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ARTICLE

Evaluation of the Association of the Total Cholesterol-to-High-Density Lipoprotein Cholesterol Ratio and Triglyceride-Glucose Index With Coronary Artery Disease and Their Diagnostic Utility

Na Qu[1], Qian Li[1], Xin Bai[1], Ruixiao Wang[2,*]

[1]Department of Internal Medicine, Ningxia People's Armed Police Corps Hospital, Yinchuan, Ningxia Hui Autonomous Region, China
[2]Department of Pathology, General Hospital of Ningxia Medical University, Yinchuan, Ningxia Hui Autonomous Region, China
*Correspondence: docwang1715@163.com (Ruixiao Wang)

Abstract

Aims/Background This study aimed to examine the relationship between coronary heart disease (CHD) severity, the triglyceride-glucose (TyG) index, and the total cholesterol to high-density lipoprotein cholesterol (TC/HDL-C) ratio while also assessing their diagnostic significance. A deeper understanding of the pathophysiology of CHD enables early detection, more precise screening of high-risk groups, and the development of more targeted treatment plans.
Methods A total of 196 patients with suspected acute coronary syndrome (ACS) were included in this retrospective study, of whom 134 were diagnosed with CHD. Clinical, laboratory and coronary angiography (CAG) data were collected. CHD patients were classified into low-, medium-, and high-risk groups according to their Synergy Between Percutaneous Coronary Intervention (PCI) with Taxus and Cardiac Surgery (SYNTAX) scores. The correlations and clinical relevance of the TyG index and TC/HDL-C ratio were further examined by stratifying patients into single-, dual-, and multi-vessel groups according to the number of lesions. A *p*-value < 0.05 was considered statistically significant.
Results Relative to non-CHD patients, CHD patients were significantly older and exhibited higher levels of TC, Triglycerides (TG), TyG index, and TC/HDL-C ratio ($p < 0.05$). Both the TyG index and TC/HDL-C ratio were independently associated with the risk of coronary atherosclerosis in univariate and multivariate logistic regression analyses ($p < 0.05$). The multi-vessel disease group had significantly higher TyG index and TC/HDL-C ratio values compared to the single- and dual-vessel groups ($p < 0.05$). Additionally, SYNTAX scores showed a significantly positive correlation with both indices ($p < 0.05$). The area under the curve (AUC) values for the TC/HDL-C ratio and TyG index were 0.918 and 0.893, respectively, both significantly greater than 0.5 ($p < 0.05$).
Conclusion The TC/HDL-C ratio and TyG index are associated with the risk of CHD, with their values rising as coronary artery disease severity progresses. These indices may serve as valuable tools for predicting clinical severity in patients with coronary artery lesions.

Key words: coronary disease; cholesterol; HDL; triglycerides; blood glucose; severity of illness index

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Introduction

Atherosclerotic coronary heart disease (CHD) poses a significant threat to global public health (Khan et al, 2020). In China, approximately 11.39 million individuals are affected by CHD, and the disease contributes to roughly 7 million deaths worldwide, with morbidity and mortality rates continuing to rise (Center for Cardiovascular Diseases, 2024). The etiological basis for CHD is complex and interconnected, primarily driven by the deposition of cholesterol and lipoprotein plaques within the walls of blood vessels (Mortensen et al, 2022). This pathological process can lead to stenosis of the coronary lumen, endothelial dysfunction, platelet activation-induced thrombosis, coronary spasms, and myocardial ischemia, hypoxia, and/or necrosis, all of which contribute to cardiac dysfunction. Although numerous risk factors have been associated with CHD, the relationship between the triglyceride-glucose (TyG) index, the total cholesterol to high-density lipoprotein cholesterol (TC/HDL-C) ratio, and CHD diagnosis remains unclear. Insulin resistance (IR) is well established as a key atherosclerosis-related risk factor that contributes to endothelial dysfunction in the arteries, abnormal glycolipid metabolism, and the consequent development and progression of cardiovascular disease (Kosmas et al, 2023). The TyG index has been extensively validated as a biomarker for IR (Simental-Mendía et al, 2008), reflecting insulin resistance status and serving as an important tool for the early detection of metabolic abnormalities crucial for CHD prevention and intervention. Similarly, the TC/HDL-C ratio is remarkably linked to CHD onset and progression, providing valuable insights into the extent of atherosclerosis and the general state of lipid metabolism (Chen et al, 2020). Compared to HDL-C or total cholesterol alone, this ratio enables physicians to assist in more accurate cardiovascular risk assessment, facilitating timely intervention and appropriate treatment.

However, further research is needed to clarify the clinical utility of these indices in CHD. This study aimed to explore the relationships between CHD, the TyG index, and the TC/HDL-C ratio while examining their potential utility in assessing the severity of coronary artery disease and identifying high-risk populations. The findings from this study offer new insights into optimising the prediction of coronary atherosclerotic severity among CHD patients, lessening the overall impact of CHD on society.

Methods

Participant Selection

This study enrolled 196 patients with suspected acute coronary syndrome (ACS) who received medical care in the Cardiovascular Department of the Affiliated Hospital of Ningxia Medical University between June 2019 and June 2021 and underwent coronary angiography (CAG). All participants provided informed consent for the CAG examination, and their general clinical data, laboratory test results, and CAG findings were collected. CAG results were applied to divide the patients into the non-CHD group (n = 62) and the CHD group (n = 134). Only patients meeting the inclusion and exclusion criteria with sufficient medical records were retained for final analysis.

Inclusion criteria: (1) Age >18 years; (2) patients with chest tightness and pain consistent with the Guidelines for Rapid Emergency Diagnosis and Treatment of Acute Coronary Syndromes (2019) for ACS diagnosis; (3) patients who underwent

CAG with coronary indications for the first time; (4) patients with complete CAG results and complete clinical and biochemical test data.

Exclusion criteria: (1) A history of coronary balloon dilatation, Percutaneous Coronary Intervention (PCI), or coronary artery bypass grafting; (2) a history of autoimmune diseases or malignant tumors; (3) a history of hepatic failure or severe renal disease; (4) presence of cardiomyopathy, congenital heart disease, valvular heart disease, pulmonary heart disease, rheumatic heart disease, or severe heart failure; or (5) an allergy to contrast media.

Research Methods

(1) Initially, medical records of patients who underwent CAG between June 2019 and June 2021 were reviewed, and retrospective data were collected, including age, gender, ethnicity, history of diabetes, hypertension, hyperlipidemia, and smoking status.

(2) Laboratory examinations: All enrolled patients underwent laboratory testing using an automated biochemical analyser (Dirui Biochemical Immune Integrated Machine 8000, Dirui Industrial Co., Ltd., Changchun, China) and routine blood examination with an appropriate instrument (Xisen Mekon 550, Sysmex Corporation, Kobe, Japan). The analysed parameters included total cholesterol (TC), serum triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), uric acid (UA), fasting blood glucose (FBG), and other relevant biochemical markers. All laboratory tests were conducted by certified medical laboratory technologists.

(3) CAG: CAG was performed using a Siemens Digital Subtraction Angiography (DSA) system, employing the Judkins technique with radial or femoral artery access to inspect the left and right coronary arteries. As required by the formal method, all procedures were conducted and evaluated by at least two skilled clinical interventional physicians.

(4) Evaluation criteria: Vascular lesions were used to classify patients as having single-, dual-, or multi-vessel disease. A stenosis rate of $\geq$50% was considered positive for the coronary artery (left anterior descending branch, left circumflex branch, right coronary artery) and its first-order branches (diagonal branch, obtuse marginal branch, posterior descending branch, posterior lateral branch, etc.). The TyG index was calculated with the following formula:

$$\text{TyG index } = \mathrm{Ln}[\mathrm{TG}(\mathrm{mg}/\mathrm{dL}) \times \mathrm{FBG}(\mathrm{mg}/\mathrm{dL})/2].$$

(5) Synergy Between Percutaneous Coronary Intervention (PCI) with Taxus and Cardiac Surgery (SYNTAX) scoring: The SYNTAX score was calculated using an online tool (http://www.syntaxscore.com), which divides the coronary artery into 16 segments and considers lesion characteristics such as length, location, calcification, severity, and bifurcation. SYNTAX scores were used to determine the complexity of coronary artery disease and guide the selection of surgical approaches in these patients.

Table 1. Clinical characteristics of CHD and non-CHD patients.

Variable	Non-CHD (n = 62)	CHD (n = 134)	$t/Z/\chi^2$	p-value
Age (years)	56.19 ± 10.62	59.98 ± 9.07	–2.571	0.011*
Gender (male)	25 (40.32%)	78 (58.21%)	5.438	0.020*
Nationality (Han)	47 (75.81%)	98 (73.13%)	0.157	0.692
Smoking history (%)	27 (43.55%)	81 (60.45%)	4.893	0.027*
Drinking history (%)	49 (79.03%)	98 (73.13%)	0.786	0.375
History of hypertension (%)	31 (50.00%)	49 (36.57%)	3.166	0.075
History of diabetes (%)	18 (29.03%)	106 (79.10%)	45.731	<0.000*
History of cerebral infarction (%)	57 (91.94%)	126 (94.03%)	0.057	0.811
TC (mmol/L)	3.28 (2.80, 4.00)	4.62 (3.90, 5.60)	–7.380	0.000*
TG (mmol/L)	1.46 (1.10, 2.20)	1.98 (1.30, 4.00)	–3.230	0.001*
LDL-C (mmol/L)	2.82 (2.50, 3.40)	3.00 (2.30, 3.70)	–0.230	0.818
HDL-C (mmol/L)	1.16 (1.00, 1.40)	1.07 (0.90, 1.20)	–2.745	0.006*
FBG (mmol/L)	5.05 (4.70, 5.60)	5.31 (4.80, 6.10)	–1.573	0.116
UA (μmol/L)	311.85 ± 88.31	323.59 ± 95.66	–0.818	0.414
TyG index	8.79 (8.40, 9.20)	9.05 (8.60, 9.90)	–3.248	0.001*
TC/HDL-C ratio	2.86 (2.00, 3.90)	4.23 (3.40, 5.30)	–6.898	0.000*

Note: CHD, coronary heart disease; TC, total cholesterol; TG, Triglycerides; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; FBG, fasting blood glucose; UA, uric acid; TyG, triglyceride-glucose; TC/HDL-C ratio, total cholesterol-to-high-density lipoprotein cholesterol ratio. $*p < 0.05$ indicates statistical significance. Skewed data are presented as median (P25, P75), while normally distributed data are reported as mean ± standard deviation.

(6) CAG results were used to separate patients into three groups based on the extent of coronary artery involvement: single-vessel, dual-vessel, and multi-vessel. In the single-vessel group, the degree of stenosis of the anterior descending branch, circumflex branch, and right coronary artery was ≥50%, while in the dual-vessel group, patients exhibited two vessels with ≥50% degree of stenosis or left main disease with a stenosis degree of ≥50%. Patients in the multi-vessel group presented with ≥50% stenosis degree in three or more vessels or a stenosis degree of ≥50% in the left main artery and right main artery.

Statistical Analyses

The data obtained from this study were analysed using SPSS (Version 26.0, IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test was utilised to assess the normality of the data distribution. For continuous variables, normally distributed data were expressed as mean ± standard deviation and were analysed using an independent t-test or one-way analysis of variance (ANOVA). Non-normally distributed data were presented as median and interquartile range and analysed using the Mann-Whitney U test or the Kruskal-Wallis test. For categorical variables, when the expected frequency (T) ≥5 and sample size (n) ≥40, the Chi-square test was used; when $1 \leq T < 5$ and $n \geq 40$, the Chi-square test with Yates's continuity correction was used. Spearman's correlation analysis was used to analyse the correlation between each factor and CHD. Categorical variables were expressed as frequencies

Table 2. Spearman correlation coefficients between specific variables and CHD.

Variable	Coefficient of association	p-value
Age (years)	0.195	0.006*
TC (mmol/L)	0.529	0.000*
TG (mmol/L)	0.231	0.001*
LDL-C (mmol/L)	0.016	0.819
HDL-C (mmol/L)	–0.197	0.006*
FBG (mmol/L)	0.113	0.116
UA (µmol/L)	0.054	0.456
TyG index	0.233	0.001*
TC/HDL-C ratio	0.494	0.000*

Note: *$p < 0.05$ indicates statistical significance.

and percentages and were analysed using the Chi-square test, Fisher's exact test, or Yates's continuity correction as appropriate.

Additionally, univariate and multivariate logistic regression analyses were conducted to identify the factors influencing coronary artery disease. The predictive ability of the TyG index and TC/HDL-C ratio for CHD status and SYNTAX scores was evaluated using the area under the curve (AUC). A p-value < 0.05 was considered statistically significant.

Results

Clinical Characteristics of Study Participants

CHD patients exhibited significantly higher values for age, gender, smoking history, history of diabetes, TC, TG, TyG index, and TC/HDL-C ratio, whereas HDL-C levels were significantly lower in CHD patients than in non-CHD individuals ($p < 0.05$) (Table 1).

Evaluation of Factors Associated With CHD

Analysis of the Relationship Between Factors and CHD Incidence

Spearman correlation analysis revealed a significant relationship between CHD incidence and age, gender, smoking history, history of diabetes, TC, TG, HDL-C, TyG index, and TC/HDL-C ratio ($p < 0.05$) (Table 2).

Univariate Logistic Regression Analysis of Risk Factors Associated With CHD

In univariate logistic regression analyses, age, gender, smoking history, history of diabetes, TC, TG, HDL-C, TyG index, and TC/HDL-C ratio were significantly associated with CHD status ($p < 0.05$) (Tables 3,4).

Multivariate Logistic Regression Analysis of Associations Between CHD and TyG Index and TC/HDL-C Ratio

In the multivariate logistic regression model, after adjusting for age, gender, smoking history, and history of diabetes, the TyG index and TC/HDL-C ratio were all independently associated with CHD risk ($p < 0.05$) (Table 5).

Table 3. Variable scoring criteria for binary logistic regression analysis.

Variable	Assignment
Coronary heart disease (dependent variable)	Control group = 0, CHD group = 1
Gender	Male = 1, Female = 0 (male-by-male)
Smoking history	No = 0, Yes = 1 (With or without reference)
Drinking history	No = 0, Yes = 1 (With or without reference)
History of hypertension	No = 0, Yes = 1 (With or without reference)
History of diabetes	No = 0, Yes = 1 (With or without reference)
History of cerebral infarction	No = 0, Yes = 1 (With or without reference)

Table 4. Univariate logistic regression analysis of factors associated with CHD.

Variable	β	SE	Wald	p-value	OR	95% CI
Age (years)	0.041	0.016	6.254	0.012*	1.042	1.009–1.076
Gender	0.723	0.313	5.356	0.021*	2.061	1.117–3.804
Nationality	0.141	0.355	0.157	0.692	1.151	0.574–2.307
Smoking history	0.684	0.311	4.827	0.028*	1.981	1.077–3.646
Drinking history	0.325	0.368	0.783	0.376	1.385	0.673–2.847
History of hypertension	0.551	0.311	3.138	0.076	1.735	0.943–3.191
History of diabetes	2.261	0.353	40.993	<0.001*	9.597	4.803–19.177
History of cerebral infarction	–0.323	0.592	0.298	0.585	0.724	0.227–2.310
TC (mmol/L)	1.392	0.224	38.700	0.000*	4.025	2.595–6.241
TG (mmol/L)	0.588	0.157	14.077	0.000*	1.800	1.324–2.446
LDL-C (mmol/L)	0.115	0.156	0.544	0.461	1.122	0.826–1.525
HDL-C (mmol/L)	–1.857	0.592	9.849	0.002*	0.156	0.049–0.498
FBG (mmol/L)	0.029	0.082	0.122	0.727	1.029	0.876–1.210
UA (μmol/L)	0.001	0.002	0.670	0.413	1.001	0.998–1.005
TyG index	0.920	0.266	11.999	0.001*	2.510	1.491–4.226
TC/HDL-C ratio	1.196	0.200	35.748	0.000*	3.307	2.235–4.895

Note: OR, odds ratio; CI, confidence interval; SE, standard error. *$p < 0.05$ indicates statistical significance.

Table 5. Multivariate logistic regression analysis of associations between CHD, TyG index, and TC/HDL-C ratio.

Variable	β	SE	Wald	p-value	OR	95% CI
TyG index	0.978	0.305	10.275	0.001*	2.660	1.462–4.837
TC/HDL-C ratio	1.280	0.226	32.137	0.000*	3.598	2.311–5.602

Note: *$p < 0.05$ indicates statistical significance.

Comparison of the General Characteristics Across Different CHD Lesion Counts

Among the 134 patients diagnosed with CHD via CAG, coronary artery lesions were classified into three groups: single-, dual-, and multi-vessel groups. Baseline characteristics were compared across these groups, revealing significant differences in hypertension history, TC, TG, TyG index, TC/HDL-C ratio, and SYNTAX scores ($p < 0.05$). TyG index, TC/HDL-C ratio, and SYNTAX scores increased with the number of affected vessels, with substantially higher values in the multi-vessel group relative to the single- and dual-vessel groups ($p < 0.05$). Pairwise comparisons between groups demonstrated that TG, TyG index, TC/HDL-C ratio, and SYNTAX scores were significantly higher in the multi-vessel group compared to both the single- and dual-vessel groups ($p < 0.05$). Furthermore, the SYNTAX score showed statistically significant differences between the single-vessel and dual-vessel groups ($p < 0.05$) (Table 6).

Correlations Among TyG Index, TC/HDL-C Ratio, and Lesion Count in CHD Patients

Spearman correlation analysis indicated that both TyG index (r = 0.470, p = 0.000) and TC/HDL-C ratio (r = 0.304, p = 0.000) were significantly positively correlated with the number of coronary lesions in CHD patients (Table 7).

Relationships Among SYNTAX Scores, TC/HDL-C Ratio, and TyG Index

Patients were separated into low-, medium-, and high-risk groups according to their SYNTAX scores. As SYNTAX scores increased, the TyG index and TC/HDL-C ratio exhibited a corresponding rise, with statistically significant differences observed among the three groups ($p < 0.05$) (Table 8).

Analysis of Factors That Impact SYNTAX Scores

Correlations Between SYNTAX Scores and Other Parameters in CHD Patients

Spearman correlation analysis revealed strong positive correlations between SYNTAX scores and both the TyG index (r = 0.714, p = 0.000) and TC/HDL-C ratio (r = 0.543, p = 0.000) (Table 9).

Univariate Logistic Regression Analysis of SYNTAX Scores in CHD Patients

Univariate logistic regression analysis of data from CHD patients indicated that history of diabetes, hypertension, LDL-C, HDL-C, TC, TG, TyG index, and TC/HDL-C ratio were significantly associated with SYNTAX scores ($p < 0.05$) (Tables 10,11).

Multivariate Logistic Regression Analysis of SYNTAX Scores and Their Association With TyG Index and TC/HDL-C Ratio

In the multivariate logistic regression analyses, after adjusting for history of hypertension, history of diabetes, and LDL-C levels, TyG index and TC/HDL-C ratio were identified as independent predictors of SYNTAX scores ($p < 0.05$) (Table 12).

Evaluation of the Predictive Value of TyG Index and TC/HDL-C Ratio for SYNTAX Scores

Receiver operating characteristic (ROC) curves analysis was performed using SYNTAX scores as the dependent variable and either TyG index or TC/HDL-C ratio as the independent variable (Fig. 1). The TyG index had an AUC of 0.893, with a critical threshold of 9.663, sensitivity of 1.000, specificity of 0.803, and a Youden index of 0.803. The AUC was significantly greater than 0.5 ($p < 0.05$),

Table 6. Comparison of baseline characteristics across single-, dual-, and multi-vessel disease groups.

Variable	Simple-vessel (n = 57)	Dual-vessel (n = 38)	Multi-vessel (n = 39)	F/H/χ^2	*p*-value
Age (years)	60 (56, 66)	59 (51, 67)	66 (49, 73)	0.729	0.695
Gender (male, %)	34 (59.65%)	18 (47.37%)	26 (66.67%)	3.031	0.220
Nationality (Han, %)	40 (70.18%)	25 (65.79%)	33 (84.62%)	1.894	0.388
Smoking history (%)	34 (59.65%)	27 (71.05%)	20 (51.28%)	3.173	0.205
Drinking history (%)	44 (77.19%)	31 (81.58%)	23 (58.97%)	5.837	0.054
History of hypertension (%)	8 (14.04%)^{a}	14 (36.84%)	27 (69.23%)	30.422	0.001*
History of diabetes (%)	49 (85.96%)	32 (84.21%)	25 (65.79%)	6.405	0.041
History of cerebral infarction (%)	54 (94.74%)	37 (97.37%)	35 (89.74%)	2.082	0.353
TC (mmol/L)	4.31 (3.69, 5.20)	4.61 (3.59, 5.58)	5.23 (4.40, 5.94)^{a}	10.470	0.005*
TG (mmol/L)	1.65 (1.19, 2.22)	1.65 (1.24, 2.64)	4.66 (3.16, 5.32)^{ab}	34.098	0.000*
LDL-C (mmol/L)	2.67 (2.29, 3.42)	3.17 (2.18, 3.68)	3.07 (2.43, 3.94)	2.299	0.317
HDL-C (mmol/L)	1.10 ± 0.23	1.10 ± 0.29	1.00 ± 0.21	2.337	0.107
FBG (mmol/L)	5.09 (4.70, 5.86)	5.18 (4.92, 6.07)	5.43 (4.85, 6.64)	3.419	0.181
UA (µmol/L)	305.30 (276.35, 379.80)	300.40 (257.83, 363.25)	337.8 (248.8, 384.10)	0.741	0.690
TyG index	8.87 (8.50, 9.25)	8.93 (8.53, 9.40)	9.94 (9.51, 10.14)^{ab}	34.796	0.000*
TC/HDL-C ratio	4.04 (3.12, 4.60)	4.02 (3.23, 5.12)	5.11 (3.90, 6.64)^{ab}	15.329	0.000*
CK (U/L)	66.70 (41.95, 88.10)	68.10 (49.05, 92.90)	64.40 (47.00, 88.50)	0.125	0.939
LADH (U/L)	193.80 (168.20, 211.60)	193.35 (159.75, 242.73)	190.50 (170.30, 224.10)	0.838	0.658
GOT (U/L)	20.80 (18.10, 31.85)	23.95 (19.08, 42.35)	20.60 (17.90, 36.70)	2.630	0.268
α-HBDH (U/L)	147.40 (130.70, 168.00)	157.55 (132.30, 192.28)	141.30 (132.20, 172.40)	80.38	0.270
SYNTAX	7.00 (3.50, 9.00)	14.00 (10.00, 21.00)^{c}	26.00 (22.00, 32.00)^{ab}	85.073	0.000*

Note: CK, creatine kinase; LADH, lactic dehydrogenase; GOT, glutamic oxalacetic transaminase; α-HBDH, alpha-hydroxybutyrate dehydrogenase; SYNTAX, Synergy Between Percutaneous Coronary Intervention (PCI) with Taxus and Cardiac Surgery.
*$p < 0.05$ indicates statistical significance; ^{a} indicates comparison between the single-vessel and the dual-vessel groups; ^{b} indicates comparison between dual-vessel and the multi-vessel groups; ^{c} indicates comparison between the single-vessel and the dual-vessel groups.

Table 7. Spearman correlation analysis of the relationship between TyG index, TCHDL-C ratio, and lesion number.

Variable	Correlation coefficient	p-value
TyG index	0.470	0.000*
TC/HDL-C ratio	0.304	0.000*

Note: $*p < 0.05$ indicates statistical significance.

Table 8. Association between TYG index, TC/HDL-C, and SYNTAX scores.

Variable	Low-risk ($\leq$22)	Medium-risk (23–32)	High-risk ($\geq$33)	F/H	p-value
Number	23	12	99		
TyG index	8.87 $\pm$ 0.51	9.22 $\pm$ 0.67	9.97 $\pm$ 0.39^{ab}	84.76	0.000*
TC/HDL-C ratio	3.91 (3.20, 4.60)	5.36 (4.23, 6.20)	7.70 (5.97, 10.10)^{ab}	40.20	0.000*

Note: $*p < 0.05$ indicates statistical significance; ^{a} indicates comparison with the low-risk group; ^{b} indicates comparison with the medium-risk group.

supporting the predictive utility of the TyG index for SYNTAX scores. The AUC for the TC/HDL-C ratio was 0.918, with a critical value of 5.825, sensitivity of 0.833, specificity of 0.902, and a Youden index of 0.735 (Table 13).

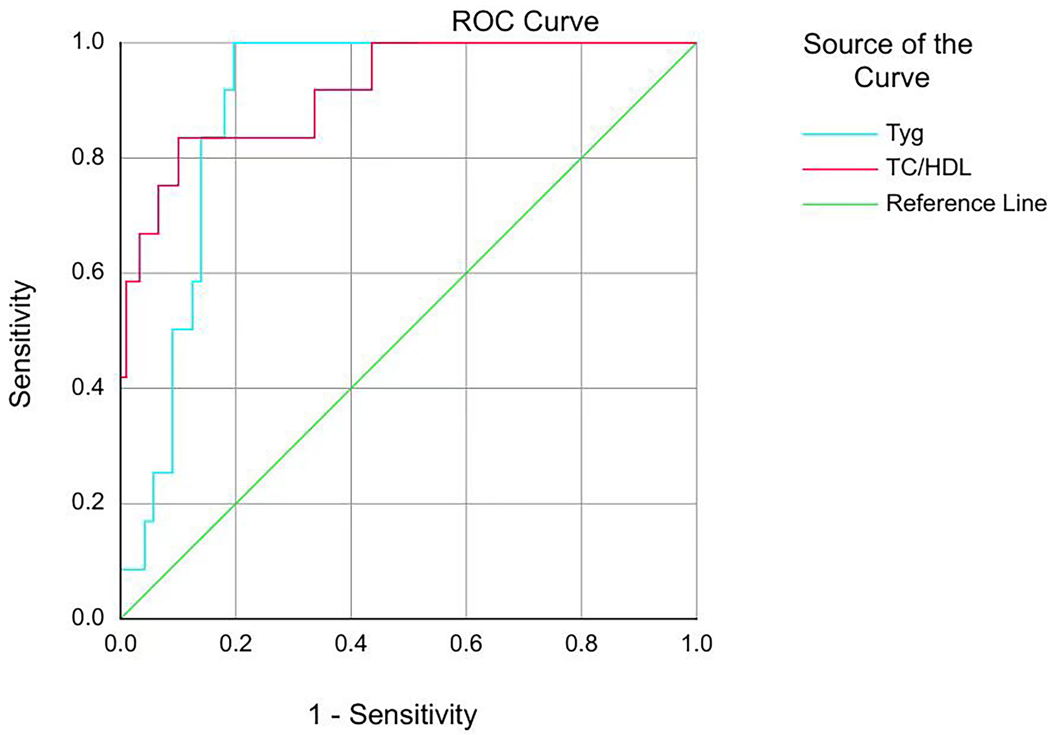

Fig. 1. AUC of the TyG index and the TC/HDL-C ratio in diagnosing coronary severity in patients with coronary heart disease. ROC, receiver operating characteristic.

Table 9. Spearman correlation analysis between various variables and SYNTAX scores.

Variable	Correlation coefficient	*p*-value
Age (years)	0.004	0.963
TC (mmol/L)	0.377	0.000*
TG (mmol/L)	0.727	0.000*
LDL-C (mmol/L)	0.145	0.095
HDL-C (mmol/L)	–0.428	0.000*
FBG (mmol/L)	0.186	0.032
UA (μmol/L)	–0.022	0.800
TyG index	0.714	0.000*
TC/HDL-C ratio	0.543	0.000*
Number of stenosed coronary vessels	0.640	0.000*

Note: $*p < 0.05$ indicates statistical significance.

Table 10. Variable scoring criteria for logistic regression analyses.

Variable	Assignment
SYNTAX grading	Low-risk = 0, Medium-risk = 1, High-risk = 2
Gender	Male = 1, Female = 0 (male-by-male)
Smoking history	No = 0, Yes = 1 (With or without reference)
Drinking history	No = 0, Yes = 1 (With or without reference)
History of hypertension	No = 0, Yes = 1 (With or without reference)
History of diabetes	No = 0, Yes = 1 (With or without reference)
History of cerebral infarction	No = 0, Yes = 1 (With or without reference)

Discussion

CHD remains a major global health threat associated with high incidence rates and an immense economic and social burden. While Percutaneous Coronary Intervention (PCI) is an effective treatment for ACS, its application is restricted to adequately equipped hospitals and patients meeting specific eligibility criteria. Consequently, the ability to predict CHD risk and severity based on patient-specific risk factors is crucial for appropriate intervention. Multiple studies have demonstrated a link between IR and the onset of atherosclerosis (Howard et al, 1996; Li et al, 2019), demonstrating its utility as a diagnostic marker for CHD. Reduced HDL-C levels limit reverse cholesterol transport, and the TC/HDL-C ratio may serve as a strong indicator of coronary atherosclerosis (Chen et al, 2020; Simental-Mendía et al, 2008). Elevated insulin and soluble CD40 ligand levels as a result of IR can further result in the production and release of tissue factors and thromboxane A2, platelet activation, vascular damage, vasoconstriction, thrombosis, and raise the risk of atherosclerotic plaque rupture and haemorrhage (Nofal et al, 2024). The TC/HDL-C ratio represents the status of lipid metabolic balance, with abnormal levels contributing to excessive cholesterol deposition beneath the arterial intima, which inhibits cholesterol reverse transport (Adorni et al, 2021). This condition damages vascular endothelial function, activates coagulation factors, releases inflammatory factors like interleukin-1 (IL-1), and triggers a chain of events that

Table 11. Univariate logistic regression analysis of factors associated with SYNTAX score grades in CHD patients.

Variable	β	SE	Wald	p-value	OR	95% CI
Age (years)	0.001	0.022	0.002	0.967	1.001	0.959–1.044
Gender	–0.235	0.400	0.345	0.557	0.791	0.361–1.731
Smoking history	0.275	0.394	0.485	0.486	1.316	0.608–2.850
Drinking history	0.723	0.416	3.015	0.082	2.061	0.911–4.661
History of hypertension	0.929	0.452	4.224	0.040*	2.533	1.044–6.146
History of diabetes	1.031	0.444	5.391	0.020*	2.803	1.174–6.690
History of cerebral infarction	1.012	0.704	2.065	0.151	2.751	0.692–10.938
TC (mmol/L)	0.804	0.188	18.291	0.000*	2.235	1.546–3.231
TG (mmol/L)	1.545	0.231	44.755	0.000*	4.690	2.982–7.376
LDL-C (mmol/L)	0.404	0.168	5.759	0.016*	1.498	1.077–2.084
HDL-C (mmol/L)	–6.226	1.281	23.609	0.000*	0.002	0.000–0.024
FBG (mmol/L)	0.155	0.097	2.568	0.109	1.168	0.966–1.412
UA (μmol/L)	–0.001	0.002	0.295	0.587	0.999	0.995–1.003
TyG index	4.488	0.734	37.361	0.000*	88.977	21.098–375.251
TC/HDL-C ratio	0.837	0.154	29.593	0.000*	2.310	1.709–3.124

Note: *$p < 0.05$ indicates statistical significance.

Table 12. Multivariate logistic regression analysis of the associations between SYNTAX score grades, TyG index, and TC/HDL-C ratio.

Variable	β	SE	Wald	p-value	OR	95% CI
TyG index	5.237	0.895	34.209	0.000*	188.107	32.527–1087.836
TC/HDL-C ratio	1.280	0.216	35.064	0.000*	3.598	2.355–5.497

Note: *$p < 0.05$ indicates statistical significance.

promote the development of CHD (Irace et al, 2013; Little et al, 2021). Elevated TC levels have also been linked to the development of coronary atherosclerosis.

Wang et al (2021) conducted a study involving 2792 CHD patients, identifying the TyG index as an independent predictor of ACS risk following univariate and multivariate analyses. Similarly, Che et al (2023) evaluated 403,335 UK Biobank subjects over an 8.1-year follow-up period and determined that higher TC/HDL-C ratios were notably positively correlated with CHD risk following multivariate adjustment. In the present study, the TyG index and TC/HDL-C ratio were significantly elevated among CHD patients compared to non-CHD patients. Univariate and multivariate analyses further confirmed that both indices were independently associated with CHD, which is consistent with these previous reports.

Limited studies have focused on the relationship between the TyG index, TC/HDL-C ratio, and the number of coronary lesions. Notably, our findings reveal that a progressive increase in coronary lesion number was positively correlated with the TyG index and TC/HDL-C ratio. Specifically, patients in the multi-vessel group exhibited significantly higher TyG index values and TC/HDL-C ratios compared to those in the single- and dual-vessel groups. These findings support the hypothesis

Table 13. Predictive performance of the TyG index and TC/HDL-C ratio for SYNTAX score classification.

Variable	AUC	Cutoff value	Sensitivity	Specificity	Youden index	p-value	95% CI
TyG index	0.893	9.663	1.000	0.803	0.803	0.000*	0.837–0.948
TC/HDL-C ratio	0.918	5.825	0.833	0.902	0.735	0.000*	0.835–1.000

Note: AUC, area under the curve. $*p < 0.05$ indicates statistical significance.

that elevated insulin resistance (IR) contributes to more pronounced lipid homeostasis disruption and accelerates the progression of atherosclerotic plaques. Both indices may thus serve as valuable predictors of multi-vessel coronary lesions and overall lesion burden (Sultani et al, 2020), aligning with findings from Khalaji et al (2024) and several international studies (Che et al, 2023; Song et al, 2024; Sultani et al, 2020). Previous research has also reported a gradual increase in the number of coronary artery lesions (Jin et al, 2018; Mao et al, 2019; Hill et al, 2021; Saffar Soflaei et al, 2025). Patients with multi-vessel lesions frequently exhibited elevated TyG index levels, further supporting its utility in predicting the severity and prognosis of multi-vessel lesions in ACS patients. The findings of this study, combined TC/HDL-C ratio, further reinforce the role of the TC/HDL-C ratio as a predictive marker for atherosclerosis and lipid metabolism dysfunction. A higher TC/HDL-C ratio indicated an elevated risk of atherosclerosis and lipid metabolism dysfunction.

The present analyses revealed strong positive correlations between the TyG index and TC/HDL-C ratio levels and SYNTAX scores, indicating that these indices tended to increase with higher SYNTAX scores. Notably, the high-risk group exhibited significantly higher TC/HDL-C ratio and TyG index values compared to the low- and medium-risk groups, consistent with findings from Sánchez-Íñigo et al (2016), Liu et al (2021), and Carnero-Alcázar et al (2011). Univariate and multivariate logistic regression analyses further confirmed that both indices were independently associated with coronary artery lesion severity in CHD patients. The AUC values for the TyG index (0.893) and TC/HDL-C ratio (0.918) exceeded 0.5, supporting their predictive value for coronary lesion severity. Both indices were also identified as independent risk factors for patients with a SYNTAX score >32 (OR: 6.055, 95% CI: 2.915–12.579), aligning with previous findings on their predictive value for cardiovascular adverse events, as reported by Zhang et al (2017). They observed that the TyG index independently correlated with the SYNTAX scores. The AUC value for the TyG index in assessing the severity of coronary artery disease was 0.673 (95% CI: 0.620–0.726). These findings support the TyG index as a valuable predictor of cardiovascular adverse events and a marker of coronary artery disease severity. The present study supports this conclusion by demonstrating the combined value of the TyG index and TC/HDL-C ratio. Pathological alterations like insulin resistance, glucose metabolism disorders, lipid metabolism imbalances, inflammatory responses, and endothelial dysfunction contribute to the rapid spread and complexity of coronary artery lesions, making them more challenging to treat.

Several limitations apply to the study. First, the study is a retrospective single-center study with a relatively small sample size, which could introduce sample bias and reduce robustness. Future studies should employ multicenter designs with larger and more diverse cohorts, encompassing variations in age, gender, lifestyle, and genetic background. Cross-institutional collaborations and the integration of advanced technologies, such as artificial intelligence and big data analytics, could further enhance the robustness and clinical applicability of the conclusions.

Second, although the statistical analysis accounted for several known confounding variables, some potential influencing factors were not considered, potentially affecting the precision of the study's findings. Third, this study did not dynamically assess variations in the TC/HDL-C ratio and TyG index over time or their predictive value in ACS prognosis and potential adverse cardiovascular events. Instead, data were only collected at the time of patient admission. Longer follow-up periods are required to increase the accuracy, validity, and applicability of the conclusions of this study. Further analysis of the internal relationship between these variables and CHD can be done by creating a dynamic database.

Despite these limitations, this study provides significant clinical insights. The data presented are reliable and demonstrate that the TC/HDL-C ratio is positively correlated with the severity of coronary lesions, independent of its association with the TyG index and CHD. These findings may serve as a reference for patients unable to undergo CAG examinations in clinical practice, supporting early CHD prevention and intervention strategies. In the future, a comprehensive CHD diagnostic model that incorporates the TC/HDL-C ratio, TyG index, and additional clinical markers, such as aberrant electrocardiogram (ECG) manifestations and imaging abnormalities, could be developed to enhance diagnostic accuracy in clinical practice.

Conclusion

The findings of this study confirm that the TC/HDL-C ratio and TyG index constitute independent risk factors for CHD. Furthermore, these biomarkers consistently demonstrated predictive value in diagnosing severe, complex coronary disease and multi-vessel lesions among CHD patients. This study provides clinicians with a robust framework for identifying high-risk CHD populations and developing personalised treatment strategies.

Key Points

- The TC/HDL-C ratio and TyG index are independent risk factors for CHD. Both biomarkers exhibit a strong correlation with the SYNTAX score and the number of coronary lesions, indicating significant clinical value in predicting the severity of coronary artery disease.
- The two biomarkers provide a novel, non-invasive approach to CHD diagnosis, facilitating early risk assessment during initial clinical screenings, particularly in cases where invasive procedures are contraindicated or not immediately available.
- A significant correlation was identified between CHD severity and the TyG index and the TC/HDL-C ratio index. These findings enable clinicians to accurately assess disease progression and develop stratified treatment plans through enhanced early screening systems, optimised risk assessment protocols, and informed therapeutic decision-making.

Availability of Data and Materials

All the data of this study are included in this article.

Author Contributions

RW designed the study and reviewed the manuscript. NQ designed the study and wrote the manuscript. QL completed the data collection. XB completed the data analysis. All authors contributed to the important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Written informed consent was obtained from all participants, and the study protocol was approved by the local institutional ethical review board of the General Hospital of Ningxia Medical University (Approval No. KYLL-2024-1549). The study was conducted in accordance with the principles of the Declaration of Helsinki.

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Conflict of Interest

The authors declare no conflict of interest.

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