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Original Article

Utility of the Triglyceride Glucose Index and Atherogenic Lipid Indices in Differentiating Type 2 Diabetic Patients with and Without Coronary Heart Disease

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Abstract

Objectives: To assess the use of the Triglyceride-Glucose Index and atherogenic lipid indices to distinguish between T2DM with and without CHD.

Methodology: This retrospective analytical study was conducted in the Department of Biochemistry, Khyber Medical College, Peshawar, from July 2025 to Dec 2025 (six months) and included 200 patients with T2DM, comprising 100 with CHD and 100 without CHD. We assessed demographic, clinical, glycaemic, lipid, and inflammatory parameters. We calculated TYG, AIP, Castelli risk indices I and II, non-HDL-C, and TYG/HDL-C.

Results: Fasting Blood Glucose (FBG), HbA1c, triglycerides, CRP, and fibrinogen levels were significantly higher in cardiac diabetic patients than in diabetic patients without CHD. The TYG index was significantly higher in patients with CHD (10.237 ± 0.703 vs. 9.849 ± 0.802 , $p < 0.001$), as were AIP (0.537 ± 0.309 vs. 0.387 ± 0.312 , $p = 0.001$) and median TYG/HDL-C ratio [8.220 (IQR 8.84) vs. 5.779 (IQR 5.79), $p = 0.002$]. TYG demonstrated the highest discriminatory performance, with an AUC of 0.644 (95% CI: $0.567-0.721$, $p < 0.001$) and a sensitivity of 85.0% at a cut-off of 9.494 . Both AIP and TYG/HDL-C had an AUC of 0.629 . TYG was also weakly positive and significantly associated with CRP ($p = 0.190$, $p = 0.007$).

Conclusion: The TYG index, AIP, and TYG/HDL-C ratio were significantly higher in T2DM patients with CHD. TYG had the highest discriminatory power among the indices evaluated, but with only moderate overall diagnostic power. TYG could therefore be a simple screening metabolic marker for cardiovascular risk assessment in T2DM patients.

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Introduction

Type 2 diabetes mellitus (T2DM) is a major metabolic disorder characterized by chronic hyperglycemia, insulin resistance, and progressive disturbances in carbohydrate and lipid metabolism [1,2]. One of the most common causes of morbidity and mortality is cardiovascular disease in T2DM patients. Diabetic patients are at risk for endothelial dysfunction, vascular inflammation, and earlier onset and greater extent of atherosclerotic plaques than nondiabetics, and may have more severe coronary artery disease (CAD) than nondiabetics [3,4]. Hence, it is still clinically relevant to identify simple, readily available biochemical markers that can aid in identifying diabetic patients at high cardiovascular risk. Insulin resistance is a crucial factor in the development of T2DM and cardiovascular disease. The hyperinsulinemic-euglycemic clamp is regarded as the gold standard for measuring insulin resistance, but is too complex and resource-intensive to be routinely used clinically [5,6]. Thus, the triglyceride-glucose (TYG) index, computed from fasting triglyceride and glucose levels, has been a focus of interest as an inexpensive, widely available surrogate marker of insulin resistance [7,8]. Associations between high TYG values, coronary artery stenosis, adverse cardiovascular events, and cardiovascular outcomes have been previously shown in patients with diabetes and acute coronary syndromes. Thai et al. reported that the TYG index is a useful tool for diagnosing asymptomatic coronary artery stenosis in patients with T2DM, and Wang et al. showed that the TYG index was independently associated with MACE in patients with diabetes and ACS [9,10]. In addition to the TYG index, several lipid-derived indices have been proposed as simple markers of atherogenic risk. The atherogenic index of plasma (AIP), triglyceride/high-density lipoprotein cholesterol (TYG/HDL-C) ratio, Castelli risk indices, and non-high-density lipoprotein cholesterol (non-HDL-C) provide different representations of lipid-related cardiovascular risk and may offer additional information beyond individual lipid parameters. However, their comparative utility for differentiating T2DM patients with and without coronary heart disease (CHD) remains incompletely characterized. Therefore, this study aimed to evaluate and compare the utility of the TYG index and selected atherogenic lipid indices in differentiating patients with T2DM with and without CHD. The study also assessed the discriminatory performance of these indices using receiver operating characteristic (ROC) curve analysis. It examined their relationships with the inflammatory markers C-reactive protein (CRP) and fibrinogen.

Material and Methods

This retrospective analytical study was conducted in the Department of Biochemistry, Khyber Medical College, Peshawar, from July to December 2025 and included 200 patients with T2DM, comprising 100 with CHD and 100 without CHD. This study assessed the usefulness of the triglyceride-glucose (TYG) index and selected atherogenic lipid indices in distinguishing type 2 diabetes mellitus (T2DM) patients with/without coronary heart disease (CHD). Institutional Research/Ethical Committee of Khyber Medical College (Reference No. 559 dated 2/08/2025) gave ethical clearance. This research was carried out in accordance with the Declaration of Helsinki, and written informed consent was obtained from all participants.

Sample Size and Participants

We enrolled 200 patients with established T2DM and divided them equally into two groups: 100 with documented CHD and 100 without CHD. The sample size was determined for comparing two independent

groups at an 80% power, 5% significance level, and an expected standardized effect size of ~ 0.40 . Patients enrolled in the study were ≥ 18 years of age and had a diagnosis of T2DM. The diagnosis of CHD was based on the clinical history, previous coronary angiography, evidence of myocardial ischemia/infarction, coronary revascularization, or a clinical diagnosis by the cardiologist. Type 1 diabetes, acute infection, active inflammatory or autoimmune diseases, severe hepatic dysfunction, malignancy, pregnancy, incomplete clinical/biochemical record, and unavailable fasting glucose/lipid measurements were omitted.

Data Collection and Laboratory Assessment

We collected demographic and clinical information, including age, sex, residence, hypertension, body mass index (BMI), and blood pressure, using a structured data-collection form. Venous blood samples were drawn using routine methods after a 12-hour fast. Blood tests performed in the laboratory were fasting blood glucose, glycated hemoglobin (HbA1c), total cholesterol, triglycerides, HDL-C, LDL-C, C-reactive protein (CRP), and fibrinogen. We calculated the TYG index using fasting triglyceride and glucose levels. We assessed the atherogenic indices AIP, Castelli risk indices I and II, non-HDL-C, and the TYG/HDL-C ratio.

Statistical Analysis

We analyzed data using IBM SPSS 24.0. We expressed continuous variables as mean $\pm$ standard deviation or median (interquartile range), depending on data distribution, and presented categorical variables as frequencies and percentages. We used an independent-samples t-test or Mann-Whitney U test to compare continuous variables, and Pearson's chi-square test for categorical variables. We evaluated TYG and atherogenic indices by their receiver operating characteristic (ROC) curve discriminating power; we calculated the area under the curve (AUC) with 95% confidence interval (CI) and the maximum Youden index (YI) to determine sensitivity, specificity, and optimal cut-off values. We used Spearman's rank correlation to examine associations between the calculated indices and inflammatory markers. We considered $p < 0.05$ statistically significant.

Results

Fasting blood glucose was significantly higher in cardiac diabetic patients than in diabetic patients without coronary heart disease (213.80 ± 91.63 vs. 175.68 ± 59.16 mg/dL) ($p = 0.001$). HbA1c was also significantly elevated in the cardiac diabetic group ($10.17 \pm 3.45\%$ vs. $8.30 \pm 3.04\%$, $p < 0.001$). Triglycerides were significantly higher in the diabetic patients with cardiac complications [313.50 (IQR 232.50) mg/dL] than in the non-cardiac diabetic patients [227.50 (IQR 335.25) mg/dL] ($p = 0.018$). Likewise, cardiac diabetic and non-diabetic groups had significantly higher levels of CRP ($p \leq 0.003$) and fibrinogen ($p = 0.002$). No statistically significant differences were observed in age, systolic blood pressure, diastolic blood pressure, BMI, total cholesterol, HDL-C, or LDL-C.

Table 1. Comparison of clinical, glycaemic, lipid, and inflammatory parameters between cardiac diabetic and diabetic patients

Parameter	T2DM with CHD (n=100)	T2DM without CHD (n=100)	Test statistic	p-value
Age (years), mean ± SD	62.52 ± 8.98	60.48 ± 10.59	t = 1.469	0.143
Systolic BP (mmHg), mean ± SD	153.26 ± 22.91	156.71 ± 21.11	t = 1.107	0.269
Diastolic BP (mmHg), mean ± SD	93.70 ± 11.65	93.18 ± 10.45	t = 0.332	0.740
BMI (kg/m²), median (IQR)	30.00 (5.00)	30.00 (5.00)	U = 4424.50	0.100
Fasting blood glucose (mg/dL), mean ± SD	213.80 ± 91.63	175.68 ± 59.16	t = 3.495	0.001
HbA1c (%), mean ± SD	10.17 ± 3.45	8.30 ± 3.04	t = 4.050	<0.001
Total cholesterol (mg/dL), mean ± SD	279.62 ± 151.74	272.11 ± 121.11	t = 0.387	0.699
Triglycerides (mg/dL), median (IQR)	313.50 (232.50)	227.50 (335.25)	U = 4032.50	0.018
HDL-C (mg/dL), mean ± SD	40.64 ± 16.49	44.34 ± 15.24	t = 1.648	0.101
LDL-C (mg/dL), median (IQR)	149.50 (272.75)	157.00 (178.25)	U = 4930.50	0.865
CRP (mg/L), mean ± SD	18.43 ± 4.23	12.67 ± 6.17	t = 7.709	<0.001
Fibrinogen (mg/dL), mean ± SD	478.55 ± 165.95	413.46 ± 139.76	t = 3.000	0.003

BMI, body mass index; BP, blood pressure; CHD, coronary heart disease; CRP, C-reactive protein; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; LDL-C, low-density lipoprotein cholesterol; SD, standard deviation; T2DM, type 2 diabetes mellitus. Sex, residence, hypertension, and BMI distributions did not differ significantly between groups. Obesity was the most common BMI category (72.0% vs. 67.0%), while hypertension was highly prevalent in both groups (81.0% vs. 82.0%).

Table 2. Demographic and clinical characteristics according to study group

Variable	Category	Cardiac diabetic (n=100), n (%)	Diabetic (n=100), n (%)	χ²	p-value
Sex	Male	51 (51.0)	48 (48.0)	0.180	0.671
	Female	49 (49.0)	52 (52.0)		
Residence	Urban	73 (73.0)	76 (76.0)	0.237	0.626
	Rural	27 (27.0)	24 (24.0)		
Hypertension	Hypertensive	81 (81.0)	82 (82.0)	0.033	0.856
	Normal	19 (19.0)	18 (18.0)		
BMI category	Normal	6 (6.0)	4 (4.0)	1.541	0.463
	Overweight	22 (22.0)	29 (29.0)		

Obese 72 (72.0) 67 (67.0)

Cardiac diabetic patients had significantly higher TYG, AIP, and TYG/HDL-C ratios than non-CHD patients, while non-HDL-C and Castelli risk indices did not differ significantly.

Table 3. Comparison of triglyceride–glucose and atherogenic lipid indices between the study groups

Parameter	Cardiac diabetic (n=100)	Diabetic (n=100)	Test statistic	p-value
TYG index, Mean ± SD	10.237 ± 0.703	9.849 ± 0.802	t = 3.641	<0.001
Atherogenic index of plasma, Mean ± SD	0.537 ± 0.309	0.387 ± 0.312	t = 3.427	0.001
Non-HDL-C (mg/dL), Mean ± SD	238.98 ± 151.30	227.77 ± 123.30	t = 0.574	0.566
Castelli risk index I, Median (IQR)	6.688 (6.96)	6.250 (5.51)	U = 4704.0	0.470
Castelli risk index II, Median (IQR)	4.036 (8.04)	3.501 (4.76)	U = 4781.0	0.593
TYG/HDL-C ratio, Median (IQR)	8.220 (8.84)	5.779 (5.79)	U = 3705.0	0.002
LDL/HDL-C ratio, Median (IQR)	4.036 (8.04)	3.501 (4.76)	U = 4781.0	0.593

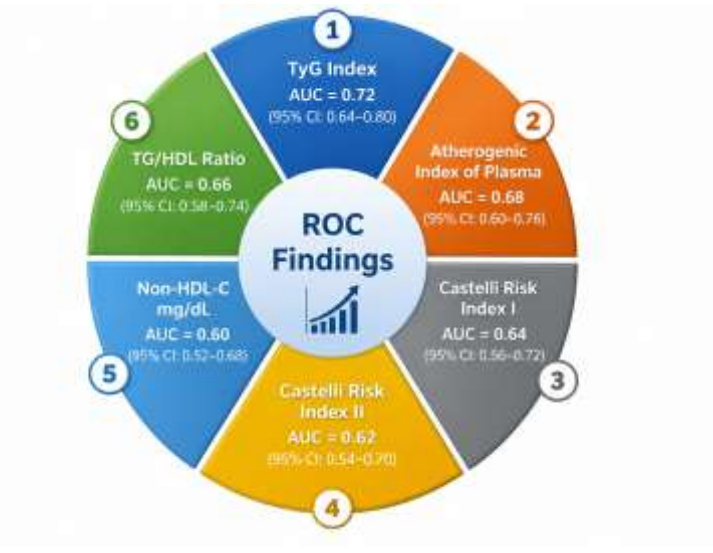
Data are presented as mean ± SD or median (IQR), as appropriate. TYG triglyceride–glucose index; AIP = atherogenic index of plasma.

Table 4. ROC curve analysis of triglyceride–glucose and atherogenic indices for differentiating cardiac diabetic from diabetic patients

Index	AUC	95% CI	p-value	Optimal cut-off*	Sensitivity (%)	Specificity (%)
TYG index	0.644	0.567–0.721	<0.001	9.494	85.0	43.0
Atherogenic index of plasma	0.629	0.553–0.706	0.002	0.250	83.0	38.0
Castelli risk index I	0.530	0.449–0.610	0.470	10.162	30.0	82.0
Castelli risk index II	0.522	0.440–0.604	0.593	6.872	37.0	81.0
Non-HDL-C (mg/dL)	0.507	0.426–0.587	0.865	373.0	23.0	87.0
TYG/HDL-C ratio	0.629	0.553–0.706	0.002	4.069	83.0	38.0

AUC = area under the receiver operating characteristic curve; CI = confidence interval; TYG = triglyceride–glucose index; HDLC = high-density lipoprotein cholesterol. *Optimal cut-offs were selected using the maximum Youden index (sensitivity + specificity – 1).

Figure 1. Receiver Operating Characteristic (ROC) Analysis of the Triglyceride–Glucose Index and Atherogenic Lipid Indices for Differentiating Type 2 Diabetes Mellitus With and Without Coronary Heart Disease.



Receiver operating characteristic (ROC) curves of the TyG index and atherogenic lipid indices for differentiating patients with type 2 diabetes mellitus with and without coronary heart disease. AUC, area under the curve; CI, confidence interval; TyG, triglyceride–glucose index; AIP, atherogenic index of plasma; HDLC, high-density lipoprotein cholesterol.

Table 5. Correlation of triglyceride–glucose and atherogenic indices with inflammatory markers

Index	CRP, Spearman’s ρ	p- value	Fibrinogen, Spearman’s ρ	p- value
TYG index	0.190	0.007	0.065	0.360
Atherogenic index of plasma	0.135	0.057	0.056	0.429
Castelli risk index I	-0.058	0.418	-0.013	0.855
Castelli risk index II	-0.066	0.352	-0.026	0.715
Non-HDLC	-0.048	0.503	-0.045	0.527
TYG/HDLC ratio	0.135	0.056	0.056	0.430

ρ = Spearman’s rank correlation coefficient; CRP = C-reactive protein; TYG = triglyceride–glucose index; HDLC = high-density lipoprotein cholesterol

Discussion

The present study demonstrated that patients with T2DM and CHD had significantly higher fasting glucose, HbA1c, triglycerides, CRP, fibrinogen, TYG, AIP, and TYG/HDL-C than those without CHD. In contrast, age, blood pressure, BMI, total cholesterol, HDL-C, and LDL-C did not differ significantly. These findings suggest that combined abnormalities in glucose and triglyceride metabolism may provide additional information regarding cardiovascular risk in T2DM. The TYG index was significantly higher in patients with CHD, consistent with previous studies. Thai et al. reported that there was a relationship between the higher TYG values and severe coronary stenosis in asymptomatic T2DM patients [11]. Similarly, Si et al. reported an association between TYG and coronary artery disease in T2DM patients, and Li et al. reported an independent association between TYG and CHD [12,13]. Other studies have associated higher TYG with multivessel coronary disease, coronary calcium, and coronary collateral development [14-16]. However, TYG's discriminatory performance was modest in the present study (AUC 0.644), which may reflect differences in study population, CHD definitions, treatment patterns, glycaemic status, and CHD severity. AIP and TYG/HDL-C were also significantly elevated in CHD patients, while Castelli risk indices and non-HDLC showed no significant differences. The comparable performance of AIP and TYG/HDL-C is biologically plausible, as AIP is a log transformation of the TYG/HDL-C ratio. The above studies also showed a correlation between AIP, TYG, and coronary artery disease [12]. These results suggest that triglyceride-related indices could provide additional information beyond traditional lipid markers. Evidence from longitudinal studies further supports the clinical relevance of TYG. Increased levels of TYG have been linked to serious cardiovascular outcomes in patients with diabetes and acute coronary syndrome, as well as poor outcomes following PCI [17,19], acute myocardial infarction, or coronary artery bypass surgery. However, the low specificity of the present study suggests that TYG is not a diagnostic test for CHD in itself, but rather a supplementary marker. The present study also identified a weak but statistically significant positive correlation between TYG and CRP, whereas no significant association was observed between TYG and fibrinogen. This finding suggests a possible relationship between insulin resistance-related metabolic abnormalities and systemic inflammation, although the weak correlation indicates that these markers likely reflect partly distinct biological processes. This study has several limitations, including its cross-sectional design, a single TYG measurement, a relatively small sample size, no angiographic assessment of disease severity, no medication-adjusted regression analysis or renal-function adjustment, and no longitudinal cardiovascular outcomes. The modest specificity of TYG, AIP, and TYG/HDL-C also limits their use as individual diagnostic markers. Larger prospective multicenter studies are needed to determine whether these indices provide incremental prognostic value beyond established cardiovascular risk factors and conventional biomarkers.

Conclusion

Patients with T2DM and CHD had significantly higher glycaemic, lipid, and inflammatory markers. The TYG index showed the highest discriminatory ability, although overall performance was modest. Its weak association with CRP suggests a possible link between insulin resistance and inflammation. TYG may serve as a simple adjunctive marker of cardiovascular risk alongside conventional clinical and biochemical assessment.

Ethical Approval

The Institutional Research/Ethics Committee of Khyber Medical College, Peshawar, Pakistan, approved this study (Reference No. 559, dated 02 August 2025).

Informed Consent

We obtained written informed consent from all participants before enrollment. We informed participants about the study's purpose and procedures, and participation was voluntary.

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Conflict of Interest

The authors declare that they have no competing interests or conflicts of interest related to this study.

Authors' Contributions

Sobia Ali: Conceptualization, study design, supervision, data interpretation, critical revision of the manuscript for important intellectual content, final approval of the version to be published, and accountability for all aspects of the work.

Bibi Hajira Ishaq: Conceptualization, study design, data collection, data curation, statistical analysis, data interpretation, manuscript drafting, critical revision of the manuscript, final approval of the version to be published, and accountability for all aspects of the work.

Ubaid Ullah: Data collection, data curation, literature review, interpretation of data, manuscript revision, final approval of the version to be published, and accountability for all aspects of the work.

Zafar Ali: Data collection, laboratory assessment, data curation, literature review, manuscript revision, final approval of the version to be published, and accountability for all aspects of the work.

Ubaid Ur Rahman: Study supervision, interpretation of findings, critical review of the manuscript for important intellectual content, final approval of the version to be published, and accountability for all aspects of the work.

Abdul Samad Khan: Statistical analysis, data interpretation, manuscript drafting and revision, critical review of the manuscript for important intellectual content, final approval of the version to be published, and accountability for all aspects of the work.

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