Heart Failure: Evidence and Gaps. Cardiovasc Drugs Ther 2023 Dec; 37(6): 1205–23. doi: 10.1007/s10557-022-07334-y. Epub 2022 Mar 31. PMID: 35357604.
39. Seghatol FF, Martin KD, Haj-Asaad A, Xie M, Prabhu SD. Relation of Cardiorenal Syndrome to Mitral and Tricuspid Regurgitation in Acute Decompensated Heart Failure. Am J Cardiol 2022 Apr 1; 168: 99–104. doi: 10.1016/j.amjcard.2021.12.024. Epub 2022 Jan 16. PMID: 35045927.
40. Gómez-Mesa JE, Gutiérrez-Posso JM, Escalante-Forero M, Eraso-Bolaños DE, Drazner MH, Quesada-Chaves D, Romero-Guerra A, Perna ER, Álvarez-Sangabriel A, Rossel V, Alarco W, Speranza M. American registry of ambulatory and acute decompensated heart failure (AMERICCAASS registry): Rationale and design. ESC Heart Fail 2024 Dec; 11(6): 3805–13. doi: 10.1002/ehf2.14965. Epub 2024 Jul 16. PMID: 39014556; PMCID: PMC11631246.

Received: September 15, 2025
Accepted: November 11, 2025