Submitted: 29 August, 2023 Accepted: 24 October, 2023 Published: 08 January, 2025 DOI:10.22514/sv.2025.007

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ORIGINAL RESEARCH

Fasting blood glucose to lymphocyte ratio predicting the long-term cardiac mortality in unstable angina pectoris patients

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Abstract

Background: This retrospective study aims to explore the predictive value of the fasting blood glucose to lymphocyte count ratio (GLR) for coronary artery lesion severity and long-term cardiac mortality in patients with unstable angina pectoris (UAP), which has not been previously reported. **Methods**: 4110 patients with UAP were included in the study. The patients were classified into two groups based on their GLR values and were followed for an average of 36 months. Outcomes, including cardiac mortality, all-cause mortality, and rehospitalization rate, were analyzed, and the predictive value of GLR for long-term cardiac mortality was determined. **Results**: Among all patients, 865 (21.0%) were re-hospitalized and 103 (2.5%) died, including 39 cardiac deaths (0.9%). The high GLR group had a greater SYNTAX score compared to the low GLR group ($p < 0.001$). The cardiac mortality ($p = 0.006$) and rehospitalization ($p = 0.004$) rates were higher in the high GLR group. Kaplan-Meier curve indicated higher cardiac mortality when GLR was $\geq$3.38 ($p = 0.005$). Receiver operating characteristic (ROC) analysis revealed that a GLR of 2.9861 was an effective cutoff value for predicting cardiac mortality ($p = 0.001$). Multivariate Cox regression analysis showed that serum creatinine ($p = 0.003$), GLR ($p = 0.029$), and SYNTAX score ($p < 0.001$) were independent predictors of cardiac mortality. **Conclusions**: GLR was significantly correlated with coronary artery lesion severity and can be used as an independent predictor of cardiac mortality in patients with UAP.

Keywords

Unstable angina pectoris (UAP); Fasting blood glucose to lymphocyte ratio (GLR); SYNTAX score; Cardiac mortality

1. Introduction

The unstable angina pectoris (UAP) as a subtype of acute coronary syndrome (ACS) has high morbidity and mortality rates. UAP patients have 38% higher mortality rate and a similar rate of major adverse cardiovascular events (MACE) compared to the stable angina pectoris (SAP) patients [1]. UAP and non-ST-segment elevation myocardial infarction (NSTEMI) are characterized as non-ST-segment elevation acute coronary syndrome (NSTE-ACS) with similar clinical manifestations and electrocardiogram (ECG) characteristics [2, 3]. NSTEMI is considered to have greater mortality risk than UAP, however UAP accounts for a large portion of NSTE-ACS and depicts higher mortality than SAP [4], even with the absence of elevated myocardial enzymes. Therefore, the prognosis of UAP patients cannot be undermined.

Current guidelines recommend the usage of TIMI (thrombosis in myocardial infarction) score, global registry of acute coronary events (GRACE) risk score, SYNTAX score, and the other prediction models for prognosing NST-ACS and ST-segment elevation myocardial infarction (STEMI), which are closely associated to coronary artery lesion severity [5]. Intermountain Risk Score (IMRS) estimates mortality risk by employing common objective laboratory predictors. Recent study reveals that the survived STEMI patients have higher IMRS score compared to those who did not survive. Moreover, the IMRS predictive value for short-term and long-term mortality rates is non-inferior to the TIMI and GRACE scores [6]. The Naples Score can predict adverse outcomes while STEMI patients have high SYNTAX score [7].

The coronary atherosclerosis mechanisms involve metabolic dysfunction and inflammatory progress [8–11]. Reports using GLR as a composite biomarker for metabolic and inflammatory indexes to predict the severity and clinical prognosis of coronary artery disease are nonexistent. This retrospective single-center study is conducted to correlate GLR levels with coronary artery lesion severity and cardiac mortality in UAP patients. The outcomes can guide regarding the clinical prognosis and treatment.

2. Materials and methods

2.1 Study design and population

This single-center retrospective study included 4573 UAP patients hospitalized in the cardiovascular center of Beijing Friendship Hospital between December 2012 to December 2018. The follow-up ended on 31 December 2020. The patients' data were collected, reviewed, and double-checked by investigators of China Beijing Friendship Hospital Database Study Group.

2.1.1 Inclusion criteria

(1) Patients who were diagnosed with UAP during hospitalization and underwent coronary angiography (CAG); (2) patients 18–90 years old; (3) patients meeting the diagnostic criteria for the diagnosis and treatment of NSTE-ACS in the guidelines issued by the Chinese Medical Association in 2016, including a presentation with typical symptoms, such as long-term resting angina pectoris, new-onset angina pectoris, manifestation as spontaneous angina pectoris or exertional angina pectoris, worsening symptoms of SAP in the last month (worsening angina pectoris), and angina pectoris occurring within 1 month after myocardial infarction; ECG findings not limited to characteristic ECG changes, including T-wave changes, ST-segment depression, and transient ST-segment elevation; no increase or decrease of creatine kinase myocardial band (CK-MB) or high sensitivity cardiac troponin I (hs-TnI); and (4) patients undergoing CAG showing at least one major coronary artery stenosis $\geq$50%, using a visual method combined with quantitative coronary angiography.

2.1.2 Exclusion criteria

(1) Patients with previous coronary artery bypass grafting (CABG), percutaneous coronary intervention (PCI), or cardiac insufficiencies such as decompensated heart failure or cardiomyopathy; (2) patients having infection, malignant tumors, liver and kidney dysfunction, or autoimmune diseases; and (3) patients with no clinical or follow-up data.

2.2 Clinical data and laboratory analysis

Necessary clinical data were collected at the time of patients getting admitted. Medical records were retrospectively consulted to extract valid information including age, sex, systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR). Furthermore, records were searched for the history of stroke, diabetes mellitus, hypertension, dyslipidemia, previous PCI or CABG, dilated cardiomyopathy, decompensated heart failure, active infection, severe trauma, chronic obstructive pulmonary disease (COPD), blood system diseases, liver and kidney dysfunction, inflammatory and immune diseases, malignant tumors or pregnancy. The body mass index (BMI) was calculated as body weight (kg) divided by height squared (m^2).

The fasting blood sample was collected on the morning after admission. Data were extracted pertaining to the levels of hemoglobin, platelets, lymphocytes, neutrophils, fasting blood glucose, total cholesterol (TC), total triglyceride (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and serum creatinine. The other relevant laboratory data were also gathered from fasting blood sample. GLR was calculated as fasting blood glucose (mmol/L) divided by lymphocyte count (10^9/L). Guidelines indicated that the basic medical treatment for UAP included antiplatelet medication, beta-blockers, statins, and nitrates.

2.3 Calculation of SYNTAX score

CAG was conducted by following the standard operating procedures as recommended in the guidelines. CAG imaging data were collected from patients' medical records. The data regarding severity (percentage of coronary occlusion) and the number (single or multiple vessels) of involved coronary arteries were recorded.

SYNTAX score was utilized to assess the severity of coronary artery atherosclerotic lesions. Two cardiovascular experts calculated the patients' SYNTAX scores by applying online tools (http://www.syntaxscore.com) [12]. The cardiologists were blinded throughout the evaluation process regarding patients' clinical and laboratory data. Coronary artery lesions having stenosis $\geq$50% and vessel diameter $\geq$1.5 mm were included in the score. Senior cardiologist made final evaluation upon the differences found in evaluation of CAG results by the two cardiologists.

2.4 Follow-up and clinical endpoints

The patients necessarily had to participate in clinical follow-up in 1st, 3rd and 6th months of enrollment. The follow-up continued at the 1st, 2nd, 3rd and 5th years of discharge. They were followed up with earlier in case of any related symptoms. All kinds of follow-ups ended on 31 December 2020. The follow-up data were collected through hospital medical records, outpatient records, and telephonic interviews. In each follow-up, the medical treatment, occurrence, frequency of related symptoms, adverse events, rehospitalization, and death cause were recorded. This study had the primary endpoint of cardiac death, and secondary endpoint of all-cause death and rehospitalization.

Cardiac death was caused by cardiac events such as acute myocardial infarction, congestive heart failure, cardiac arrest, malignant arrhythmia, and death from unknown cause. All-cause death was from causes other than cardiac events. Rehospitalization referred to the unplanned hospitalization because of the same or related diseases such as NSTE-ACS, STEMI, arrhythmia, cardiac arrest, and heart failure.

2.5 Statistical analysis

Kolmogorov-Smirnov test was employed to determine the normal distribution of continuous variables, and the continuous variables conforming to normal distribution were expressed as mean $\pm$ standard deviation. A *t*-test was utilized for the inter-group comparison. Continuous variables having non-normal distribution were expressed as median and interquartile range. Mann-Whitney U nonparametric test analyzed the differences between groups. Categorical variables were expressed as quantity and percentage, and chi-square test was employed for the inter-group comparison. Spearman's correlation analysis

evaluated the correlation between GLR and SYNTAX score. The univariate and multivariate Cox proportional hazards models determined the independent factors associated with cardiac death. The hazard ratio (HR) was expressed by 95% confidence interval (CI), and the prediction effectiveness by HR and the corresponding 95% CI. The receiver operating characteristic curve (ROC) evaluated the GLR accuracy in predicting cardiac mortality and determined its critical value. A Kaplan-Meier survival curve was drawn to evaluate the GLR prognostic value. Statistical analyses were conducted via SPSS (Version 25.0, IBM Corp, Armonk, NY, USA), where $p < 0.05$ was considered statistically significant.

3. Results

3.1 Characteristics of the low GLR and high GLR groups

A total of 4110 patients (2507 males and 1603 females; 29–90 years old) were included in the study based on inclusion and exclusion criteria. Patients were classified into low GLR group (GLR <3.38, n = 2061) and high GLR group (GLR ≥3.38, n = 2049), according to median GLR. Baseline clinical data, laboratory assays, and CAG findings were given in Table 1. The patients in high GLR group were younger compared to low GLR group. Moreover, high GLR group had higher proportion of men, higher HR levels, histories of hypertension, diabetes mellitus and stroke, higher levels of serum creatinine, neutrophil count, fasting blood glucose, multi-vessel disease and SYNTAX score, while lower levels of hemoglobin, platelets, lymphocyte count, and LDL-C.

3.2 Correlation between GLR and SYNTAX score

Spearman's correlation analysis exhibited correlation between GLR levels and coronary artery lesion severity (indicated as SYNTAX score, $p < 0.001$, Table 2). Wilcoxon two-sample rank sum test revealed that the SYNTAX score in high GLR group was higher than in low GLR group ($Z = 5.63$, $p < 0.001$, Table 3).

3.3 Correlation between GLR and Clinical Outcome

In the follow-up period, 865 patients (21.0%) were re-hospitalized, and 103 patients (2.5%) died, including the cardiac deaths in 39 patients (0.9%). Cardiac mortality (1.37% *vs.* 0.53%, $p = 0.006$) and rehospitalization rate (22.89% *vs.* 19.21%, $p = 0.004$) were greater in high GLR group compared to the low GLR group. All-cause mortality was higher in high GLR group than in low GLR group (2.83% *vs.* 2.18%), however the trend was not statistically significant ($p = 0.184$). Furthermore, there was no significant difference in the follow-up duration between the low GLR group (36 months) and high GLR group (36 months, $p = 0.715$, Table 4).

Kaplan-Meier survival curve analysis revealed that the patients of high GLR group had higher cardiac mortality ($p = 0.005$, Fig. 1). Receiver operating characteristic curve (ROC) analysis exhibited that GLR ≥2.9861 had 87.2% sensitivity and 36.8% specificity in predicting the cardiac mortality (area under the curve: 0.650, $p = 0.001$, Fig. 2). A GLR of 2.9861 was thus the best cutoff point to predict the cardiac mortality in UAP cohort.

Independent risk factors of cardiac mortality in UAP patients were determined by Cox regression analysis, wherein the statistically significant predictors were diabetes ($p = 0.008$), fasting blood glucose ($p = 0.015$), serum creatinine ($p < 0.001$), hemoglobin ($p = 0.012$), lymphocyte ($p = 0.006$), GLR ($p < 0.001$), and SYNTAX score ($p < 0.001$). These statistical or clinical indicators were included in the multivariate Cox regression analysis demonstrating that serum creatinine ($p = 0.003$), GLR ($p = 0.029$), and SYNTAX score ($p < 0.001$) were the independent risk factors for predicting cardiac mortality (Table 5).

4. Discussion

The studies have established that GLR correlates with the prognosis of hepatocellular carcinoma, pancreatic cancer, pancreatitis, gallbladder cancer, lung cancer, AECOPD, and acute respiratory distress syndrome [13–19]. However, the correlations of GLR with coronary artery lesion severity and cardiac mortality have not been reported. This study elaborates that the GLR assessed at the time of hospital admission correlates with coronary artery lesion severity and is an independent predictor of long-term cardiac mortality in UAP patients.

Other studies have revealed that the SYNTAX score, GENSINI score, and the three-vessel disease prevalence are higher in those with non-normal fasting blood glucose levels compared to the patients with normal fasting blood glucose levels among coronary heart disease patients [20]. Impaired fasting blood glucose leads to the increased triple coronary artery stenosis and acute myocardial infarction [21]. In addition, the hyperglycemia leads to more diffuse and severe coronary atherosclerosis and calcification [22]. Moreover, the extent of elevated blood glucose levels independently correlate with the cardiovascular events, rapid progression, and luminal narrowing progression in all non-culprit lesions [23]. The higher fasting blood glucose also causes vascular endothelial cell dysfunction including the barrier function, vascular regulation function, anti-thrombotic function, and anti-inflammatory function. The increased fasting blood glucose acts on endothelial cells to cause the release of pro-inflammatory cytokines, an increase of adhesion molecules, and the formation of pro-thrombotic state [24, 25]. The increase in fasting blood glucose is thus closely associated to the coronary artery lesion severity.

Studies have demonstrated that certain inflammatory cells and biochemical markers can predict the adverse clinical outcomes in ACS patients [26]. These indicators indirectly affect the clinical outcomes of ACS patients by indicating the body's inflammatory response, nutritional status, or vascular injury [27]. Immune cells have both pro-inflammatory and anti-inflammatory roles in plaque formation. Interferon γ (IFN γ) from = T-helper 1 lymphocytes activates mononuclear phagocytes to promote inflammation. Contrarily, T-helper 2 lymphocytes secrete Transforming Growth Factor-β (TGF-β), Interleukin-10 (IL-10), and other cytokines to play anti-

TABLE 1. Baseline clinical data of GLR-stratified groups.

Variables, units	Low GLR (<3.38) n = 2061	High GLR (≥3.38) n = 2049	*p* Value
Age, years	64 (59, 72)	63 (58, 71)	0.006
Gender, male (%)	1205, 58.47%	1302, 63.54%	0.001
BMI, kg/m^2	25.89 ± 3.63	26.03 ± 3.43	0.198
SBP, mmHg	130 (120, 140)	130 (120, 140)	0.766
DBP, mmHg	76 (70, 80)	78 (70, 81)	0.192
Heart rate, bpm	68 (62,75)	70 (63, 77)	<0.001
Hypertension, %	1429, 69.34%	1544, 75.35%	<0.001
Diabetes, %	478, 23.19%	1022, 49.88%	<0.001
Dyslipidemia, %	952, 46.19%	942, 45.97%	0.889
Stroke, %	285, 13.83%	362, 17.67%	0.001
Serum creatinine, μmol/L	80.38 ± 36.18	84.28 ± 48.53	0.004
Hemoglobin, g/L	137.24 ± 14.66	133.49 ± 15.35	<0.001
Platelet, $\times10^9$/L	230.34 ± 58.79	209.48 ± 57.12	<0.001
Lymphocyte, $\times10^9$/L	2.07 ± 0.52	1.38 ± 0.39	<0.001
Neutrophil, $\times10^9$/L	3.27 ± 1.37	4.04 ± 1.29	<0.001
Fasting blood glucose, mmol/L	5.0 (4.6, 5.5)	6.0 (5.1, 7.6)	<0.001
TG, mmol/L	1.37 (1.01, 1.88)	1.34 (0.97, 1.90)	0.171
TC, mmol/L	4.16 (3.53, 4.85)	4.11 (3.48, 4.81)	0.084
HDL-C, mmol/L	1.10 (0.95, 1.29)	1.09 (0.94, 1.30)	0.581
LDL-C, mmol/L	2.33 (1.85, 2.84)	2.27 (1.80, 2.77)	0.015
GLR, %	2.64 (2.25, 3.02)	4.50 (3.85, 5.65)	<0.001
Multi-vessel Diseases, %	1599, 77.58%	1698, 82.87%	<0.001
SYNTAX score	15.0 (9.0, 22.0)	16.0 (10.0, 25.0)	<0.001
Treatment, PCI or PTCA (%) (PCI/PCI + PTCA), %	1998, 96.9%	1994, 97.3%	0.359

Abbreviations: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglyceride; TC, total cholesterol; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; GLR, glucose to lymphocyte ratio; PCI, percutaneous coronary intervention; PTCA, percutaneous transluminal coronary angioplasty.

TABLE 2. Spearman correlation coefficient matrix of GLR and SYNTAX score.

GLR	Spearman's coefficient	*p* Value
SYNTAX score	0.105**	<0.001

***Correlation is significant at the 0.01 level (2-tailed). $p < 0.001$.*
Abbreviations: GLR, Glucose to lymphocyte ratio.

TABLE 3. Wilcoxon two-sample rank sum test of GLR rating and SYNTAX score.

Groups	SYNTAX score M (P25, P75)	Wilcoxon two sample rank sum test	
		Z Value	*p* Value
Low GLR group	15.0 (9.0, 22.0)	5.63	<0.001
High GLR group	16.0 (10.0, 25.0)		

Abbreviations: GLR, Glucose to lymphocyte ratio.

TABLE 4. Clinical outcomes of GLR-stratified groups.

Variables, units	Low GLR (<3.38) n = 2061	High GLR (≥3.38) n = 2049	*p* Value
Cardiac mortality, %	11, 0.53%	28, 1.37%	0.006
All-cause mortality, %	45, 2.18%	58, 2.83%	0.184
Rehospitalization rate, %	396, 19.21%	469, 22.89%	0.004
Follow-up time, months	36 (17, 48)	36 (24, 48)	0.715

GLR, Glucose to lymphocyte ratio.

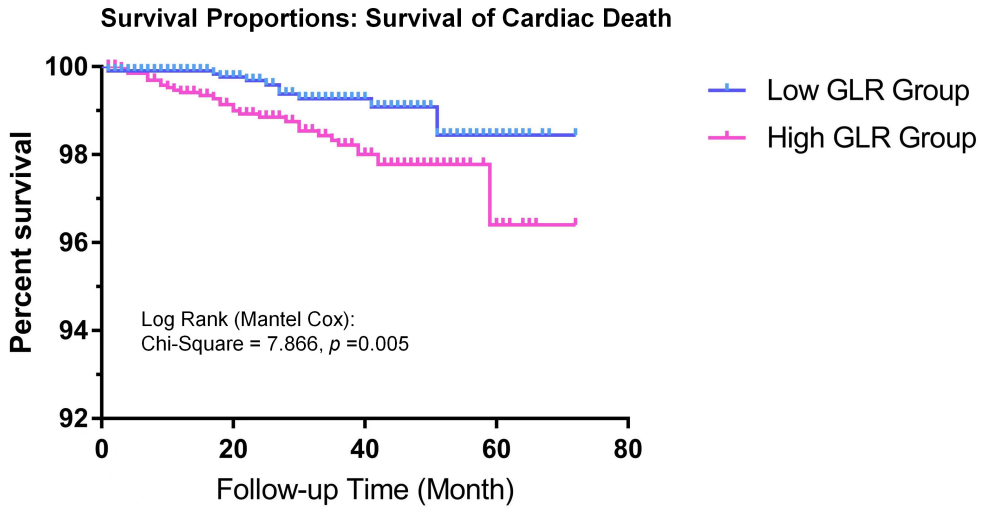

FIGURE 1. Kaplan-Meier survival curves for cardiac death comparing low and high GLR groups. GLR, Glucose to lymphocyte ratio.

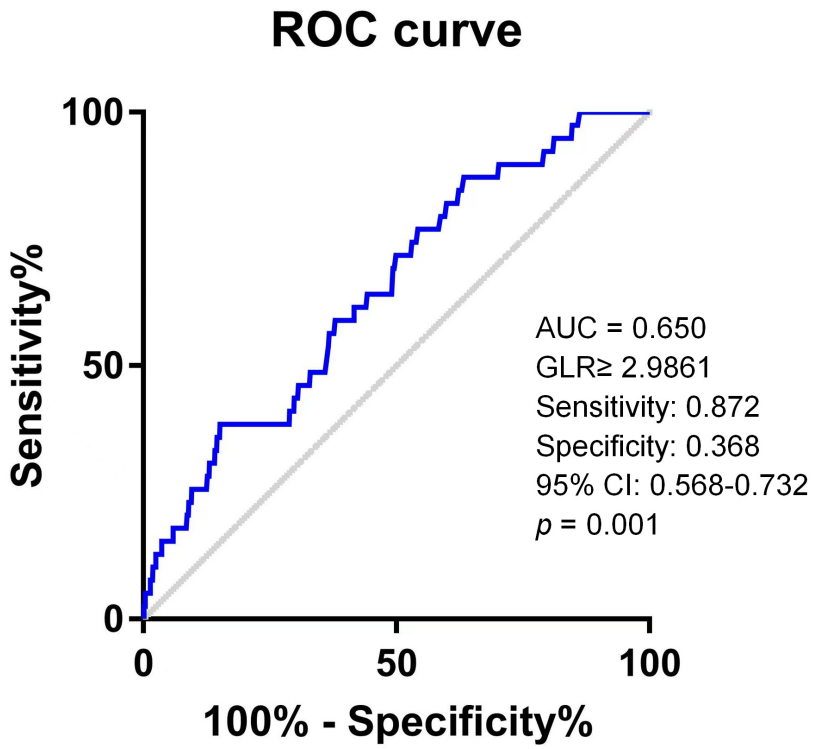

FIGURE 2. Receiver operating characteristic curve (ROC) of GLR. GLR, Glucose to lymphocyte ratio; CI, confidence interval; AUC, Area Under the Curve.

TABLE 5. Univariate and Multiple Cox regression analysis of the factors predicting cardiac mortality in patients with UAP.

Variables	Univariate Cox regression analysis			Multiple Cox regression analysis		
	HRs	95% CIs	*p* Value	HRs	95% CIs	*p* Value
Age	1.785	0.990–1.057	0.181			
Gender	1.376	0.337–1.314	0.241			
BMI	1.394	0.965–1.153	0.238			
Heart rate	1.013	0.989–1.039	0.274			
Hypertension	0.945	0.676–3.199	0.331			
Diabetes	2.345	1.245–4.416	0.008	1.589	0.818–3.085	0.172
Stroke	1.835	0.794–3.526	0.176			
Serum creatinine	14.245	1.002–1.006	<0.001	1.003	1.001–1.005	0.003
Hemoglobin	0.974	0.954–0.994	0.012	0.983	0.963–1.003	0.097
Neutrophil	3.497	0.991–1.454	0.061			
Lymphocyte	0.389	0.199–0.762	0.006			
Monocyte	0.906	0.078–10.587	0.937			
Platelet	0.065	0.994–1.005	0.799			
TC	0.079	0.769–1.419	0.779			
TG	0.176	0.668–1.229	0.675			
HDL-C	0.000	0.326–3.140	0.984			
LDL-C	0.083	0.702–1.608	0.773			
GLR	19.188	1.096–1.272	<0.001	1.101	1.010–1.200	0.029
SYNTAX score	25.300	1.040–1.094	<0.001	1.056	1.028–1.084	<0.001

Abbreviations: BMI, body mass index; TG, triglyceride; TC, total cholesterol; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; GLR, glucose to lymphocyte ratio; HR: heart rate; CI: confidence interval.

inflammatory role. B1 lymphocytes also produce certain antibodies to have anti-atherosclerotic role [28]. Studies on optical coherence imaging (OCT) depict that Cluster of Differentiation 8 (CD 8) T lymphocytes protect atherosclerotic plaque from rupture and erosion, however patients with cardiovascular events have low number of lymphocytes [29]. Studies have included lymphocytes in their scope as they affect the coronary artery lesions severity through inflammatory factors and immune responses.

A single parameter reliability is low since it reflects part of the body's condition. Composite parameters are thus suitable to illustrate the comprehensive state of inflammation and metabolism in the body. Indicators like fasting blood glucose and lymphocytes can conveniently be obtained in clinical practice. Fasting blood glucose indicates the body metabolism while lymphocytes reflect on the inflammatory reaction. This study shows for the first time that combination of the two can be employed as novel risk indicator of cardiac death in UAP patients. GLR on one hand is related to the damage of vascular endothelial function caused by elevated blood glucose which leads to the coronary atherosclerosis aggravation, while on other hand GLR reduces lymphocyte count and weakens anti-inflammatory and anti-atherosclerosis effects. Although a few studies investigated the relationship between the prognosis and GLR [30], the reasons for exacerbation of coronary artery disease and increase in cardiac mortality caused by GLR might become much clear through further studies. GLR can be conveniently obtained in underdeveloped areas and those with insufficient medical technology support, and employed as an indicator of risk stratification in UAP patients.

The multiple Cox regression analysis in this study suggests that serum creatinine is also an independent predictor of cardiac death. Studies show an increase in IL-6 and major cardiovascular adverse events in chronic coronary syndrome and chronic kidney disease patients, suggesting that serum creatinine may affect cardiovascular events by exacerbating inflammation levels [31].

Artificial intelligence (AI) and machine learning (ML) in the recent years have made contributions to the biomedicine development. One can establish a digital health biomarker for quantifying the atherosclerosis severity, prognosing the coronary artery disease and identifying the underdiagnosed individuals by electronic health record-based AI and ML [32]. Studies have confirmed that miRNA levels improve the ACS diagnosis by applying an *in silico* neural network [33]. However, research lacks regarding AI, ML and GLR.

In this study, above 4000 UAP patients are included with the follow-up of over 3 years. The results herein demonstrate a correlation between GLR levels and SYNTAX scores, with serious coronary artery lesions in the high GLR group. Furthermore, GLR is associated with cardiac mortality and rehospitalization rates, and is an independent predictor of car-

diac mortality in UAP patients. This research is the first to demonstrate a correlation between GLR levels and coronary artery lesion severity and cardiac mortality in UAP patients.

5. Limitations

Some limitations exist in this study. First, GLR has the advantage of objectivity and ease of acquisition in clinical practice, however, the prognosis of UAP patients is affected by the factors such as advanced age, diabetes, renal dysfunction, and SYNTAX score. More key variables can thus be included in a risk model to enhance the accuracy of its prediction ability. Second, the prognostic value of single fasting blood glucose, lymphocytes, and GLR measurement may be limited and thus their repeated obtained levels can add value to the prognosis. This will be validated in future research. Third, the predictive value of GLR in UA, NSTEMI or STEMI patients is not compared because of the limitation of current data. Additional studies are thus necessary for further investigations.

6. Conclusions

GLR is a composite biomarker integrating the metabolic and inflammatory indicators. This study on large sample of UAP patients depicts that GLR is correlated with coronary artery lesion severity (indicated as SYNTAX score). SYNTAX score, cardiac mortality, and rehospitalization rates in the high GLR group are higher than in low GLR group. Furthermore, GLR is an independent predictor of cardiac mortality in UAP patients. Further work is necessary to discover and explain the action mechanism of GLR's influence on coronary artery disease and its prognostic significance.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

WCL and HHC—designed the research study. WCL and SBL—performed the research; wrote the manuscript. HHC—analyzed the data. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Study was conducted according to the Helsinki Declaration (as revised in 2013). The study was approved by the Ethical Committee of Beijing Friendship Hospital and individual consent for this retrospective analysis was waived (No. 2017-P2-013-01).

ACKNOWLEDGMENT

Not applicable.

FUNDING

This work was supported by the National Key R&D Program of China (Grant No. 2021ZD0111000), Beijing Key Clinical Subject Program and Baoding Science and Technology Plan Project (Grant No. 2341ZF105).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Fladseth K, Wilsgaard T, Lindekleiv H, Kristensen A, Mannsverk J, Løchen ML, *et al*. Outcomes after coronary angiography for unstable angina compared to stable angina, myocardial infarction and an asymptomatic general population. International Journal of Cardiology. Heart & Vasculature. 2022; 42: 101099.

[2] Collet JP, Thiele H, Barbato E, Barthélémy O, Bauersachs J, Bhatt DL, *et al*. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. European Heart Journal. 2021; 42: 1289–1367.

[3] Keykhaei M, Ashraf H, Rashedi S, Farrokhpour H, Heidari B, Zokaei S, *et al*. Differences in the 2020 ESC versus 2015 ESC and 2014 ACC/AHA guidelines on the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. Current Atherosclerosis Reports. 2021; 23: 77.

[4] Piątek Ł, Janion-Sadowska A, Piątek K, Zandecki Ł, Zabojszcz M, Siudak Z, *et al*. Long-term clinical outcomes in patients with unstable angina undergoing percutaneous coronary interventions in a contemporary registry data from Poland. Coronary Artery Disease. 2020; 31: 215–221.

[5] Hammami R, Jdidi J, Mroua F, Kallel R, Hentati M, Abid L, *et al*. Accuracy of the TIMI and GRACE scores in predicting coronary disease in patients with non-ST-elevation acute coronary syndrome. Revista Portuguesa De Cardiologia. 2018; 37: 41–49.

[6] Çınar T, Şaylık F, Akbulut T, Korkmaz Y, Çiçek V, Asal S, *et al*. Evaluation of intermountain risk score for short- and long-term mortality in ST elevation myocardial infarction patients. Angiology. 2023; 74: 357–364.

[7] Oner E, Kahraman S, Agus HZ, Guner A, Dogan AC, Yildiz MM, *et al*. Naples score is associated with SYNTAX Score in patients with ST-segment elevation myocardial infarction. Coronary Artery Disease. 2023; 34: 504–509.

[8] Medina-Leyte DJ, Zepeda-García O, Domínguez-Pérez M, González-Garrido A, Villarreal-Molina T, Jacobo-Albavera L, *et al*. Endothelial dysfunction, inflammation and coronary artery disease: potential biomarkers and promising therapeutical approaches. International Journal of Molecular Sciences. 2021; 22: 3850.

[9] Libby P, Pasterkamp G, Crea F, Jang I. Reassessing the mechanisms of acute coronary syndromes. Circulation Research. 2019; 124: 150–160.

[10] Xia J, Yin C. Glucose variability and coronary artery disease. Heart, Lung and Circulation. 2019; 28: 553–559.

[11] Feng W, Li Z, Guo W, Fan X, Zhou F, Zhang K, *et al*. Association between fasting glucose variability in young adulthood and the progression of coronary artery calcification in middle age. Diabetes Care. 2020; 43: 2574–2580.

[12] Sotomi Y, Collet C, Cavalcante R, Morel M, Suwannasom P, Farooq V, *et al*. Tools and techniques-clinical: SYNTAX score II calculator. EuroIntervention. 2016; 12: 120–123.

[13] Yılmaz A, Şimşek M, Hannarici Z, Büyükbayram ME, Bilici M, Tekin SB. The importance of the glucose-to-lymphocyte ratio in patients with hepatocellular carcinoma treated with sorafenib. Future Oncology. 2021; 17: 4545–4559.

[14] Zhang Y, Xu Y, Wang D, Kuang T, Wu W, Xu X, *et al*. Prognostic value of preoperative glucose to lymphocyte ratio in patients with resected pancreatic cancer. International Journal of Clinical Oncology. 2021; 26: 135–144.

[15] Chen Y, Tang S, Wang Y. Prognostic value of glucose-to-lymphocyte ratio

in critically ill patients with acute pancreatitis. International Journal of General Medicine. 2021; 14: 5449–5460.
[16] Navarro J, Kang I, Hwang HK, Yoon DS, Lee WJ, Kang CM. Glucose to lymphocyte ratio as a prognostic marker in patients with resected pT2 gallbladder cancer. Journal of Surgical Research. 2019; 240: 17–29.
[17] Hu T, Liu X, Liu Y. Usefulness of glucose to lymphocyte ratio to predict in-hospital mortality in patients with AECOPD admitted to the intensive care unit. COPD: Journal of Chronic Obstructive Pulmonary Disease. 2022; 19: 158–165.
[18] Zhang Y, Zhang S. Prognostic value of glucose-to-lymphocyte ratio in critically ill patients with acute respiratory distress syndrome: a retrospective cohort study. Journal of Clinical Laboratory Analysis. 2022; 36: e24397.
[19] Yang M, Zhang Q, Ge YZ, Tang M, Hu CL, Wang ZW, *et al*. Prognostic roles of glucose to lymphocyte ratio and modified glasgow prognosis score in patients with non-small cell lung cancer. Frontiers in Nutrition. 2022; 9: 871301.
[20] Yang J, Zhou YJ, Zhang TY, Lin X, Ma X, Wang Z, *et al*. Fasting blood glucose and HBA_{1c} correlate with severity of coronary artery disease in elective PCI patients with HbA_{1c} 5.7% to 6.4. Angiology. 2020; 71: 167–174.
[21] Chen C, Chen YQ, Xiao JX, Zhang Y, Yang Z, Yang P, *et al*. Association of impaired fasting blood glucose with triple coronary artery stenosis and myocardial infarction among patients with coronary artery stenosis. Frontiers in Cell and Developmental Biology. 2022; 10: 820124.
[22] Naito R, Miyauchi K. Coronary artery disease and type 2 diabetes mellitus. International Heart Journal. 2017; 58: 475–480.
[23] Yamamoto H, Shinke T, Otake H, Kawamori H, Toba T, Kuroda M, *et al*. Impact of daily glucose fluctuations on cardiovascular outcomes after percutaneous coronary intervention for patients with stable coronary artery disease undergoing lipid-lowering therapy. Journal of Diabetes Investigation. 2021; 12: 1015–1024.
[24] Janjusevic M, Fluca AL, Gagno G, Pierri A, Padoan L, Sorrentino A, *et al*. Old and novel therapeutic approaches in the management of hyperglycemia, an important risk factor for atherosclerosis. International Journal of Molecular Sciences. 2022; 23: 2336.
[25] Alexander Y, Osto E, Schmidt-Trucksäss A, Shechter M, Trifunovic D, Duncker DJ, *et al*. Endothelial function in cardiovascular medicine: a consensus paper of the European society of cardiology working groups on atherosclerosis and vascular biology, aorta and peripheral vascular diseases, coronary pathophysiology and microcirculation, and thrombosis. Cardiovascular Research. 2021; 117: 29–42.
[26] Li S, Chen H, Zhou L, Cui H, Liang S, Li H. Neutrophil-to-lymphocyte ratio predicts coronary artery lesion severity and long-term cardiovascular mortality in patients with unstable angina pectoris. Acta Cardiologica. 2022; 77: 708–715.
[27] Saito Y, Tanaka A, Node K, Kobayashi Y. Uric acid and cardiovascular disease: a clinical review. Journal of Cardiology. 2021; 78: 51–57.
[28] Peter Libby. Inflammation during the life cycle of the atherosclerotic plaque. Cardiovascular Research. 2021; 117: 2525–2536.
[29] Leistner DM, Kränkel N, Meteva D, Abdelwahed YS, Seppelt C, Stähli BE, *et al*. Differential immunological signature at the culprit site distinguishes acute coronary syndrome with intact from acute coronary syndrome with ruptured fibrous cap: results from the prospective translational OPTICO-ACS study. European Heart Journal. 2020; 41: 3549–3560.
[30] Liu J, Hu X. Association between glucose-to-lymphocyte ratio and in-hospital mortality in acute myocardial infarction patients. PLOS ONE. 2023; 18: e0295602.
[31] Batra G, Ghukasyan Lakic T, Lindbäck J, Held C, White HD, Stewart RAH, *et al*. Interleukin 6 and cardiovascular outcomes in patients with chronic kidney disease and chronic coronary syndrome. JAMA Cardiology. 2021; 6: 1440–1445.
[32] Forrest IS, Petrazzini BO, Duffy Á, Park JK, Marquez-Luna C, Jordan DM, *et al*. Machine learning-based marker for coronary artery disease: derivation and validation in two longitudinal cohorts. The Lancet. 2023; 401: 215–225.
[33] Kayvanpour E, Gi W, Sedaghat-Hamedani F, Lehmann DH, Frese KS, Haas J, *et al*. MicroRNA neural networks improve diagnosis of acute coronary syndrome (ACS). Journal of Molecular and Cellular Cardiology. 2021; 151: 155–162.

How to cite this article: Weichao Liu, Shunbao Li, Hehe Cui. Fasting blood glucose to lymphocyte ratio predicting the long-term cardiac mortality in unstable angina pectoris patients. Signa Vitae. 2025; 21(1): 52-59. doi: 10.22514/sv.2025.007.