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Prognostic Value of Admission Neutrophil-to-Lymphocyte Ratio for One-Year All-Cause Mortality in Older Adults with Chronic Heart Failure: A Retrospective Cohort Study

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Abstract

Background

Heart failure remains a major contributor to morbidity and mortality among older adults. Individuals with chronic heart failure (CHF) frequently present with multiple comorbidities, reduced physiological reserve, and persistent vulnerability after hospitalization, highlighting the need for simple and accessible markers to improve prognostic assessment in this high-risk population. The neutrophil-to-lymphocyte ratio (NLR), derived from routine blood counts, reflects systemic inflammatory status and may provide additional prognostic information. However, the association between admission NLR and post-discharge mortality in older adults with CHF remains incompletely

characterized.

Methods

This retrospective cohort study included 147 older adults with chronic heart failure who were admitted to the Department of Cardiology, Beijing Geriatric Hospital, between January 2019 and May 2020. Baseline demographic characteristics, clinical parameters, laboratory findings, echocardiographic measurements, and medication information were collected. Patients were followed for 1 year after hospital discharge, and the primary outcome was all-cause mortality. Univariable and multivariable Cox proportional hazards regression analyses were performed to identify factors associated with mortality. Receiver operating characteristic (ROC) curve analysis and Kaplan—Meier survival analysis were conducted to evaluate the prognostic value of admission NLR.

Results

During the 1-year follow-up period, 37 patients (25.2%) experienced all-cause mortality. Compared with survivors, non-survivors had higher admission heart rate, BNP levels, neutrophil counts, and NLR values, together with lower hemoglobin, lymphocyte counts, and prealbumin levels. In

multivariable Cox proportional hazards analysis, higher admission NLR remained independently associated with an increased risk of 1-year all-cause mortality (hazard ratio [HR], 1.081; 95% confidence interval [CI], 1.002—1.166; P=0.043). ROC curve analysis demonstrated modest discrimination of admission NLR for mortality risk stratification (area under the curve [AUC], 0.617; 95% CI, 0.509—0.725). Patients with an admission NLR ≥7.83 had higher observed mortality than those with lower NLR values (52.4% vs. 20.6%, log-rank P=0.005).

Conclusion

Elevated admission NLR was independently associated with an increased risk of 1-year all-cause mortality after hospital discharge among older adults with chronic heart failure. Although NLR alone demonstrated limited discriminatory ability, it may provide complementary prognostic information for identifying patients at higher risk of mortality. Further prospective multicenter studies are warranted to validate these findings and determine whether incorporating NLR into existing clinical assessment strategies can improve risk stratification in older adults with CHF.

Keywords

Older adults; Chronic heart failure; Neutrophil-to-lymphocyte ratio; Systemic inflammation; All-cause mortality; Prognostic marker

Introduction

Heart failure (HF) remains a major global public health challenge and is associated with substantial morbidity, mortality, and healthcare burden, particularly among older adults. The prevalence of HF increases markedly with advancing age, affecting approximately 10% of individuals aged over 70 years [1]. In China, HF continues to be associated with considerable risks of mortality and rehospitalization after hospital discharge, as demonstrated by the China Heart Failure (China-HF) Registry [2]. Despite advances in guideline-directed medical therapy, older adults with chronic heart failure (CHF) remain a particularly vulnerable population due to advanced age, multimorbidity, and reduced physiological reserve. Therefore, improving long-term prognostic assessment after hospitalization in older adults with CHF remains an important clinical priority. Identification of simple, accessible, and routinely available biomarkers reflecting underlying biological vulnerability may

provide complementary prognostic information beyond conventional clinical assessment and support individualized risk management.

Increasing evidence indicates that inflammation plays an important role in the development and progression of HF. Persistent inflammatory activation contributes to myocardial remodeling, fibrosis, endothelial dysfunction, and impaired cardiac performance through complex interactions involving inflammatory cytokines, immune cells, oxidative stress, and neurohormonal pathways [3,4]. In addition to promoting disease progression, systemic inflammation may reflect the underlying biological vulnerability of patients with HF, particularly among older adults who frequently experience impaired immune regulation and increased inflammatory burden. Therefore, inflammatory biomarkers may provide additional prognostic information beyond traditional clinical parameters in this high-risk population.

The neutrophil-to-lymphocyte ratio (NLR) is an easily obtainable inflammatory marker derived from routine complete blood counts. It integrates two major components of the immune response: neutrophilia, reflecting innate inflammatory activation,

and lymphopenia, reflecting physiological stress and impaired adaptive immune regulation [5,6]. Compared with individual inflammatory parameters, NLR provides a composite assessment of systemic inflammatory imbalance and has attracted increasing attention as a potential prognostic marker in cardiovascular disease.

Previous studies have demonstrated that elevated NLR is associated with adverse outcomes in patients with HF, including mortality and rehospitalization [7—13]. In acute HF populations, higher NLR has been associated with increased risks of in-hospital and long-term mortality [9,12], and recent meta-analyses have suggested a potential prognostic association between elevated NLR and adverse outcomes [8,12]. However, most previous studies have focused on acute HF cohorts, heterogeneous HF populations, or short-term outcomes. Older adults with chronic HF represent a distinct high-risk population characterized by advanced age, multimorbidity, reduced physiological reserve, and increased susceptibility to adverse clinical events. Whether admission NLR provides additional prognostic information regarding post-discharge mortality in this population remains insufficiently characterized.

Therefore, this retrospective cohort study aimed to investigate the association between admission NLR and 1-year all-cause mortality after hospital discharge in older adults with chronic HF. We further explored whether markedly elevated admission NLR was associated with higher observed mortality risk in this vulnerable population. We hypothesized that elevated admission NLR would be independently associated with increased mortality risk and may provide complementary prognostic information beyond conventional clinical characteristics.

Materials and Methods

Study Design and Population

This retrospective cohort study included older adults with chronic heart failure (CHF) who were admitted to the Department of Cardiology, Beijing Geriatric Hospital, Beijing, China, between January 2019 and May 2020. Patients were eligible if they were aged ≥65 years, had a confirmed diagnosis of CHF according to the European Society of Cardiology (ESC) guidelines, and had complete admission peripheral blood cell counts with differential leukocyte analysis.

The diagnosis of CHF was established based on

comprehensive clinical evaluation, including medical history, physical examination, electrocardiography, chest radiography, and echocardiographic findings, according to current ESC recommendations.

Patients were excluded if they had conditions that could significantly influence leukocyte counts or systemic inflammatory status, including hematological disorders, malignancy or previous chemotherapy, severe infection, chronic inflammatory diseases, glucocorticoid therapy within 3 months before admission, acute myocardial infarction, or coronary revascularization within 6 months before admission.

A total of 147 patients fulfilled the eligibility criteria and were included in the final analysis.

Data Collection and Definition of NLR

Baseline demographic characteristics, cardiovascular risk factors, comorbidities, laboratory measurements, echocardiographic parameters, and medication information were retrospectively collected from electronic medical records.

Admission neutrophil and lymphocyte counts were obtained from routine peripheral blood differential analyses performed at hospitalization. The neutrophil-to-lymphocyte ratio (NLR) was

calculated as the absolute neutrophil count divided by the absolute lymphocyte count.

Follow-Up and Clinical Outcome

All patients were followed for 1 year after hospital discharge. Follow-up information was obtained through telephone interviews and review of available hospital medical records.

The primary endpoint was 1-year all-cause mortality after discharge. Survival status and date of death were confirmed through follow-up records and available medical documentation.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were assessed for normality using the Shapiro–Wilk test. Normally distributed variables are presented as mean ± standard deviation (SD), whereas non-normally distributed variables are presented as median with interquartile range (IQR). Categorical variables are presented as numbers and percentages.

Baseline characteristics were compared between survivors and non-survivors using the independent samples t-test or Mann–Whitney U test for continuous variables and the chi-square test

or Fisher's exact test for categorical variables, as appropriate.

Time-to-event analyses were performed using Cox proportional hazards regression models. Univariable Cox proportional hazards regression analyses were conducted to identify factors associated with 1-year all-cause mortality. Variables with clinical relevance and those showing statistical significance in univariable analyses ($P<0.05$) were considered for inclusion in the multivariable Cox proportional hazards regression model. The proportional hazards assumption was assessed before model construction.

The discriminatory ability of admission NLR was assessed using receiver operating characteristic (ROC) curve analysis. The optimal cutoff value was determined using the maximum Youden index and was considered exploratory because of the limited sample size. Kaplan—Meier survival analysis with log-rank testing was subsequently performed to compare mortality between patients stratified according to the exploratory NLR cutoff value.

All statistical tests were two-sided, and a P value <0.05 was considered statistically significant.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Beijing Geriatric Hospital (approval number: BJLNYY-2021-021). The study was conducted in accordance with the Declaration of Helsinki. Due to the retrospective nature of the study and the use of anonymized clinical data, the requirement for informed consent was waived by the ethics committee.

Results

Patient Characteristics

A total of 147 older adults with chronic heart failure (CHF) were included in the final analysis. The mean age of the study population was 77.6 ± 7.9 years, and 73 patients (49.7%) were male. During the 1-year follow-up period after hospital discharge, 37 patients (25.2%) experienced all-cause mortality.

Baseline characteristics according to survival status are presented in Table 1. Hypertension (76.2%) and coronary artery disease (73.8%) were the most prevalent comorbidities. Most patients had advanced heart failure symptoms, with 130 patients (88.5%) classified as NYHA functional class III or IV.

No significant differences were observed between survivors and non-survivors regarding age, sex, blood pressure, or most baseline comorbidities. However, non-survivors had a

significantly higher admission heart rate compared with survivors (88.6 ± 21.7 vs. 79.3 ± 18.8 beats/min, P = 0.022).

Regarding laboratory findings, non-survivors showed higher BNP concentrations and NLR values, together with lower hemoglobin, prealbumin, and lymphocyte counts. Specifically, the median NLR was significantly higher among non-survivors than among survivors [4.7 (IQR, 3.0—8.5) vs. 3.7 (IQR, 2.7—5.8), P = 0.034]. In addition, digoxin use was more frequent among non-survivors compared with survivors (43.2% vs. 19.1%, P = 0.003).

Table 1. Baseline characteristics of older adults with chronic heart failure according to 1-year survival status after hospital discharge.

Variable	Total cohort （n＝147）	Death group （n＝37）	Survival group (n＝110）	P value
Age（years）	77.6±7.9	79.5±7.7	76.9±7.8	0.082
Male	73(49.7%)	16(43.2%)	57(51.8%)	0.367
Systolic blood pressure, mmHg	130.8±23.0	129.5±19.9	131.2±24.0	0.984

Diastolic blood pressure, mmHg	71.2±13.0	72.0±11.0	71.0±13.7	0.416
Heart rate, bpm	81.7±19.9	88.6±21.7	79.3±18.8	0.022
Cigarette smoking	80(54.4%)	18(48.6%)	62(56.4%)	0.415
Hypertension	112(76.2%)	26(70.3%)	86(78.2%)	0.328
Coronary artery disease	108(73.8%)	28(75.7%)	80(72.7%)	0.725
Previous myocardial infarction	57(38.8%)	15(40.5%)	42(38.2%)	0.799
Previous percutaneous coronary intervention	27(17.7%)	6(16.2%)	20(18.2%)	0.786
Previous coronary artery bypass grafting	13(8.8%)	3(8.1%)	10(9.1%)	1.000
Dilated cardiomyopathy	13(8.8%)	6(16.2%)	7(6.4%)	0.068
Diabetes mellitus	73(49.7%)	17(45.9%)	56(50.9%)	0.601
Atrial fibrillation	55(37.4%)	18(48.6%)	37(33.6%)	0.103

Chronic kidney disease	48(32.7%)	14(37.8%)	34(30.9%)	0.437
Cerebral infarction	61(41.5%)	12(32.4%)	49(44.5%)	0.196
Hyperlipidemia	132(89.8%)	32(86.5%)	100(90.9%)	0.442
NYHA class III/IV	130(88.5%)	36(97.3%)	94(85.4%)	0.099
BNP (pg/mL)	893(350.5,2158.8)	1276.4(745.5,3723.0)	776.0(222.5,1722.0)	0.001
D-Dimer （ng/mL）	0.67±1.5	0.82±1.7	0.62±1.4	0.129
Total protein (g/L)	62.4±6.3	62.5±5.6	62.4±6.6	0.955
Albumin (g/L)	36.6±4.0	35.6±3.8	37.0±4.1	0.076
Prealbumin(g/L)	177.6±62.1	151.6±48.8	186.3±63.8	0.003
Creatinine (umol/L)	145.1±125.0	161.4±146.5	139.7±117.1	0.598
Cholesterol (mmol/L)	5.7±22.9	3.7±1.0	6.3±26.5	0.190
Hemoglobin (g/L)	122(100,137)	107(91,126.5)	126(107.3,137.3)	0.006
White blood cell (10^9 /L)	7.7±4.4	8.9±7.2	7.2±2.8	0.734
Platelets (10^9 /L)	193.1±77.3	184.2±89.9	196.1±72.7	0.183

Neutrophil(10^9 /L)	5.7±4.2	6.0±3.6	5.6±4.4	0.628
lymphocyte(10^9 /L)	1.23(0.86,1.55)	1.11(0.68,1.51)	1.27(0.96,1.57)	0.036
NLR	4.0(2.7,6.2)	4.7(3.0,8.5)	3.7(2.7,5.8)	0.034
Red cell distribution width	50.0±34.0	50.4±10.4	49.8±38.9	0.058
Platelet distribution width	13.6±2.7	14.2±2.6	13.4±2.7	0.101
Mean platelet volume	10.3±1.3	10.6±1.6	10.2±1.1	0.162
NPR	0.024(0.02,0.033)	0.03(0.02,0.04)	0.02(0.019,0.03)	0.049
Uric acid(mmol/l)	480.5±166.6	488.3±200.1	477.9±154.7	0.743
HbA1c（%）	6.9±1.7	6.6±1.8	7.0±1.6	0.160
LVEF(%)	51.5±13.4	49.0±13.6	52.4±13.3	0.230
LV end-diastolic diameter(mm)	49.7±8.9	50.9±10.1	49.4±8.5	0.539
ACEI/ARB/ARNI	75(51%)	15(40.5%)	60(54.5%)	0.140
Beta-blockers	126(85.7%)	31(83.8%)	95(86.4%)	0.698
Spironolactone	66(44.9%)	16(43.2%)	50(45.5%)	0.815
Calcium-channel	54(36.7%)	10(27.0%)	44(40.0%)	0.334

blockers				
Diuretics	137(93.2%)	36(97.3%)	101(91.8%)	0.252
Digoxin	37(25.2%)	16(43.2%)	21(19.1%)	0.003
Nitrates	111(75.5%)	25(67.6%)	86(78.2%)	0.194
Antiplatelet drugs	107(72.8%)	24(64.9%)	83(75.5%)	0.211
Oral anticoagulants	10(6.8%)	2(5.4%)	8(7.3%)	0.990
Statins	120(81.6%)	27(73.0%)	93(84.5%)	0.116

NPR： neutrophil-to-platelet ratio

Factors Associated with 1-Year All-Cause Mortality in Older Adults with Chronic Heart Failure

During the 1-year follow-up period, Cox proportional hazards regression analyses were performed to evaluate the associations between baseline clinical variables and all-cause mortality (Table 2).

In univariable Cox regression analyses, higher heart rate, higher BNP concentration, higher white blood cell count, lower lymphocyte count, higher NLR, lower hemoglobin level, and lower prealbumin level were significantly associated with 1-year all-cause mortality.

Variables with clinical relevance and those showing statistically significant associations in univariable analyses were considered for inclusion in the multivariable Cox proportional hazards regression model. After multivariable adjustment, higher white blood cell count (HR, 1.060; 95% CI, 1.003—1.119; P = 0.038), higher NLR (HR, 1.081; 95% CI, 1.002—1.166; P = 0.043), and lower hemoglobin level (HR, 0.982; 95% CI, 0.969—0.996; P = 0.011) remained significantly associated with 1-year all-cause mortality.

Table 2. Univariable and multivariable Cox proportional hazards regression analyses of factors associated with 1-year all-cause mortality in older adults with chronic heart failure.

Variables	Univariate analysis			Multivariate analysis		
	HR	95%CI	PValue	HR	95% CI	PValue
Heart rate	1.019	1.004-1.034	0.011			
WBC	1.055	1.007-1.105	0.024	1.060	1.003-1.119	0.038
lymphocyte	0.432	0.202-0.924	0.03			
NLR	1.100	1.050-1.152	0.000	1.081	1.002-1.166	0.043
Hemoglobin	0.984	0.972-0.997	0.012	0.982	0.969-0.996	0.011
Prealbumin	0.992	0.987-0.997	0.003			
BNP	1.002	1.007-1.037	0.005			

HR: hazard ratio

Discriminatory Ability of Admission NLR for 1-Year Mortality

Receiver operating characteristic (ROC) curve analysis showed that admission NLR had modest discriminatory ability for 1-year all-cause mortality (area under the curve [AUC], 0.617; 95% confidence interval [CI], 0.509─0.725; P = 0.034) (Figure 1).

The exploratory optimal cutoff value determined using the maximum Youden index was 7.83, with a sensitivity of 29.7% and a specificity of 90.8%. Although the sensitivity was limited, patients with an admission NLR ≥7.83 had a higher observed mortality risk, suggesting that markedly elevated NLR may provide additional prognostic information in older adults with CHF.

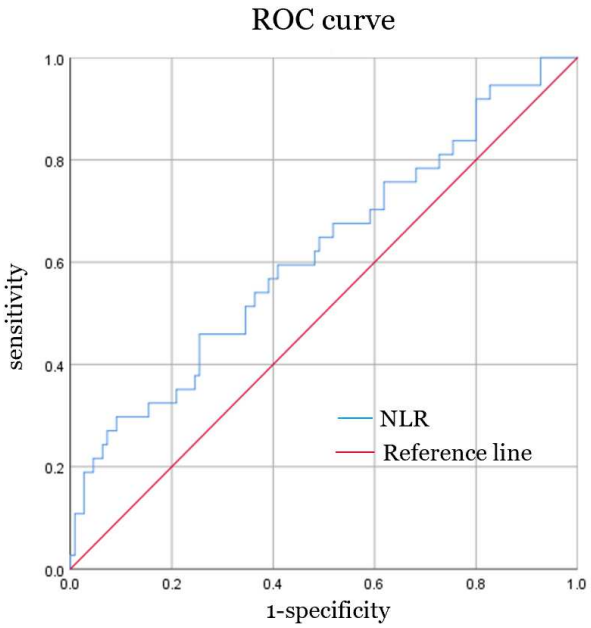

Figure 1. Receiver operating characteristic (ROC) curve of admission neutrophil-to-lymphocyte ratio (NLR) for 1-year all-cause mortality in older adults with chronic heart failure.

Kaplan–Meier Survival Analysis According to Admission NLR Cutoff Value

Kaplan–Meier survival analysis demonstrated a significant difference in survival between patients stratified according to the exploratory admission NLR cutoff value (log-rank P = 0.005) (Figure 2).

Patients with an admission NLR ≥7.83 had a significantly higher observed 1-year all-cause mortality compared with those with an NLR <7.83 (52.4% vs. 20.6%). These findings suggest that markedly elevated admission NLR levels were associated with a higher mortality burden during follow-up among older adults with CHF.

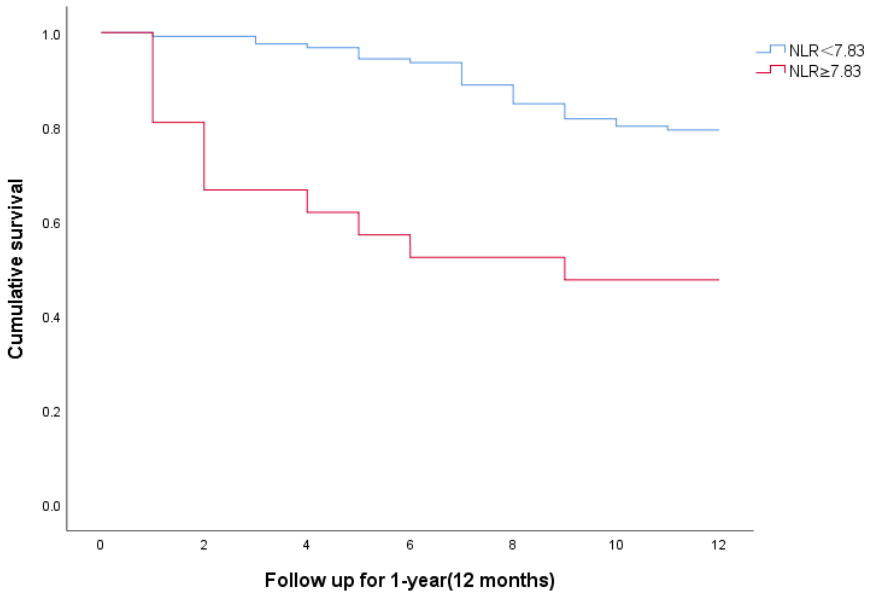

Figure 2. Kaplan—Meier survival curves for 1-year all-cause mortality according to the exploratory admission neutrophil-to-lymphocyte ratio (NLR) cutoff value (7.83).

Discussion

In this retrospective cohort study of older adults with chronic heart failure (CHF), we found that an elevated neutrophil-to-lymphocyte ratio (NLR) at hospital admission was independently associated with an increased risk of 1-year all-cause mortality after adjustment for clinically relevant variables. During the 1-year follow-up period after hospital discharge, 37 patients (25.2%) experienced all-cause mortality, highlighting the substantial residual mortality burden among older adults with CHF despite advances in guideline-directed medical therapy.

Furthermore, patients with markedly elevated admission NLR demonstrated higher observed mortality during follow-up. These findings suggest that admission NLR may reflect underlying inflammatory vulnerability and provide complementary prognostic information beyond conventional clinical characteristics in older adults with CHF.

Previous studies have demonstrated the prognostic relevance of NLR in patients with heart failure; however, much of the available evidence has been derived from acute heart failure populations, heterogeneous heart failure cohorts, or studies focusing on in-hospital outcomes and short-term events [10,12,14]. In contrast, the present study specifically focused on older adults with chronic heart failure and evaluated long-term mortality after hospital discharge. Older adults with CHF represent a distinct high-risk population characterized by advanced age, multimorbidity, and reduced physiological reserve, all of which may influence disease progression and long-term outcomes. Therefore, identifying simple, accessible, and routinely available biomarkers that reflect biological vulnerability may provide additional information for post-discharge clinical assessment. Our findings extend previous observations by suggesting that admission NLR may be

associated with long-term mortality risk in this vulnerable population.

Inflammation and Heart Failure

The pathophysiological role of inflammation in heart failure has received increasing attention in recent years. Beyond the traditional concept of heart failure as primarily a hemodynamic disorder, accumulating evidence indicates that persistent immune activation and systemic inflammatory responses contribute to myocardial injury, adverse remodeling, fibrosis, and progressive cardiac dysfunction through complex interactions involving inflammatory cytokines, immune cells, oxidative stress, and neurohormonal pathways [3,4,15]. These inflammatory processes may not only accelerate cardiac deterioration but also reflect the systemic biological stress experienced by patients with advanced cardiovascular disease.

The relationship between systemic inflammation and prognosis may be particularly relevant in older adults with CHF. Aging is associated with immune dysregulation, impaired immune response, and chronic low-grade inflammatory activation, which may increase susceptibility to cardiovascular stress and adverse clinical outcomes. In addition, older adults with CHF frequently

have multiple comorbid conditions, including hypertension, diabetes mellitus, chronic kidney disease, and ischemic heart disease, which may further contribute to systemic inflammatory burden [3,4]. Therefore, inflammatory biomarkers may provide insight into the complex interaction between aging, comorbidity burden, and cardiovascular vulnerability.

NLR is a composite inflammatory index derived from routine complete blood counts and reflects the balance between innate and adaptive immune responses. Increased neutrophil levels represent activation of innate inflammatory pathways, whereas reduced lymphocyte counts may indicate physiological stress, neurohormonal activation, and impaired adaptive immune regulation [5,6]. Compared with individual inflammatory parameters, NLR integrates these two complementary components and may provide a broader assessment of systemic inflammatory imbalance [16,17].

Consistent with previous findings, our study demonstrated that non-survivors had significantly higher admission NLR levels than survivors. Furthermore, after adjustment for potential confounding factors, elevated NLR remained significantly associated with 1-year all-cause mortality. These findings

support the hypothesis that systemic inflammatory activation may contribute to adverse clinical trajectories among older adults with chronic heart failure.

Potential Mechanisms Linking NLR to Adverse Outcomes

Several biological mechanisms may explain the observed association between elevated NLR and mortality risk in older adults with CHF. First, increased neutrophil activation may reflect enhanced systemic inflammatory activity and contribute to cardiovascular injury through the release of pro-inflammatory cytokines, reactive oxygen species, and proteolytic enzymes. These processes may promote endothelial dysfunction, extracellular matrix degradation, myocardial fibrosis, and adverse ventricular remodeling, thereby accelerating heart failure progression [3,16].

Second, lymphopenia may represent a marker of physiological stress, neurohormonal activation, and impaired immune regulation. Advanced heart failure is frequently accompanied by increased sympathetic nervous system activity and elevated circulating stress hormones, which may contribute to lymphocyte apoptosis and suppression of adaptive immune responses [4,17]. Therefore, an elevated NLR may reflect the

combined influence of inflammatory activation, systemic stress, and impaired immune homeostasis rather than a single biological mechanism [6].

In the present study, patients who died during follow-up exhibited higher NLR and BNP levels compared with survivors. BNP is an established biomarker reflecting cardiac hemodynamic stress and disease severity; therefore, the coexistence of elevated NLR and BNP may indicate the interaction between systemic inflammatory burden and worsening cardiac dysfunction. In addition, the higher prevalence of digoxin use among non-survivors may reflect greater disease severity and clinical complexity rather than a direct causal relationship with mortality. Collectively, these findings suggest that elevated NLR may characterize older adults with CHF who have greater inflammatory burden and increased vulnerability to adverse outcomes.

Comparison With Previous Studies

Our findings are broadly consistent with previous studies reporting associations between elevated NLR and adverse outcomes in different heart failure populations, including acute heart failure, chronic heart failure, preserved and reduced

ejection fraction phenotypes, and hospitalized or outpatient cohorts [7—11,14,18]. Previous investigations have suggested that higher NLR levels are associated with increased risks of all-cause mortality, cardiovascular mortality, and heart failure-related hospitalization.

However, several important differences should be considered when interpreting these findings. First, many previous studies have focused on acute decompensated heart failure, whereas our study specifically evaluated older adults with chronic heart failure and examined mortality after hospital discharge over a 1-year follow-up period. Second, older adults with CHF may have distinct inflammatory characteristics due to age-related immune changes, chronic inflammatory activation, multimorbidity, and reduced physiological reserve. These factors may influence both baseline NLR levels and their clinical significance. Therefore, the prognostic relevance of NLR may vary according to patient characteristics, disease stage, and clinical setting. Our study provides additional evidence supporting the potential value of admission NLR as a complementary marker for long-term outcome assessment in older adults with chronic heart failure.

Clinical Interpretation of the Exploratory NLR Cutoff Value

An important aspect of the present study was the exploratory evaluation of a potential admission NLR threshold associated with mortality risk. In our cohort, the cutoff value identified using the maximum Youden index was 7.83, which was higher than thresholds reported in several previous heart failure studies. Previous meta-analyses have suggested that NLR cutoff values associated with mortality risk in patients with heart failure generally range between approximately 5.91 and 6.18, although considerable heterogeneity exists among studies [8]. Another meta-analysis of prospective cohort studies reported that cutoff values associated with increased risk were commonly within the range of >4.0—6.5, depending on patient characteristics, clinical setting, and methodological differences [11].

Several factors may explain the relatively higher threshold observed in our study. First, our cohort consisted exclusively of older adults with chronic heart failure, a population characterized by advanced age, multimorbidity, and altered inflammatory profiles. Second, differences in study populations, outcome definitions, follow-up duration, and statistical approaches may contribute to variation in derived NLR

thresholds across studies.

Importantly, the identified cutoff value should be interpreted cautiously. Although patients with NLR ≥7.83 had significantly higher observed mortality compared with those with lower NLR values, the overall discriminatory ability of NLR alone was modest, with an area under the ROC curve of 0.617. Furthermore, the identified cutoff showed relatively high specificity (90.8%) but limited sensitivity (29.7%). Therefore, NLR should not be considered a standalone marker for mortality prediction. Instead, markedly elevated admission NLR may provide additional prognostic information and may help characterize older adults with CHF who require closer clinical monitoring.

Given the relatively small sample size and single-center design of the present study, this exploratory cutoff requires validation in larger multicenter cohorts before its potential clinical application can be established.

Clinical Implications

From a clinical perspective, NLR has several practical advantages as a potential adjunctive biomarker. It is inexpensive, routinely available from standard complete blood

counts, and does not require additional laboratory testing or specialized equipment. These characteristics make NLR particularly attractive for older adults with CHF, who frequently undergo repeated clinical assessments and often have complex medical conditions.

Nevertheless, NLR should not be considered a replacement for established prognostic markers, such as BNP, or comprehensive clinical assessment approaches. Instead, NLR may provide additional information regarding systemic inflammatory status and physiological stress when interpreted together with conventional clinical characteristics. In particular, markedly elevated admission NLR may characterize a subgroup of patients with greater inflammatory burden and reduced biological reserve who may benefit from closer clinical follow-up and careful post-discharge management.

Future studies should investigate whether NLR provides incremental prognostic information when combined with established clinical parameters and validated heart failure assessment strategies. In addition, prospective studies incorporating serial NLR measurements may help determine whether dynamic changes in inflammatory status provide

additional prognostic value beyond a single admission measurement.

Study Limitations

Several limitations should be acknowledged. First, this was a retrospective, single-center cohort study with a relatively small sample size. Although multivariable Cox regression analysis was performed to adjust for potential confounding factors, residual confounding cannot be completely excluded. The limited sample size may also have reduced statistical power and affected the external validity of the findings.

Second, NLR was assessed only at hospital admission, and serial measurements during follow-up were unavailable. Therefore, we were unable to determine whether longitudinal changes in NLR provide additional prognostic information beyond baseline inflammatory status. Future studies incorporating repeated inflammatory assessments may further clarify the clinical significance of NLR trajectories.

Third, although admission NLR remained independently associated with 1-year all-cause mortality, its overall discriminatory ability was modest, with an AUC of 0.617 and limited sensitivity at the exploratory cutoff value. Therefore, NLR

should be interpreted as a complementary biomarker rather than a standalone marker for mortality assessment.

Fourth, the primary endpoint of this study was all-cause mortality. Detailed information regarding cause-specific mortality, heart failure hospitalization, and other cardiovascular outcomes was unavailable, preventing further evaluation of the relationship between NLR and specific clinical events.

Finally, because this study was conducted at a single institution and included only older adults with CHF, external validation in larger and more diverse populations is required. Future multicenter prospective studies should evaluate whether NLR provides additional prognostic information beyond established biomarkers and validated clinical assessment approaches.

Conclusion

In older adults with chronic heart failure, elevated admission neutrophil-to-lymphocyte ratio was independently associated with an increased risk of 1-year all-cause mortality after adjustment for clinical variables. Although NLR alone demonstrated modest discriminatory ability, markedly elevated admission NLR was associated with substantially higher observed mortality during follow-up. Given its simplicity, low

cost, and widespread availability, NLR may serve as a useful adjunctive biomarker for supporting long-term prognostic assessment in older adults with CHF. Further prospective multicenter studies are warranted to validate these findings and determine the incremental prognostic value of incorporating NLR into existing heart failure assessment strategies.

Declarations

Abbreviations

CHF: chronic heart failure

NLR: neutrophil-to-lymphocyte ratio

BNP:B-type natriuretic peptide

HF: Heart failure

NYHA: New York Heart Association

NPR: neutrophil-to-platelet ratio

LVEF: Left ventricular ejection fraction

ACEI: Angiotensin-converting enzyme inhibitor

ARB: Angiotensin receptor blocker

ARNI: Angiotensin receptor-neprilysin inhibitor

WBC: White blood cell

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of Beijing Geriatric Hospital (Approval No. BJLNYY-2021-021) and was conducted in accordance with the principles of the Declaration of Helsinki. Due to the retrospective and non-interventional nature of the study and the use of anonymized clinical data, the requirement for informed consent was waived by the Ethics Committee.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to patient privacy protection. However, the datasets are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

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Authors' contributions

All authors contributed to the conception and design of the study. Study design: Jia Ding, Zufang Yang, Hong Liu, Zhi Luo, and Jian Wang. Data collection and clinical information acquisition: Jia Ding and Zufang Yang. Data analysis and interpretation: Jia Ding, Hong Liu, and Zhi Luo. Manuscript drafting: Jia Ding. Manuscript review and revision: Jian Wang. All authors commented on previous versions of the manuscript and read and approved the final manuscript.

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