GMR
The Original

TRIGLYCERIDE GLUCOSE INDEX – A PREDICTIVE MARKER FOR CORONARY ARTERY DISEASE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

Shinde Yogita Mahendra[1], Badade ZG[2]*, Kaul SK[3], Rai Sandeep[4], Kadam Shilpa[5]

[1]Assistant Professor, Department of Biochemistry, MGM Medical College & Hospital, Kamothe, Navi Mumbai
[2]Professor, Department of Biochemistry, MGM Medical College & Hospital, Kamothe, Navi Mumbai
[3]Professor, Department of CVTS, MGM Medical College & Hospital, Kamothe, Navi Mumbai
[4]Professor, Department of General Medicine, MGM Medical College & Hospital, Kamothe, Navi Mumbai
[5]Professor, Department of Cardiology, MGM Medical College & Hospital, Kamothe, Navi Mumbai
*Corresponding Author: Badade ZG, Email: badadezg@gmail.com

ABSTRACT
Background: The diagnostic standard of coronary artery disease (CAD) is coronary angiography (CAG). Since CAG is an invasive procedure underscores the need for identifying non-invasive, effective, and innovative biomarkers. Coronary artery disease is a leading complication among individuals with uncontrolled type 2 diabetes mellitus (T2DM), often linked to insulin resistance. The Triglyceride-Glucose (TyG) index, derived from fasting triglycerides and glucose levels, has emerged as a promising surrogate marker for insulin resistance and early predictor of cardiovascular risk.
Objective: To evaluate the TyG Index as a simple, cost-effective, and non-invasive predictive marker for CAD in patients with T2DM and to assess its association with inflammatory and cardiometabolic risk parameters for early identification of high-risk diabetic individuals.
Methods: This prospective, cross-sectional study was conducted at MGM Medical College and Hospital, Kamothe, Navi Mumbai, involving 393 subjects (30–60 years), divided equally into healthy controls (n=131), T2DM without CAD (n=131), and T2DM with angiographically confirmed CAD (n=131). The TyG index was calculated using fasting triglyceride and glucose values, and other parameters including diabetic and lipid profile, hsCRP were assessed. Statistical analysis was performed using SPSS version 25. Data were expressed as mean ± SD; Chi-square test, independent t-test, one-way ANOVA, Pearson's correlation, and ROC curve analysis were applied as appropriate, with $p < 0.05$ considered statistically significant.
Results: Diabetic profile and lipid profile with TyG index, and high-sensitivity C-reactive protein (hs-CRP) significantly differed among the three groups. The TyG index demonstrated higher values in CAD patients with T2DM (9.92 ±0.21) and patient with only T2DM (9.61±0.71) compared to those with healthy controls (8.2±0.21). The AUC of the TyG index was 0.872 (95% confidence interval (CI), P <0.001), with a cut-off value of >9, with excellent sensitivity and specificity for predicting future CAD risk in uncontrolled type 2 diabetic patients. The TyG index was significantly elevated in Group III (T2DM with CAD) compared to both Group I and Group II (p<0.001). Furthermore, the TyG index showed a strong positive correlation with hsCRP, total cholesterol, LDL, and triglyceride levels, and a negative correlation with HDL in diabetic patients.
Conclusion: The TyG index is a simple, economical, and reliable marker useful to improve diagnostic efficiency, suggesting its potential role as a novel indicator for predicting and diagnosing CAD risk in uncontrolled T2DM patients.

KEYWORDS: Triglyceride-Glucose Index, Type 2 Diabetes Mellitus, Coronary Artery Disease, Insulin Resistance, Cardiovascular Risk, high sensitive C-reactive protein.

INTRODUCTION

Diabetes mellitus (DM) is a severe health problem in the world and it is currently viewed as an epidemic. The predicted number of adults aged 20-79 years with DM was 537 million in 2021, and is projected to increase to 643 million in 2030 and 783 million in 2045, adding to the burden of patients and healthcare professionals [1]. DM is the tenth largest cause of mortality worldwide (World Health Organization (WHO) report) [2]. As stated in 2019, 1.5 million deaths have been reported [3, 4]. DM is a chronic condition that predisposes the development of cardiovascular disease (CVD) and associated consequences [1]. CVD is the largest cause of death worldwide and the main cause of death in people with DM [4]. Heart failure is the most common cause of death in industrialized countries [5]. Diabetes Mellitus and Cardiovascular disease are intimately linked, CVD was the most common underlying cause of death, accounting for 44% of deaths in those with T1DM and 52% of mortality in people with T2DM [1].
Diabetic adults are 2–4 times more likely to die from myocardial infarction (MI), ischemic heart disease, congestive heart failure (CHF), and stroke compared to non-diabetic individuals. Factors such as hyperglycemia, hypertension, obesity, dyslipidaemia, and insulin resistance (IR) contribute to the development of CVD in diabetic patients [1]. The risk of CVD

increases proportionally with increasing blood sugar levels, even before blood glucose reaches to diabetic thresholds [6,7]. Given this strong association, one of the major goals of DM treatment is the early identification and management of potential CVD risks [6]. The triglyceride glucose (TyG) index was newly proposed as a simple, reliable, easily obtainable and appropriate applicable tool for routine clinical practice for predicting insulin resistance (IR). Which is calculated by fasting triglyceride and glucose levels, and it may be more reliable than the commonly used indicator for clinical assessment, homeostasis model assessment insulin resistance (HOMA-IR), in terms of both sensitivity and specificity [8]. Studies have shown that a higher TyG index is associated with an increased risk of cardiovascular events and mortality in the general population [9–11].Despite growing evidence supporting the clinical significance of the TyG index, the present data regarding TyG index shows predictive role for CAD among Indian patients with T2DM remain limited. Therefore, the present study aims to evaluate the association between the Triglyceride-Glucose Index and coronary artery disease in patients with Type 2 Diabetes Mellitus and to assess its utility as a predictive marker for CAD.

MATERIAL AND METHOD

Present prospective cross-sectional study carried out in Departments of Biochemistry, OPD & IPD of CVTS and General Medicine, MGM Medical College and Hospital, Navi Mumbai. Study comprised 393 subjects (30 to 60 years); are stratified into three groups as, healthy individuals in a control and two study groups: known cases of T2DM without CAD and known cases of T2DM with angiographically proven CAD (n=131 in each group). The diabetic cases confirmed as per WHO criteria and lipid profile was assessed by Adult Treatment Panel III. After clarifying about study, informed consent was taken from all the participants. Patients with acute coronary syndrome (ACS) chronic renal & liver diseases, diabetic cases those who are on insulin, and inflammatory disorders, were excluded. After selection of appropriate study subjects, written informed consent was obtained from all participants formerly explaining the details about the study protocol. The study was approved by Institutional Ethics Committee (IEC registration number- MGMIHS/ RS/2025-26). The BMI (kg/m^2) was calculated by formula, weight (kg)/height (m^2) and WHO classification as normal 18.5-24.9, overweight 25-29.9 and for obese ≥ 30. All participants were advised for 10-12 hours overnight fasting and the 5-8ml of venous blood sample were collected under aseptic condition by using BD vacutainer system. All known cases of T2DM also evaluated for their blood sugar levels by glucose oxidase-peroxidase (GOD-POD) method and HbA1c done by high performance liquid chromatography technique (HPLC). Among lipid profile, serum level of Total cholesterol, Triglyceride (TG), and HDL-C was measured using commercially available kits. Friedwald formula used for calculating LDL-C = [TC–(TG/5) –HDL] and VLDL-C = TG/5. The upper normal levels for total cholesterol, TG and LDL-C, were considered 200 mg/dl, 150 mg/dl, and 100 mg/dl respectively. TyG index,[12] was calculated as In[fasting triglycerides (mg/dl) x fasting glucose (mg/dl)/2]. Serum hsCRP levels were estimated by ELISA [Cal-biotech] and compared with TyG index. Statistical analysis done on SPSS version 25 by using Chi-square and independent t-test applied and result express in mean ± SD with 95% CI. Pearson's correlation (r) to assess relationship between different parameters. Descriptive Statistics is expressed as Mean ± SD. The independent t-test (2-tailed) is used to examine the statistically significant difference between two variables. One way ANOVA is used to examine statistical difference between more than two means among the respondents.

Receiver Operating Characteristic (ROC) curve analysis was used to evaluate the diagnostic accuracy of the test. It was generated by plotting sensitivity against specificity at different cutoff values. The area under the curve (AUC) was calculated to assess the overall performance of the test, and the optimal cutoff value was determined based on maximum sensitivity and specificity. A p-value < 0.05 was considered statistically significant.

RESULT

TABLE NO. 1: TOTAL NUMBER OF SUBJECTS WITH FAMILY HISTORY OF DIABETES IN T2DM AND T2DM WITH CAD GROUPS

T2DM Patients (n=131)		
Family History	No. of Patients	Percent
Yes	95	72.5
No	36	27.5
Total	131	100
T2DM with CAD Patients (n=131)		
Family History	No. of Patients	Percent
Yes	91	69.6
No	26	30.4
Total	131	100

Table no. 1 shows 72.5% (n=95) of T2DM patients with positive family history of diabetes with respect to first and second degree of relatives following 69.6% (n= 91) in T2DM with CAD group.

TABLE NO. 2: TOTAL NUMBER OF SUBJECTS WITH FAMILY HISTORY OF CVDS IN T2DM WITH CAD GROUPS

Family History of CVDs	T2DM with CAD (n, %)

Yes	88 (67%)
No	43(33%)
Total	131

Table no. 2 shows, positive family history for CVDs by considering first and second-degree relatives, that was higher in T2DM with CAD group n= 88 (67 %).

TABLE NO. 3: COMPARISON OF AGE, BMI, CIRCULATORY DIABETIC PROFILE IN STUDY POPULATION

Parameters	Control	T2DM	T2DM+CAD
Age (years)	50.7±5.9	51.2±7.0a	52.06±3.7b, c
BMI (kg/m^2)	21.2±1.65	26.02±2.44 a*	26.6±4.3b*, c
BSL-F (mg/dl)	82.9±8.21	175.73±35.3 a*	249.5±35.7b**, c*
BSL-PP (mg/dl)	105.5±7.43	264.3±49.3 a*	277.5±57.5b*c
HbA1c (%)	4.6±0.49	8.78±2.30 a*	10.6±2.9 b*, c*

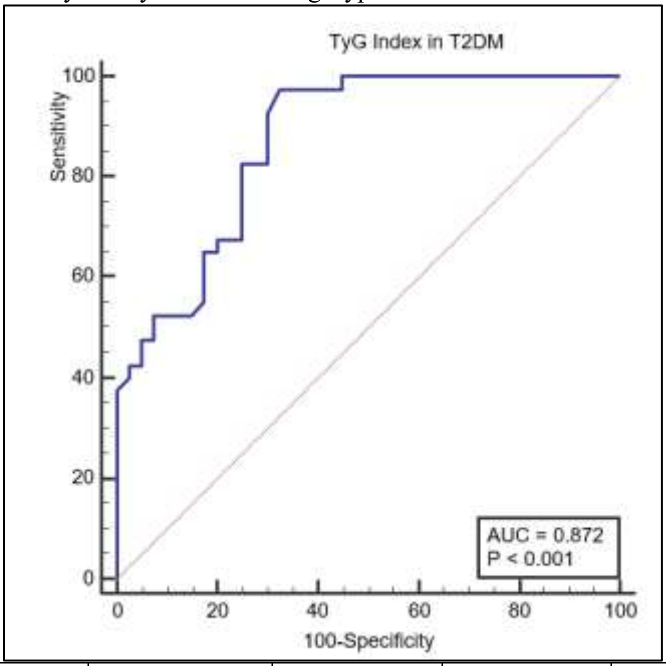
Table no. 3 shows diabetic profile in T2DM and T2DM with CAD compared with healthy control group and also within the study groups. Results expressed as Mean ± SD, p*≤0.05 significant, p**≤0.01 highly significant with 95 % CI and a, b, & c without asteric is Non-significant (NS). Above table shows a) comparison of control to T2DM, b) comparison of control to T2DM with CAD, c) comparison of T2DM to T2DM with CAD

TABLE NO.4: COMPARISON OF LIPID PROFILE IN STUDY POPULATION

Parameters	Control	T2DM	T2DM+CAD
TCholesterol (mg/dl)	167.7±25.6	202.1±27.7a*	228.2±25.7b**, c**
TG (mg/dl)	95.4±20.2	174.5±15.3 a**	199.6±15.7 b**, c*
HDL-C (mg/dl)	56.8±6.85	42.01±5.6a**	37.6±3.6 b**, c
LDL-C (mg/dl)	81.8±18.9	125.1±18.8 a**	154.5±17.9 b**, c*
VLDL-C (mg/dl)	19.09±4.0	34.9±5.3 a*	39.92±3.1 b**, c
TyG Index	8.2±0.21	9.61±-.71 a**	9.92±0.21b**, c
hsCRP	0.67 ± 0.34	8.2 ± 1.8 a **	9.0 ± 3.8 b ** c

Table no. 4 shows a) Comparison of lipid profile in control to T2DM, b) Comparison of control to T2DM with CAD, c) Comparison of T2DM to T2DM with CAD, result expressed as (Mean ±SD, p*≤0.05 significant, p**≤0.01 highly significant with 95 % CI and a, b, & c without asteric shows non-significant difference).

GRAPH 1: Receiver Operating Characteristic (ROC) Curve Showing Diagnostic Accuracy of TyG Index in Predicting Coronary Artery Disease among Type 2 Diabetes Mellitus Patients



Sensitivity	95% CI	Specificity	95% CI	Associated criterion	AUC	P value
97.50	86.8 – 99.9	67.50	50.9 – 81.4	>9	0.872	<0.001

PPV: 75(65.7 – 82.5), NPV: 96.4(79.4 – 99.5)

DISCUSSION

In table no. 1, showed 72.5% of T2DM and 69.6% of T2DM with CAD were having positive family history (FH) of diabetes. The high prevalence of family history in the two study groups shows a high genetic susceptibility to T2DM. Family history is a known risk factor for T2DM as genetic susceptibility plays a role in insulin resistance (IR) and pancreatic beta cell malfunction and glucose metabolism. Genetic and environmental factors, such as diet, lack of physical exercise and obesity, can all contribute to the chance of getting diabetes. People with diabetes in their first-degree and second-degree relatives are at increased risk of the disease.

The slightly lower proportion of positive family history in T2DM with CAD group compared to T2DM group may suggest that although genetic predisposition plays a major role in the pathogenesis of diabetes, the development of CAD in diabetic patients is also influenced by other factors like duration of diabetes, poor glycemic control, dyslipidaemia, hypertension, smoking, obesity and chronic inflammation. Thus, family history appears to be a major factor to the risk of diabetes, although the development of CAD is probably complex. The present finding is in accordance with the study done by Vassou et al [12].

Table no. 2 revealed that 67% of T2DM patients with CAD had a positive family history of CVD. The result suggests that genetic redisposition and shared familial lifestyle factors contribute not only the development of T2DM but also to the occurrence of CAD. A positive family history reflects inherited susceptibility to insulin resistance, dyslipidaemia, hypertension and atherosclerosis, thereby increasing cardiovascular risk among diabetic patients.

The present finding is in accordance with the study done by Chacko et al [13], who reported that a positive family history of CVD is an independent risk factor for coronary heart disease (CHD). The author observed that the risk of CHD increased significantly with the presence of affected family members, highlighting the role of genetic redisposition and shared environmental factors in the development of CVD.

Table no. 3 shows the age was similar in control, T2DM and T2DM with CAD groups, so that effects of age on the observed metabolic anomalies would be reduced. BMI was significantly greater in the T2DM without CAD and T2DM with CAD groups compared with the healthy control group, but there was no difference between the two diabetes groups. BMI is a known risk factor for development of insulin resistance and T2DM. Excess adipose tissue produces pro-inflammatory cytokines such as TNF-α and IL-6 leading to persistent low-grade inflammation, poor insulin signalling and endothelial dysfunction. The high incidence of obesity in the present study is comparable to the findings of Li et al [14] and Kaze et al. [15], who demonstrated significant relationship between obesity, T2DM and risk of cardiovascular diseases.

Blood sugar levels (fasting, post prandial and HbA1C) were significantly elevated in T2DM without CAD patients compared to controls and T2DM with CAD group had considerable further elevation. Data imply increasing loss of glycemic control in patients with diabetes and coronary artery disease. Chronic hyperglycemia leads to advanced glycation end products formation (AGEs), oxidative stress, inflammation and endothelial damage that contribute to the formation of atherosclerotic plaques and the development of coronary artery disease.

The significantly higher levels of FBSL and PPBSL in T2DM with CAD group can be attributed to increased insulin resistance and inefficient utilization of glucose. "Likewise, Li Y et al [14] observed a substantially higher fasting and postprandial glucose level in diabetic patients with CVD compared to those without cardiovascular disease". Postprandial hyperglycaemia has been associated with endothelial dysfunction and accelerated vascular damage.

HbA1c, a marker of long-term glycemic control, was significantly higher in both that is in diabetes groups and highest in the T2DM with CAD group. High HbA1c is a measure of long-term hyperglycaemia and an independent predictor of cardiovascular morbidity and mortality. All the elements of vascular inflammation, dyslipidaemia, platelet activation and endothelial dysfunction are related to glycaemic control and these are all fundamental to the aetiology of CAD. Our results are in agreement with the findings reported by Siha et al. [16]. Present study findings provide evidence for the idea that sustained hyperglycemia and obesity are critical in the etiology of coronary artery diseases (CAD) in type 2 diabetes mellitus (T2DM) and highlight the importance of tightly regulated glycemic control, in the reduction of future CAD risk in diabetic without CAD patients.

In the present study (table no. 4), we analysed lipid profile, TyG index and hsCRP levels in healthy control, T2DM without CAD and T2DM with CAD groups (table no. 4). Results indicated significant dyslipidaemia and elevated systemic inflammation in diabetic individuals, particularly in those with CAD. Total cholesterol level was significantly greater in T2DM and T2DM with CAD compared to control, the greatest level being in T2DM with CAD group. Increased internal cholesterol loading in arterial occlusion contributes to endothelial dysfunction and formation of atherosclerotic plaque in hypercholesterolemia. The increasing levels of total cholesterol from control to T2DM to T2DM with CAD indicate the impairment of lipid metabolism and the rise of cardiovascular disease risk. Similar discovery was published by Marx et al [17], who found that elevated cholesterol levels are directly linked with cardiovascular problems among diabetic people.

Both diabetes and diabetic CAD groups showed considerable increase in triacylglycerol (TG). The primary cause of the hypertriglyceridemia is insulin resistance (IR), characteristic of diabetic dyslipidaemia. IR enhances the release of free fatty acids from adipose tissue to the liver, resulting in increased hepatic VLDL-C production and decreased TG clearance. Elevated triglycerides result in small, dense LDL-C particles that are highly atherogenic and accelerate CAD risk. Similar findings have been reported by Hirano et al. [18] and Feng et al. [19], who demonstrated the significant role of hypertriglyceridemia, VLDL, and small dense LDL in the pathogenesis of diabetic cardiovascular complications.

Both diabetic groups reported lower HDL-C levels than controls. HDL-C offers cardioprotective advantages by reverse cholesterol transport, antioxidant activity and anti-inflammatory properties. Reduced HDL levels impaired cholesterol removal from peripheral tissues and accelerated atherosclerosis. Patients with T2DM and CAD had the lowest amounts of HDL-C indicating a higher risk for cardiovascular disease. Similar results were reported by Li Y et al. [14]. They reported that diabetic individuals had a higher prevalence of dyslipidaemia, including reduced HDL-C, which was associated with increased cardiovascular risk.

T2DM and T2DM with CAD groups showed significantly elevated LDL-C values. LDL-C contributes to the formation of atherosclerotic plaque by oxidation and accumulation in the arterial wall. High levels of LDL-C in T2DM with CAD patients show the role of LDL-C in CAD etiology. High LDL-C cause endothelial damage, inflammation and plaque instability therefore, increases cardiovascular risk. The concentration of VLDL-C was significantly greater in diabetic individuals, and highest in the T2DM with CAD group. Insulin resistance results in increased VLDL-C production and increased hepatic triglyceride synthesis. Elevated VLDL-C is connected with dyslipidaemia and increased atherosclerotic burden and cardiovascular risk. This is in accordance to Feng et al [19], they demonstrated that elevated VLDL-C and LDL-C particles are significantly associated with coronary atherosclerosis in patients with T2DM and contribute to increased cardiovascular risk.

The present study demonstrated that TyG index was significantly higher in T2DM patients (9.61 0.71) and T2DM with CAD (9.92 0.21) in comparison to healthy control (8.20 0.21). Furthermore, TyG index was significantly elevated in T2DM with CAD as compared with T2DM without CAD. Our results reveal a gradual progression of insulin resistance and cardiovascular risk from healthy people to diabetic patients and subsequently to diabetic patients with coronary artery disease.

The TyG index is a useful surrogate marker of insulin resistance, computed using fasting triacylglycerol and fasting glucose concentrations. Insulin resistance is a key element in the pathogenesis of type 2 diabetes and atherosclerosis. Thus, the higher TyG index reflects the underlying metabolic abnormalities that put one at risk for cardiovascular disease. The TyG index was significantly greater in individuals with diabetes which can be explained by the fact that the action of insulin was hindered with increased hepatic glucose synthesis, decreased peripheral glucose uptake and increased lipolysis. This in turn increases circulating free fatty acids, which accelerate hepatic triglyceride synthesis and VLDL-C generation. Thus, both fasting glucose and triglyceride levels are increased and TyG index is elevated.

The rise in TyG index was more prominent among T2DM with CAD, indicating a higher degree of insulin resistance and metabolic dysfunction. Insulin resistance is associated with endothelial dysfunction, oxidative stress, chronic inflammation and proliferation of vascular smooth muscle. These activities stimulate the formation, growth and stability of atherosclerotic plaque and thereby raise the risk of coronary artery disease in diabetic patient.

In agreement with the systemic review and meta-analysis by Liang et al [20], we observed that the high TyG index was significantly associated with the higher risk and severity of CAD. Similarly, higher TyG index values were independently associated with significant coronary artery stenosis and adverse cardiovascular events. Song et al. [21] also reported that high TyG index was associated with a higher prevalence of multivessel coronary artery disease, and a larger atherosclerotic burden.

The results of the present investigation suggest that, the TyG index may be a useful and cost-effective diagnostic tool in identifying T2DM persons at increased risk of coronary artery disease. The TyG index can be easily incorporated into cardiovascular risk assessment as fasting glucose and triglyceride are routinely assessed in clinical practice and may be useful in the early identification and prevention of CAD in diabetic patients.

Type 2 Diabetes Mellitus (T2DM) is increasingly recognized as a chronic low-grade inflammatory disorder that significantly contributes to the development and progression of coronary artery disease (CAD). Persistent hyperglycemia and insulin resistance promote oxidative stress, endothelial dysfunction, and activation of inflammatory pathways, resulting in accelerated atherosclerosis [22].

CRP is synthesized and secreted in the liver 6 h after an acute inflammatory stimulus. CRP is positively associated with the metabolic syndrome and may be an independent risk factor in patients with CAD. It is thought that CRP inhibits endothelial nitric oxide production and promotes the recruitment of monocytes into atheromatous plaques by increasing the expression of endothelial cell adhesion molecules, and leading to plaque instability. An increasing body of evidence suggests that hs-CRP levels above 2 mg/L indicate residual inflammatory risk [24]. Interestingly, an association between higher plasma levels of hs-CRP and cardiovascular events has been documented in patients with type 2 diabetes [23].

In the present study (table no.4), high sensitive C-reactive protein (hsCRP), a well-recognized inflammatory marker was considerably greater found in both diabetic groups with highest in T2DM with CAD patients. Chronic low-grade inflammation is an important promoter of insulin resistance and atherosclerosis. hsCRP is a measure of persistent vascular inflammation, endothelial dysfunction, and plaque instability. High levels of hsCRP in T2DM with CAD patients suggest the role of inflammation in progression of cardiovascular disease. We found significant association of hsCRP with TyG index in diabetic patients ($r=0.584$, $p<0.01$). In the present study, hsCRP showed a significant positive association with the TyG index among diabetic patients with coronary artery disease. This finding is in agreement with Cui C et al. [25] who reported a significant interrelationship between hsCRP and the TyG index, demonstrating that inflammation significantly mediated the association between insulin resistance and cardiovascular disease risk. Their findings support the concept that systemic inflammation and insulin resistance are closely linked mechanisms contributing to the development and progression of atherosclerotic cardiovascular disease.

Receiver operating characteristic curve analysis was performed to evaluate the diagnostic efficacy of the triglyceride-glucose index for predicting the risk of coronary artery disease in type 2 diabetes mellitus patients. The investigation showed (graph No 1), the TyG index had an Area Under the Curve (AUC) of 0.872 ($p<0.001$), indicating an excellent discriminative ability to identify the risk of CAD in diabetic individuals. The AUC value of 0.872 implies that the TyG index has significant diagnostic accuracy in effectively distinguishing T2DM patients with CAD from those without CAD risk. An AUC value of 0.80 to 0.90 is considered excellent and values greater than 0.90 indicate outstanding diagnostic ability. The cut-off value obtained in this investigation was more than 9. At this cut-off, the TyG index showed a sensitivity of 97.5% and a specificity of 67.5%. The excellent sensitivity means that the TyG index correctly identified 97.5% of the T2DM patients with CAD, suggesting its effectiveness as a screening tool. In clinical practice, increased sensitivity is important since it decreases false negative results and prevents missing high cardiovascular risk patients. In this study, the specificity of 76.5% suggests that the TyG index correctly identified 76.6% of T2DM patients without CAD. This finding demonstrates that the TyG index is able to discriminate between Non-CAD and CAD patients. Higher TyG values suggest aberrant glucose and lipid metabolism. Therefore, patients without obvious metabolic dysfunction are less likely to have higher TyG index values, which improves the ability of the TyG index to better identify patients without CAD.

Our results are consistent with those of Liang et al. [20], who showed that increased TyG index is strongly connected with the risk and severity of CAD and possesses a high discriminatory power for the identification of high-risk people. Similarly, Wu et al. [25] reported that the TyG index showed good sensitivity and specificity in diagnosing severe coronary artery stenosis. "These studies support the use of TyG index as a feasible and cost-effective biomarker for cardiovascular risk assessment in patients with type 2 diabetes mellitus."

CONCLUSION

The TyG index was a good predictor of coronary artery disease in patients with type 2 diabetes mellitus. Our results support its use as a simple, reliable and cost-effective surrogate marker for cardiovascular risk assessment, especially in resource-limited clinical settings.

LIMITATIONS

The study was done in a single tertiary care centre and this may affect the generalizability of the results. The cross-sectional design limits causal inference and potential confounding factors such as lifestyle and dietary habits were not taken into consideration. Future multicentre and longitudinal studies are warranted to validate the utility of TyG index for different populations.

ACKNOWLEDGEMENTS

We are thankful to the Department of Biochemistry, Departments of CVTS and General Medicine, MGM Medical College and Hospital, Kamothe, Navi Mumbai for their support and cooperation during the study. We would like to thank all the participants who consented to be part of this research.

FUNDING: The authors declare that they have no funding agency to acknowledge for this work.

DECLARATIONS: The authors declare that they have no conflict of interests.

REFERENCES

1. Siam NH, Snigdha NN, Tabasumma N, Parvin I. Diabetes mellitus and cardiovascular disease: exploring epidemiology, pathophysiology, and treatment strategies. *Rev Cardiovasc Med*. 2024;25(12):436. doi:10.31083/j.rcm2512436
2. Khan MAB, Hashim MJ, King JK, Govender RD, Mustafa H, Al Kaabi J. Epidemiology of Type 2 Diabetes- Global Burden of Disease and Forecasted Trends. Journal of Epidemiology and Global Health. 2020; 10: 107–111.
3. Antini C, Caixeta R, Luciani S, Hennis AJM. Diabetes mor tality: trends and multi-country analysis of the Americas from 2000 to 2019. International Journal of Epidemiology. 2024; 53: dyad182.
4. WHO. Global Health Estimates. 2023. Available at: https://ww w.who.int/data/global-health-estimates (Accessed: 29 March 2024).
5. Gaidai O, Cao Y, Loginov S. Global Cardiovascular Diseases Death Rate Prediction. Current Problems in Cardiology. 2023; 48: 101622.
6. Yun JS, Ko SH. Current trends in epidemiology of cardiovas cular disease and cardiovascular risk management in type 2 diabetes. Metabolism: Clinical and Experimental. 2021; 123: 154838.
7. Singh GM, Danaei G, Farzadfar F, Stevens GA, Woodward M, Wormser D, et al. The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. PloS One. 2013; 8: e65174.
8. Liu F, Ling Q, Xie S, Xu Y, Liu M, Hu Q, et al. Association between triglyceride glucose index and arterial stiffness and coronary artery calcification: a systematic review and exposure-effect meta-analysis. *Cardiovasc Diabetol*. 2023;22:111. doi:10.1186/s12933-023-01819-2.
9. Zhao S, et al. Association between macro- and microvascular damage and the triglyceride glucose index in community-dwelling elderly indi viduals: the Northern Shanghai Study. Cardiovasc Diabetol. 2019;18(1):95.

10. Li H, et al. Triglyceride-glucose index variability and incident cardio vascular disease: a prospective cohort study. Cardiovasc Diabetol. 2022;21(1):105.
11. Baydar O, et al. The triglyceride-glucose index, a predictor of insulin resistance, is associated with subclinical atherosclerosis. Angiology. 2021;72(10):994–1000.
12. Vassou C, Tsiampalis T, Georgousopoulou EN, Chrysohoou C, Yannakoulia M, Pitsavos C, et al. Association between family history of diabetes, irrational beliefs, and health anxiety with 10-year risk of Type 2 Diabetes Mellitus: the ATTICA epidemiological study (2002–2012). *Int J Behav Med*. 2024;31:516-526. doi:10.1007/s12529-023-10189-8.
13. Chacko M, Sarma PS, Harikrishnan S, Zachariah G, Jeemon P. Family history of cardiovascular disease and risk of premature coronary heart disease: a matched case-control study. *Wellcome Open Res*. 2020;5:70.
14. Li Y, Teng D, Shi X, et al. Prevalence of diabetes and associated cardiovascular risk factors among adults. *Cardiovasc Diabetol*. 2023;22:118.
15. Kaze AD, Santhanam P, Erqou S, et al. Obesity, diabetes and cardiovascular disease risk: a contemporary review. *Nutrients*. 2023;15(9):2045.
16. Sinha N, Sharma R, Gupta A, et al. Glycemic indices and coronary artery disease among patients with type 2 diabetes mellitus. *Indian Heart J*. 2024;76(1):45-52.
17. Marx N, Federici M, Schütt K, Müller-Wieland D, Ajjan RA, Antunes MJ, et al. 2023 ESC Guidelines for the management of cardiovascular disease in patients with diabetes: developed by the Task Force on the Management of Cardiovascular Disease in Patients with Diabetes of the European Society of Cardiology (ESC). *Eur Heart J*. 2023;44(39):4043-4140. doi:10.1093/eurheartj/ehad192.
18. Hirano T. Hypertriglyceridemia contributes significantly to high prevalence of small dense LDL-cholesterol in patients with type 2 diabetes, even when LDL-C targets are achieved. *Diabetol Int*. 2023;14:288-293. doi:10.1007/s13340-023-00634-0.
19. Feng W, Guo L, Liu Y, Ren M. Unraveling the role of VLDL in the relationship between type 2 diabetes and coronary atherosclerosis: a Mendelian randomization analysis. *Front Cardiovasc Med*. 2023;10:1234271. doi:10.3389/fcvm.2023.1234271.
20. Liang S, Wang C, Zhang J, Liu Z, Bai Y, Chen Z, et al. Triglyceride-glucose index and coronary artery disease: a systematic review and meta-analysis of risk, severity, and prognosis. *Cardiovasc Diabetol*. 2023;22:170. doi:10.1186/s12933-023-01906-4.
21. Song Y, Zhang J, Yuan H, Zhao P. An overview of the application and potential mechanism of the triglyceride-glucose index in multi-vessel coronary disease. *Lipids Health Dis*. 2024;23:238. doi:10.1186/s12944-024-02228-4.
22. Ridker PM. High-sensitivity C-reactive protein and atherosclerotic cardiovascular disease: measure or not? *US Cardiology Review*. 2024;18:e15.
23. Guo L, Lv H, Wang J, Zhang B, Zhu Y, Zhang X, et al. Predictive value of high sensitivity C-reactive protein in three-vessel disease patients with and without type 2 diabetes. *Cardiovasc Diabetol*. 2023;22:91. doi:10.1186/s12933-023-01830-7.
24. Świątkiewicz I, Magielski P, Kubica J. C-Reactive protein as a risk marker for post-infarct heart failure over a multi-year period. Int J Mol Sci. 2021;22:3169.
25. Cui C, et al. Joint association of TyG index and high-sensitivity C-reactive protein with cardiovascular disease. Cardiovasc Diabetol. 2024.
26. Xu Z, Chen P, Wang L, Yan J, Yan X, Li D. Relationship between triglyceride-glucose index and the degree of coronary artery lesions in patients with H-type hypertension. *Cardiovasc Diabetol*. 2024;23(1): —. doi:10.1186/s12933-023-02013-0.