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INFLUENCES OF THE NEUTROPHIL-HDL RATIO, MONOCYTE-HDL RATIO AND LYMPHOCYTE-HDL RATIO ON PATIENTS WITH ACUTE EXACERBATION OF CHRONIC HEART FAILURE

UTICAJ ODNOSA NEUTROFILA I HDL-A, MONOCITA I HDL-A, KAO I LIMFOCITA I HDL-A KOD PACIJENATA SA AKUTNOM EGZACERBACIJOM HRONIČNE SRČANE INSUFICIJENCIJE

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Summary

Background: To investigate the role of the neutrophil/high-density lipoprotein cholesterol ratio, monocyte/high-density lipoprotein cholesterol ratio, and lymphocyte/high-density lipoprotein cholesterol ratio in the diagnosis and management of patients experiencing an acute flare-up of chronic heart failure.
Methods: The study included 386 individuals who were hospitalised between March 2022 and September 2024 and had acute exacerbations of chronic heart failure. To determine if the research participants had acute renal injury, they were split into two groups: those with kidney injury and those without. Based on whether major adverse cardiovascular events (MACE) happened six months after discharge, the patients were further separated into groups with poor prognoses and those with excellent prognoses. N-terminal B-type brain natriuretic peptide (NT-proBNP), blood lipids, renal function, soluble tumour factor 2 inhibitor (sST2), and routine blood parameters were assessed 24 hours and 3 days following admission. The NHR, MHR, and LHR were calculated, and the glomerular filtration rate (eGFR) was estimated. The left ventricular ejection fraction (LVEF) was measured at 24 hours and

Kratak sadržaj

Uvod: Cilj je bio da se ispita uloga odnosa neutrofila i holesterola lipoproteina visoke gustine (HDL), odnosa monocita i HDL holesterola, kao i odnosa limfocita i HDL holesterola u dijagnostici i lečenju pacijenata sa akutnom egzacerbacijom hronične srčane insuficijencije.
Metode: Studija je obuhvatila 386 osoba hospitalizovanih u periodu od marta 2022. do septembra 2024. godine zbog akutne egzacerbacije hronične srčane insuficijencije. U zavisnosti od prisustva akutnog oštećenja bubrega, ispitanici su podeljeni u dve grupe: sa oštećenjem i bez oštećenja bubrega. Na osnovu pojave velikih neželjenih kardiovaskularnih događaja (MACE) šest meseci nakon otpusta, pacijenti su dodatno podeljeni na grupu sa lošom prognozom i grupu sa dobrom prognozom. N-terminalni pro-B-tip natriuretskog peptida (NT-proBNP), lipidi u krvi, parametri bubrežne funkcije, rastvorljivi inhibitor tumorskog faktora 2 (sST2) i rutinski hematološki parametri određivani su 24 sata i 3 dana nakon prijema. Izračunati su NHR, MHR i LHR, a procenjena je i brzina glomerularne filtracije (eGFR). Ejekciona frakcija leve komore (LVEF) merena je 24 sata i 3 dana nakon prijema, dok je pojava MACE praćena tokom šest meseci nakon otpusta.

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3 days after admission, and the occurrence of major adverse cardiovascular events (MACE) was followed up for 6 months after discharge.
Results: The renal injury group's NHR, MHR, LHR, sST2, and NT-proBNP were higher than those of the non-renal injury group and the favourable prognosis group, respectively, 24 hours after admission, whereas the LVEF was lower than that in the non-renal injury group and the good prognosis group (P<0.05). There was no statistically significant difference in BUN, Scr or the eGFR between the two groups (P>0.05). The LVEF and eGFR were significantly lower than those in the non-renal-injury group and the good-prognosis group, respectively. Three days after admission, NHR, MHR, LHR, sST2, NT-proBNP, BUN, and Scr were substantially higher in the renal injury and poor prognosis groups (P<0.05). Compared with 24 hours after admission, the BUN and Scr levels of the renal damage and poor-prognosis groups were higher three days after admission, while their eGFR was lower. The statistical significance of the differences was indicated by P<0.05. Individuals with acute exacerbation of chronic heart failure showed positive correlations between NT-proBNP and the NHR, MHR, and LHR (r=0.891, P=0.001; r=0.847, P=0.001; r=0.935, P=0.001). Furthermore, it showed negative correlations with eGFR (r=0.866, P=0.001; r=0.739, P=0.001; r=0.802, P=0.006). Logistic regression analysis revealed that patients with acute exacerbation of chronic heart failure who had elevated NHRs, MHRs, and LHRs 24 hours after admission had an increased risk of concurrent acute kidney injury. The receiver operating characteristic curve analysis revealed that the most substantial predictive value for the incidence of MACEs in patients with acute exacerbation of chronic heart failure was 0.826, corresponding to the area under the curve for the combined detection of NHR, MHR, and LHR.
Conclusion: The combined detection of the NHR, MHR and LHR has early predictive value for the prognosis of patients with acute exacerbation of chronic heart failure.

Keywords: heart failure, neutrophil/high-density lipoprotein cholesterol ratio, monocyte/high-density lipoprotein cholesterol ratio, lymphocyte/high-density lipoprotein cholesterol ratio

Rezultati: Dvadeset četiri sata nakon prijema, vrednosti NHR, MHR, LHR, sST2 i NT-proBNP su bile više u grupi sa oštećenjem bubrega u poređenju sa grupom bez oštećenja bubrega, kao i u grupi sa lošom prognozom u odnosu na grupu sa dobrom prognozom, dok je LVEF bila niža (P<0,05). Nije bilo statistički značajne razlike u vrednostima BUN, Scr i eGFR između dve grupe (P>0,05). LVEF i eGFR bile su značajno niže u grupi sa oštećenjem bubrega i u grupi sa lošom prognozom. Tri dana nakon prijema, NHR, MHR, LHR, sST2, NT-proBNP, BUN i Scr bili su značajno viši u grupama sa oštećenjem bubrega i lošom prognozom (P<0,05). U poređenju sa vrednostima 24 sata nakon prijema, nivoi BUN i Scr u grupama sa oštećenjem bubrega i lošom prognozom bili su viši treć eg dana, dok je eGFR bila niža (P<0,05). Kod pacijenata sa akutnom egzacerbacijom hronične srčane insuficijencije utvrđena je pozitivna korelacija između NT-proBNP i NHR, MHR i LHR (r=0,891, P=0,001; r=0,847, P=0,001; r=0,935, P=0,001), kao i negativna korelacija sa eGFR (r=0,866, P=0,001; r=0,739, P=0,001; r=0,802, P=0,006). Logistička regresiona analiza pokazala je da su povišene vrednosti NHR, MHR i LHR 24 sata nakon prijema povezane sa povećanim rizikom od istovremenog akutnog oštećenja bubrega. Analiza ROC krive pokazala je da kombinovano određivanje NHR, MHR i LHR ima najveću prediktivnu vrednost za pojavu MACE kod pacijenata sa akutnom egzacerbacijom hronične srčane insuficijencije, sa površinom ispod krive (AUC) od 0,826.
Zaključak: Kombinovano određivanje NHR, MHR i LHR ima ranu prediktivnu vrednost za prognozu pacijenata sa akutnom egzacerbacijom hronične srčane insuficijencije.

Ključne reči: srčana insuficijencija, odnos neutrofila i HDL holesterola, odnos monocita i HDL holesterola, odnos limfocita i HDL holesterola

Introduction

A decrease in cardiac function is the hallmark of heart failure, a clinical end-stage illness, resulting in a significant reduction in blood pumping and hemodynamic disorders (1). Heart failure often leads to secondary acute kidney injury (AKI). Studies have reported that all patients with heart failure develop kidney injury during treatment. AKI worsens with increasing severity of heart failure, creating a vicious cycle and affecting the clinical prognosis of patients with heart failure. Increased inflammatory cell counts in heart failure patients have also been linked to the severity and prognosis of the condition, according to earlier research (2–4). Inflammatory reactions and heart failure are interconnected and reinforce one another (5). The incidence and outcomes of cardiovascular diseases are closely linked to novel inflammatory markers, such as the neutrophil-to-high-density lipoprotein cholesterol (NHR), monocyte-to-MHR, and lymphocyte-to-MDR ratios (6).

The acute exacerbation period of chronic heart failure (CHF) is a key clinical challenge in the management of cardiovascular diseases (7). It is associated with a high rate of repeated hospitalisations and a poor short-term prognosis. There is an urgent need to identify high-risk patients early and optimise intervention strategies. In recent years, the role of inflammatory responses and lipid metabolism disorders in the progression of heart failure has become increasingly clear. The activation of immune cells, such as neutrophils, monocytes, and lymphocytes, and the dysfunction of high-density lipoprotein cholesterol (HDL-C) form a dynamic interactive network that jointly drives myocardial injury and ventricular remodelling (8–10). On this basis, the neutro-

phil-HDL ratio (NHR), monocyte-HDL ratio (MHR), and lymphocyte-HDL ratio (LHR), as novel integrative biomarkers, simultaneously reflect the systemic inflammatory state and lipid homeostasis imbalance, providing a unique perspective for evaluating the pathophysiological process of heart failure (11). Although existing studies have confirmed the correlation between single blood cell ratios (such as the NLR and MLR) or HDL-C levels and the prognosis of heart failure, the NHR, MHR, and LHR may more sensitively capture the risk evolution during the acute decompensation stage by coupling immune inflammation and metabolic dimensions (12–14).

This study focused on patients with acute exacerbation of CHF, aiming to systematically explore the associations between the NHR, MHR, and LHR and disease severity, as well as short-term clinical outcomes (such as rehospitalisation rate and cardiovascular mortality). By analysing the dynamic changes in these ratios in emergency triage, risk stratification and treatment effect evaluation, their synergistic value in acute-phase management can be revealed.

Materials and Methods

General information

The research subjects were 386 patients with acute aggravation of chronic heart failure who were admitted to our hospital between March 2022 and September 2024. They had an average age of 70.59±4.22, with 196 men and 190 women aged 61–76. The chosen study participants met the New York Heart Association (NYHA) Classification Standards for Grade III to IV cardiac function in the United States, as well as the diagnostic criteria for heart failure in the »2022 International Guidelines for the Diagnosis and Treatment of Heart Failure«. The exclusion criteria were as follows: chronic kidney disease, kidney transplantation, or a history of kidney disease alone; cardiogenic shock; malignant tumours; combined severe liver dysfunction; pulmonary infection; autoimmune diseases; and death during hospitalisation. This study has been approved by the Medical Research Ethics Committee (No. 2022A-408).

Treatment methods

The selected patients received standardised treatment for heart failure, including vasodilators, diuretics, cardiotonic therapy, ventricular remodelling, and symptomatic treatment. The diagnostic criteria of the »Clinical Guidelines for Acute Kidney Injury« formulated in 2022 are as follows: (1) elevated serum creatinine (Scr) ≥26.5 μmol/L within 48 hours; (2) urine output ≤0.5 mL/(kg·h) within 6 hours. The research subjects were divided into a kidney-injury group and a non-kidney-injury group based on whether they had acute kidney injury. Depending on whether major adverse cardiovascular events (MACE) occurred within 6 months of discharge, the research participants were further divided into a poor-prognosis group and a favourable-prognosis group.

Detection and observation indicators

At 24 hours and 3 days after admission, 5 mL of fasting peripheral venous blood was collected in the morning. Routine blood parameters (including the absolute number of neutrophils, lymphocytes and monocytes) were detected via an automatic blood cell analyser. A 7600 fully automatic biochemical analyser produced by Hitachi was used. The levels of blood lipids [Triglycerides (TG), Total Cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C)], blood urea nitrogen (BUN), N-terminal B-type brain natriuretic peptide (NT-proBNP), and soluble tumour factor 2 inhibitor (sST2) were detected. The NHR, MHR and LHR were calculated. The Diet Improvement Study for Kidney Diseases' simplified formula, eGFR=186.3×Scr-1.155×age-0.206×(female×0.747), was used to measure the glomerular filtration rate (eGFR). Scr was continuously detected at 24 hours, 48 hours and 3 days after admission. Conventional chest X-ray examinations were used to assess lung problems, and colour Doppler ultrasound was used to quantify the left ventricular ejection fraction (LVEF) at 24 and 3 days following admission to evaluate cardiac function. Six months after discharge, the MACE status (including acute pulmonary oedema, malignant arrhythmia, repeated hospitalisation, cardiogenic death, etc.) was monitored.

Laboratory testing methods

All laboratory tests in this study were completed within 24 hours and 72 hours of admission. Serological index detection was performed using an automatic biochemical immunoassay system. Detection of N-terminal pro-B-type natriuretic peptide (NT-proBNP) was conducted on the Roche Cobas e601 electrochemiluminescence analyser with the kit (item number: 04842464). Soluble growth-stimulating expression gene 2 protein (sST2) uses the Presage® ST2 kit (Catalogue No. ST200) from Critical Diagnostics, USA. Lipid profile (including high-density lipoprotein cholesterol ŠHDL-CĆ) was determined by enzyme colourimetry using the Roche Cobas c702 biochemical analyser and its matching reagents (total cholesterol, catalogue number: 03039773; HDL-C, catalogue number: 07528528). The blood routine test was conducted

using the XN-9000 fully automatic blood analyser from Xisenmeikang (original factory reagent, product number: 003X9512) to obtain absolute counts of neutrophils, monocytes, and lymphocytes. The renal function index urea nitrogen (BUN) was calculated by the urease-glutamate dehydrogenase method (Roche Reagent No. 04718914), and creatinine (Scr) was calculated by the enzymatic method (Roche Reagent No. 11876853). The glomerular filtration rate (eGFR) was estimated from the Scr value using the CKD-EPI formula. All tests strictly follow the manufacturer's standardised operating procedures, and data are collected after the quality control of the same batch is qualified. The neutrophil/HDL ratio (NHR), monocyte/HDL ratio (MHR), and lymphocyte/HDL ratio (LHR) were calculated based on the corresponding detected values.

Statistical processing

Data analysis was conducted using SPSS 23.0, a statistical software package. Two groups were compared using a t-test, and the measurement data that fit a normal distribution are represented as $x \pm s$. The χ^2 test was used to compare count statistics, expressed as percentages or as the total number of cases. The relationships among NT-proBNP, eGFR, NHR, MHR, and LHR were examined using Pearson correlation tests. The prognostic value of the NHR, MHR, and LHR in patients with an acute exacerbation of chronic heart failure was evaluated using receiver operating characteristic (ROC) curves.

Results

Comparison of relevant index levels between the renal injury group and the non-renal injury group

There were 232 patients in the non-renal injury group and 154 patients in the renal damage group among the research participants. On the one hand, the renal injury group had higher levels of NHR, MHR, LHR, sST2, and NT-proBNP at 24 hours after admission than the non-renal inju-

Table I Comparison of relevant indicator levels between the renal injury group and the non-renal injury group.

Group	n	NHR		MHR		LHR	
		After admission 24 h	After admission 3d	After admission 24 h	After admission 3d	After admission 24 h	After admission 3d
Kidney injury group	154	16.14±4.17	10.95±2.88	1.16±0.02	0.99±0.03	1.55±0.06	1.06±0.04
Non-renal injury group	232	10.28±2.65	7.65±2.23	0.96±0.03	0.84±0.03	0.99±0.07	0.66±0.08
t		10.109	9.145	11.159	8.714	12.194	9.732
P		0.001	0.001	0.001	0.001	0.001	0.001
Group	n	ST2 (ug/L)		NT-proBNP (ug/L)		LVEF (%)	
		After admission 24 h	After admission 3d	After admission 24 h	After admission 3d	After admission 24 h	After admission 3d
Kidney injury group	154	57.66±7.78	49.78±6.45	10211.27±506.55	8265.19±873.32	32.28±4.22	35.32±5.35
Non-renal injury group	232	42.41±6.85	38.51±7.25	6637.23±813.34	4864.49±916.42	40.39±5.35	43.03±4.76
t		8.622	6.535	9.188	8.611	8.429	9.127
P		0.001	0.001	0.001	0.001	0.001	0.001
Group	n	BUN (mmol/L)		Ser (μmol/L)		eGFR [mL/(min ·1.73 m^2)]	
		After admission 24 h	After admission 3d	After admission 24 h	After admission 3d	After admission 24 h	After admission 3d
Kidney injury group	154	10.26±2.29	13.27±3.83	111.55±18.22	131.14±38.89	65.67±11.55	49.51±16.95
Non-renal injury group	232	9.35±2.54	6.89±2.33	115.47±28.25	96.94±24.32	69.25±14.29	74.03±13.69
t		1.466	9.644	1.355	15.333	1.667	10.133
P		0.139	0.001	0.215	0.001	0.118	0.001

Table II Comparison of various indicator levels between two groups.

Group	n	NHR		MHR		LHR	
		After admission 24 h	After admission 3d	After admission 24 h	After admission 3d	After admission 24 h	After admission 3d
Good prognosis group	286	11.75±3.46	8.38±212	0.99±0.04	0.89±0.03	1.16±0.07	0.77±0.07
Poor prognosis group	100	16.81±4.146	12.55±3.69	1.25±0.06	0.99±0.02	1.55±0.15	1.19±0.14
t		4.353	3.743	6.308	3.529	4.329	4.663
P		0.001	0.001	0.001	0.001	0.001	0.001
Group	n	SST2 (μg/L)		NT-proBNP (ug/L)		LVEF (%)	
		After admission 24 h	After admission 3d	After admission 24 h	After admission 3d	After admission 24 h	After admission 3d
Good prognosis group	286	45.38±7.65	40.64±6.35	7488.96±642.735	5692.85±581.44	38.17±2.33	40.46±3.93
Poor prognosis group	100	66.15±9.86	57.04±8.13	11442.14±973.96	9660.78±705.52	30.89±3.53	32.64±2.84
t		6.375	6.258	5.106	4.825	4.327	4.235
P		0.001	0.001	0.001	0.001	0.001	0.001
Group	n	BUN (mmol/L)		Scr (μmol/L)		eGFR [mL/(min·1.73 m^2)]	
		After admission 24 h	After admission 3d	After admission 24 h	After admission 3d	After admission 24 h	After admission 3d
Good prognosis group	286	9.55±2.68	8.58±2.38	108.87±4.69	105.49±4.44	68.48±4.62	67.75±7.27
Poor prognosis group	100	10.63±3.65	15.779±3.93	112.43±6.26	148.28±6.75	63.13±6.21	42.27±5.85
t		1.455	5.335	1.417	5.877	1.908	4.739
P		0.124	0.001	0.185	0.001	0.094	0.001

ry group, but the LVEF was lower. The differences were statistically significant (P<0.05). There was no statistically significant difference in BUN, Scr or the eGFR between the two groups (P>0.05). Three days after admission, the non-renal injury group's LVEF and eGFR differed significantly (P<0.05) from those of the renal injury group's NHR, MHR, LHR, sST2, NT-proBNP, BUN, and Scr.

NHR, MHR, LHR, sST2, and NT-proBNP were all significantly higher in both groups 24 hours after admission than three days later (P<0.05). The BUN and Scr levels in the renal damage group were higher three days after admission than they were twenty-four hours later, and the eGFR was lower (P<0.05) (see *Table I*).

Comparison of various indicators between the good prognosis group and the poor prognosis group

The results of the most recent MACEs, six months after discharge, showed that 286 patients

Table III Multivariate logistic analysis of acute kidney injury in patients with acute exacerbation of chronic heart failure.

Item	β	SE (β)	Wald	P	95% CI
NHR	6.317	2.273	7.733	0.005	0.004~0.158
MHR	4.389	2.099	4.386	0.032	1.344~4.898
LHR	3.312	1.688	3.799	0.045	1.012~7.728
eGFR	0.565	1.654	0.133	0.688	0.084~3.808

Table IV ROC curve analysis results.

Indicator	AUC	95% CI	Sensitivity (%)	Specificity (%)	P
NHR	0.801	0.688~0.916	81.4	74.4	0.001
MHR	0.795	0.698~0.894	84.5	71.8	0.001
LHR	0.788	0.689~0.876	79.1	66.2	0.001
NHR, MHR, and LHR joint detection	0.829	0.715~0.938	90.9	83.3	0.001
SST2	0.751	0.664~0.836	78.9	67.8	0.001
NT-proBNP	0.738	0.642~0.828	76.2	60.9	0.001
LVEF	0.711	0.612~0.829	61.3	87.2	0.001

had a favourable prognosis and 100 had a poor prognosis. While the LVEF was considerably lower in the poor-prognosis group than in the good-prognosis group ($P<0.05$), the bad-prognosis group had significantly higher levels of NHR, MHR, LHR, sST2, and NT-proBNP 24 hours after admission than the good-prognosis group. BUN, Scr, and eGFR did not differ statistically significantly between the two groups ($P>0.05$). The favourable-prognosis group had lower LVEF and eGFR levels three days after admission, whereas the bad-prognosis group had higher levels of NHR, MHR, LHR, sST2, NT-proBNP, BUN, and Scr ($P<0.05$). At 24 hours after admission, the NHR, MHR, LHR, sST2, and NT-proBNP in both groups were significantly higher than at 3 days after admission ($P<0.05$). In the poor prognosis group, the eGFR was lower three days after hospitalisation, and the BUN and Scr levels were higher than those 24 hours after admission ($P<0.05$) (see *Table II*).

Correlation analysis

The NHR, MHR, and LHR showed favourable correlations with NT-proBNP in individuals with an acute exacerbation of chronic heart failure ($r=0.893$, $P=0.001$; $r=0.844$, $P=0.001$; $r=0.939$, $P=0.001$). Furthermore, there was a negative correlation between it and the eGFR ($r=0.869$, $P=0.001$; $r=0.732$, $P=0.001$; $r=0.805$, $P=0.007$).

Stepwise logistic regression with multiple independent variables was used. The occurrence of acute kidney injury 6 months after an acute exacerbation of chronic heart failure was taken as the dependent variable, and other variables were treated as independent variables in the analysis. The results revealed that patients with acute exacerbation of chronic heart failure with elevated NHRs, MHRs, and LHRs 24 hours after admission had an increased risk of acute kidney injury (see *Table III*).

The NHR, MHR, and LHR's early prognostic value for the prognosis of patients experiencing an acute flare-up of chronic heart failure

The ROC curve showed that the area under the curve (AUC) for the combined detection of NHR, MHR, and LHR was 0.829 at 24 hours after admission. NHR's AUC was 0.801, MHR's was 0.795, LHR's was 0.788, sST2's was 0.751, NT-proBNP's was 0.738, and LVEF's was 0.711.

The combined detection of NHR, MHR, and LHR has the greatest predictive value for MACEs in patients with acute exacerbation of chronic heart failure (see *Table IV*).

Discussion

Heart failure is a complex advanced syndrome of cardiac dysfunction (15). Approximately 70% of patients with heart failure present with acute exacerbation of chronic heart failure, often involving multiple organs. It has extremely high prevalence rates, rehospitalisation rates and mortality rates. Relevant foreign studies (16–18) have shown that some patients with heart failure have kidney damage. Even transient kidney damage can increase the mortality and readmission rates of patients. Studies (19–21) have shown that 24%–45% of elderly patients with heart failure develop AKI, leading to a poor prognosis. Early prediction of AKI and effective intervention are important measures to reduce the mortality rate of patients with heart failure.

The decline in cardiac function leads to a decrease in renal artery perfusion pressure, activating the renin angiotensin aldosterone system, causing interstitial renal oedema, glomerular dysfunction, and a progressive decline in renal function (22). After renal injury, the aggravation of water and sodium retention leads to the deterioration of heart failure. The activation of the SNS and the participation of inflammatory response factors further aggravate cardiac and renal insufficiency, ultimately resulting in an increased mortality rate (23). Heart failure and renal insufficiency coexist and influence each other, involving both neuroendocrine activation and the participation of oxidative stress and inflammatory factors. Neutrophils, lymphocytes and monocytes are important white blood cells. Neutrophils are a rapid line of natural immune defence against injury and can activate inflammatory cells and release various inflammatory mediators and proinflammatory cytokines, triggering a waterwheel-like inflammatory cascade.

HDL-C, an important indicator of systemic inflammation, regulates the autoimmune system, inhibits inflammation and oxidative stress, protects endothelial cells, removes oxidised LDL-C, inhibits the expression of endothelial adhesion molecules, and prevents further inflammation expansion and damage (24). The increase in »inflammatory factors«, such as the neutrophil count, lymphocyte count and monocyte count, and the decrease in »anti-inflammatory factors«. The NHR, MHR, LHR, sST2, and NT-proBNP were considerably higher in the renal injury group than in the non-renal injury group 24 hours after admission. At present, the leading indicators for evaluating renal injury include Scr, urine output per unit time and the eGFR. For every 10 mL/min decrease in the eGFR, the rate of sudden cardiac death increased by 29%. Scr assessment of patients' conditions is relatively backward. The NHR, MHR, LHR, sST2, and NT-proBNP were significantly higher 24 hours after admission than 3 days later ($P<0.05$).

Increased levels of inflammatory factors in patients with renal insufficiency cause tubulointerstitial fibrosis and glomerular hypertension (25–27). A high MHR is associated with poor cardiovascular prognosis in patients with chronic kidney disease and can predict the occurrence of MACE. The study's findings showed that the poor-prognosis group's NHR, MHR, LHR, sST2, and NT-proBNP were considerably higher than those of the good-prognosis group 24 hours after admission. NHR, MHR, LHR, sST2, and NT-proBNP were all significantly higher in both groups 24 hours after admission than three days later ($P<0.05$). According to a pertinent investigation, patients with acute exacerbations of chronic heart failure had greater increases in NT-proBNP and more pronounced decreases in eGFR when their NHR, MHR, and LHR were higher (28). Patients with acute exacerbation of chronic heart failure with elevated NHR, MHR, and LHR had a higher risk of acute kidney injury 24 hours after admission, the ROC curve showed that the AUC of the combined detection of the NHR, MHR, and LHR was 0.825, and the incidence of MACEs in patients with acute exacerbation of chronic heart failure can be significantly predicted (29).

Neutrophils are closely associated with the clinical prognosis of patients with acute and chronic heart failure. The NHR, MHR, and LHR, as critical clinical indicators of cardiovascular disease prognosis, have greater clinical significance in early assessment than do the BUN, Scr, and eGFR. Regular monitoring can more accurately and comprehensively determine prognosis early, which is crucial for reducing the occurrence of MACEs. It is convenient to guide clinicians in evaluating patients. Since this was a single-centre study, further research is needed to determine how early kidney-protective medication intervention affects newly emerging inflammatory markers.

Conflict of interest statement

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

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