

Research Progress on the Relationship between Triglyceride-Glucose Body Mass Index and Cardiovascular Disease Risk

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Abstract: Cardiovascular diseases (CVDs) are one of the leading causes of disability and mortality worldwide. Early identification of high-risk populations and implementation of effective interventions are crucial for reducing their incidence and mortality risks. Traditional risk assessment indicators have certain limitations, while the triglyceride-glucose body mass index (TG-GBMI), as a relatively novel metabolic syndrome evaluation metric in recent years, integrates the triglyceride-glucose index with body mass index, offering advantages such as simple calculation and good reproducibility. This article systematically reviews the research on the TG-GBMI and its correlation with major CVDs, including coronary heart disease (CHD), hypertension, heart failure, and stroke, aiming to provide references for early prevention, risk stratification, and clinical intervention of CVDs.

Keywords: Triglycerides; Glucose; Body Mass Index (TyG-BMI); Cardiovascular Disease; Risk Assessment.

1. Introduction

Cardiovascular diseases (CVDs) are currently one of the leading causes of death and disability worldwide. According to statistics from the World Health Organization (WHO), CVD-related deaths account for over 30% of total annual mortality. Early identification of high-risk populations and implementation of effective interventions are crucial for reducing the incidence and mortality rates of CVDs [1]. Among traditional CVD risk assessment indicators such as blood pressure, blood lipids, and blood glucose, although widely used in clinical practice, they still have certain limitations and cannot provide a comprehensive and accurate evaluation of individual CVD risk. In recent years, the triglyceride-glucose body mass index (TG-GBMI) has emerged as a relatively novel metabolic marker. Due to its simplicity in calculation, strong reproducibility, and close association with CVDs, it has gradually become a focal point in research on CVD risk assessment [2]. This article reviews the research progress of TG-GBMI in the context of CVDs, aiming to provide insights for early prevention, risk assessment, and clinical intervention strategies.

2. Research on the Association Between TyG-BMI Index and Cardiovascular Diseases

The TyG-BMI is derived from the integration of the triglyceride-glucose index (TyG index) and BMI, calculated as $\text{TyG index} \times \text{BMI}$ ($\text{TyG index} = \ln [\text{triglycerides (mg/dL)} \times \text{fasting blood glucose (mg/dL)} / 2]$). Initially developed to assess obesity-related insulin resistance, it has been demonstrated to have superior predictive value for cardiovascular disease risk compared to either the TyG index alone or BMI, as it simultaneously incorporates metabolic abnormalities and obesity status [3-5].

(1) TyG-BMI and Coronary Heart Disease

Coronary heart disease (CHD) is pathologically based on

coronary atherosclerosis, and TyG-BMI is closely related to its risk of onset and severity of lesions.

A meta-analysis incorporating 12 cohort studies (with a sample size exceeding 150,000 participants) demonstrated that each 1-unit increase in TyG-BMI was associated with a 31% higher risk of coronary heart disease (CHD), which was significantly greater than the associations observed for the TyG index (23%) and BMI (18%). Subgroup analyses revealed the most significant association in obese individuals with metabolic abnormalities ($\text{BMI} \geq 28 \text{ kg/m}^2$ and fasting blood glucose $\geq 6.1 \text{ mmol/L}$), where the highest quartile of TyG-BMI exhibited a 3.2-fold higher incidence risk compared to the lowest quartile [6].

Clinical studies have also demonstrated a positive correlation between TyG-BMI and the number of coronary lesions as well as the Gensini score: individuals with $\text{TyG-BMI} \geq 200$ (unit: $\ln (\text{mg}^2/\text{dL}^2) \times \text{kg/m}^2$) exhibited a 2.4-fold higher incidence of multi-vessel coronary artery disease compared to those with $\text{TyG-BMI} < 150$, which can serve as an auxiliary tool for assessing lesion severity [7-10].

(II) TyG-BMI and Hypertension

Hypertension is a significant risk factor for cardiovascular diseases. The TyG-BMI is closely associated with its onset, progression, and blood pressure control efficacy, demonstrating superior predictive value.

A 6-year prospective cohort study ($n=10,235$ residents without a history of hypertension) demonstrated that the highest quartile group of TyG-BMI (≥ 185) had a 2.8-fold higher risk of hypertension onset compared to the lowest group (< 140). In stratified analysis, the association was more pronounced in non-obese individuals ($\text{BMI} < 24 \text{ kg/m}^2$) (risk ratio 2.6), suggesting that individuals with normal weight but metabolic abnormalities can be identified as high-risk through TyG-BMI [11].

Another study demonstrated that among hypertensive patients with $\text{TyG-BMI} \geq 190$, the blood pressure target attainment rate ($< 140/90 \text{ mmHg}$) was only 32.6%, significantly lower than the 65.8% observed in those with

TyG-BMI < 160. Moreover, these patients exhibited a 2.1-fold increased risk of future target organ damage (left ventricular hypertrophy, renal injury), suggesting its potential as a biomarker for risk stratification and prognostic evaluation [12].

(3) TyG-BMI and Heart Failure

Heart failure represents the end-stage manifestation of cardiovascular disease, with a 5-year survival rate of less than 50%. TyG-BMI, which reflects the dual burden of metabolic disorders and obesity on the heart, has become a focal point for risk prediction and prognosis assessment.

A 5-year follow-up study of 5,128 community residents demonstrated that each 1-unit increase in TyG-BMI was associated with a 38% elevated risk of heart failure. Individuals with TyG-BMI ≥ 200 had a 3.1-fold higher incidence risk compared to those with < 150, a difference that remained statistically significant after adjustment for age, sex, and underlying conditions, confirming it as an independent risk factor [13].

A study of 1,362 hospitalized patients with heart failure found that those with TyG-BMI ≥ 195 had a 28.7% incidence of adverse hospital events (acute pulmonary edema, cardiogenic shock), significantly higher than the 12.3% observed in those with TyG-BMI < 170. At 1-year follow-up, the risk of all-cause mortality and cardiovascular mortality was 2.3 times and 2.5 times higher, respectively, in the former group compared to the latter, indicating effective prediction of both short-term and long-term prognosis [14].

(4) TyG-BMI Index and Stroke

The incidence, disability, and mortality rates of stroke are high. TyG-BMI is associated with its risk, subtypes, and prognosis, with particularly significant predictive value for ischemic stroke.

A meta-analysis incorporating 8 cohort studies (with a sample size exceeding 200,000 participants) demonstrated that each 1-unit increase in TyG-BMI was associated with a 25% elevated risk of stroke. Subgroup analyses revealed a stronger association with ischemic stroke (risk ratio 1.28) and no significant correlation with hemorrhagic stroke (risk ratio 1.08, $P > 0.05$). This suggests that the pathological basis of ischemic stroke (atherosclerosis) may be more susceptible to metabolic and obesity-related factors [15].

Prognostic studies have shown that among ischemic stroke patients with TyG-BMI ≥ 190 , the proportion of those with a neurological deficit score (NIHSS) ≥ 5 at 3 months post-onset was 42.5%, significantly higher than the 18.3% in those with TyG-BMI < 160. Moreover, the disability rate (modified Rankin scale score ≥ 3) increased by 2.7 times, and the mortality rate increased by 2.2 times. These findings support the use of TyG-BMI as a biomarker for assessing neurological recovery and long-term prognosis [16-19].

3. Mechanisms of TyG-BMI in Influencing Cardiovascular Diseases

(1) Insulin Resistance

Insulin resistance serves as the core biological basis of TyG-BMI and represents one of the primary pathophysiological mechanisms underlying the development of cardiovascular diseases [20]. TyG-BMI indirectly assesses the degree of insulin resistance by reflecting levels of triglycerides and blood glucose. Under conditions of insulin resistance, the effects of insulin on tissues such as the liver, muscles, and adipose tissue gradually diminish, leading to

increased hepatic glucose output, reduced muscle glucose uptake, and enhanced lipolysis. This results in elevated blood glucose levels and dysregulated triglyceride metabolism. Additionally, insulin resistance promotes the progression of cardiovascular diseases through multiple pathways. For instance, it activates the renin-angiotensin-aldosterone system (RAAS), causing vasoconstriction and elevated blood pressure [21].

(II) Lipid Metabolic Disorders

Triglycerides are a crucial component of the TyG-BMI, and elevated triglyceride levels are a common manifestation of lipid metabolism disorders. Hypertriglyceridemia promotes the onset and progression of cardiovascular diseases through multiple mechanisms. Firstly, increased triglycerides lead to elevated levels of very low-density lipoprotein cholesterol (VLDL-C), thereby increasing the risk of atherosclerosis. Secondly, hypertriglyceridemia reduces high-density lipoprotein cholesterol (HDL-C) levels, which subsequently transports cholesterol from peripheral tissues to the liver for metabolism, resulting in cholesterol deposition within vascular walls and promoting the formation of atherosclerosis [22]. Additionally, elevated triglycerides increase blood viscosity, impair hemorheology, cause vascular endothelial cell damage, and facilitate thrombus formation.

(3) Inflammatory Response

Inflammatory responses play a pivotal role in the pathogenesis and progression of cardiovascular diseases. Studies have demonstrated a positive correlation between TyG-BMI and inflammatory cytokines, suggesting that TyG-BMI may promote the development of cardiovascular diseases by activating inflammatory responses. Under conditions of insulin resistance, adipocytes secrete increased amounts of inflammatory cytokines, while inflammatory reactions are also activated in tissues such as the liver and muscles, leading to systemic inflammatory responses. Inflammatory responses can damage vascular endothelial cells, disrupt the vascular endothelial barrier function, and facilitate lipid deposition in the vascular wall, resulting in the formation of atherosclerotic plaques. Furthermore, inflammatory responses may increase plaque instability and rupture, induce thrombosis, and ultimately trigger acute cardiovascular events.

(4) Oxidative Stress

Oxidative stress refers to a pathophysiological state in which the imbalance between the body's oxidative and antioxidant systems leads to excessive production of reactive oxygen species or reduced clearance, resulting in tissue and cellular damage. Research has found that TyG-BMI is correlated with oxidative stress markers such as malondialdehyde and superoxide dismutase levels, suggesting that TyG-BMI may influence the onset and progression of cardiovascular diseases by modulating oxidative stress responses [23].

4. Value of TyG-BMI in Clinical Applications of Cardiovascular Diseases

(1) Cardiovascular Disease Risk Screening

TyG-BMI is a simple, cost-effective, and highly reproducible metabolic marker that can be used for large-scale population screening of cardiovascular diseases. Compared with traditional cardiovascular disease risk assessment indicators, TyG-BMI can identify high-risk

individuals with "obesity + metabolic disorder" as well as potential high-risk individuals with "normal weight but abnormal metabolism," thereby addressing the limitations of conventional indicators. For community populations, calculating TyG-BMI based on fasting triglyceride and blood glucose levels can rapidly identify high-risk individuals for cardiovascular diseases, providing a basis for subsequent personalized interventions [24]. For example, individuals with a TyG-BMI ≥ 8.5 may be recommended to undergo further examinations such as blood pressure, lipid profile, and electrocardiogram (ECG) to determine the presence of cardiovascular diseases or risk factors, and to implement corresponding interventions, thereby reducing the risk of cardiovascular disease [25].

(II) Cardiovascular Disease Assessment

TyG-BMI can also be applied to the assessment of cardiovascular disease patients. For patients with coronary heart disease (CHD), the level of TyG-BMI is closely associated with the severity of coronary artery lesions and can serve as an auxiliary indicator for evaluating the severity of coronary artery lesions [26]. For patients with heart failure, TyG-BMI can predict the prognosis of patients. Patients with higher TyG-BMI indices have a higher risk of all-cause mortality and cardiovascular mortality. Clinicians can develop personalized treatment plans based on TyG-BMI levels and strengthen follow-up and management for high-risk patients [27]. For stroke patients, TyG-BMI can assess the degree of neurological deficits and prognosis, providing references for subsequent clinical treatment and rehabilitation guidance.

(3) Monitoring of Therapeutic Efficacy in Cardiovascular Diseases

TyG-BMI can also be applied to monitor the therapeutic efficacy of cardiovascular diseases. During the treatment of cardiovascular disease patients, regular monitoring of TyG-BMI levels can effectively evaluate the effectiveness of the treatment regimen [28]. For instance, in patients with diabetes and cardiovascular disease undergoing hypoglycemic and lipid-lowering therapy, a significant decrease in TyG-BMI levels indicates that the treatment is effective, and the current regimen can be maintained. If there is no significant change or an increase in TyG-BMI levels, it suggests that the treatment may need adjustment, such as by increasing the dosage or changing the medication [29]. Additionally, TyG-BMI can be used to assess the effectiveness of lifestyle interventions, such as dietary control and increased physical activity. A reduction in TyG-BMI levels indicates that the lifestyle intervention is effective, and further efforts to strengthen lifestyle modifications can be made [30].

5. Epilogue

TyG-BMI is a relatively novel metabolic marker that exhibits close associations with the pathogenesis of cardiovascular diseases. Its mechanisms of action may involve insulin resistance, lipid metabolism disorders, inflammatory responses, and oxidative stress. TyG-BMI holds significant clinical value in cardiovascular disease risk screening, clinical assessment, and therapeutic monitoring. However, current research on TyG-BMI remains limited, necessitating further investigations in this field.

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