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Mini-Review

The Triglyceride-Glucose Index: An Accessible Tool for Risk Stratification in Chronic Kidney Disease

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Abstract: Background: Chronic kidney disease (CKD) presents a significant global burden, requiring accessible risk assessment tools. Insulin resistance (IR), pivotal in cardiometabolic pathologies, contributes significantly to kidney injury and progression. The triglyceride-glucose (TyG) index offers a simple, cost-effective, insulin-independent surrogate for IR. This review synthesizes evidence on TyG's utility, limitations, and future directions concerning kidney disease outcomes. **Methods:** A literature search was conducted in PubMed, Scopus, and Google Scholar for publications from December 2008 to May 2025. Systematic reviews, meta-analyses, and observational studies (cohort, cross-sectional) were included, examining TyG's relationship with kidney disease (incident CKD, progression, DKD), T2DM as a DKD risk factor, and cardiometabolic outcomes in CKD populations. **Results:** Evidence from diverse cohorts has consistently shows elevated TyG index consistently associated with increased risk of incident T2DM, incident CKD, established CKD progression (including ESRD), and prevalent/incident diabetic kidney disease (DKD). Higher TyG also independently predicted increased cardiovascular events and mortality in CKD. Mechanistically, TyG reflects IR-driven pathways (endothelial dysfunction, oxidative stress, inflammation) linked to kidney damage. Existing challenges include the lack of standardized formula/thresholds and complex associations in diverse CKD subgroups. **Conclusion:** The TyG index is a promising marker for increased risk of developing and progressing CKD, including DKD. Although evidence demonstrates its association with adverse renal/cardiorenal outcomes, this needs to be clarified and standardized through robust clinical validation in diverse CKD populations, while adjusting for potential confounders to promote its application in CKD risk assessment.

Keywords: Triglyceride-glucose index; insulin resistance; type 2 diabetes; chronic kidney disease; diabetic kidney disease; CKD progression; risk stratification

1. Introduction

Chronic kidney disease (CKD) is a major global public health challenge, not only leading to end-stage renal disease (ESRD) but also cardiovascular morbidity and mortality [1]. Insulin resistance (IR) is one of the metabolic abnormalities that may contribute to the initiation and progression of kidney injury through complex pathways [2–8]. The hyperinsulinemia-euglycemic clamp (HEC) technique is the gold standard for assessing insulin resistance, but its use in clinical trials and epidemiological studies is limited. The Triglyceride-Glucose (TyG) index, derived from routine fasting triglyceride and glucose measurements, offers a simple, alternative surrogate marker for

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insulin resistance (IR) [9–12]. Studies in diverse populations have demonstrated that elevated TyG index can predict the development of Type 2 Diabetes Mellitus and is also associated with the risk of CKD (including non-diabetic CKD), CKD progression to ESRD, and adverse cardiovascular events in CKD populations [13–16].

The emerging concept of cardiometabolic kidney disease (CMKD) highlights the critical bidirectional relationship between metabolic dysfunction, cardiovascular disease, and chronic kidney disease. This framework recognizes CKD not merely as a consequence, but as an integral component of a broader systemic cardiometabolic disorder. Insulin resistance, a central driver of CMKD, often precedes and exacerbates both cardiac and renal pathologies. Given its ability to reflect insulin resistance, the TyG index is considered an accessible tool to identifying individuals at a higher risk within this cardiometabolic spectrum, which facilitates early risk stratification and implementation of interventions for individuals with CMKD.

This mini-review synthesizes current evidence on the utility, limitations, and future directions of the TyG index in the context of chronic kidney disease. A comprehensive search of PubMed, Scopus, and Google Scholar was conducted, focusing on systematic reviews, meta-analyses, and observational studies (cohort, cross-sectional) published between December 2008 and May 2025, exploring the TyG index's association with various kidney disease outcomes and cardiometabolic comorbidities. Keywords/MeSH terms used for the search included 'Triglyceride-glucose index', 'insulin resistance', 'type 2 diabetes', 'chronic kidney disease', 'diabetic kidney disease', 'CKD progression', and 'risk stratification'.

2. The TyG Index and Chronic Kidney Disease (CKD)

The TyG index has shown a correlation in predicting the onset of CKD across various populations, including those without diabetes. A cohort study among Chinese hypertensive patients independently associated higher baseline TyG with significantly increased incident CKD risk [17]. Similarly, longitudinal data among non-diabetic individuals also demonstrated that long-term exposure to higher TyG patterns significantly increased subsequent CKD incidence [14]. In a prospective cohort study with long-term follow-up among non-diabetic adults, the adjusted Hazard Ratio for incident CKD was 1.77 (95% CI: 1.45–2.16) comparing the highest versus lowest quartile of long-term average TyG [14]. Another prospective cohort study reported an adjusted Hazard Ratio for incident CKD of 1.61 (95% CI: 1.15–2.27) comparing the highest versus lowest TyG categories [18]. Additional longitudinal and retrospective studies have reinforced these findings across diverse populations [19,20]. In a meta-analysis by Ren et al., elevated TyG was associated with the incidence of CKD with a pooled Relative Risk of 1.47 (95% CI: 1.32–1.63) compared to lower levels [21].

Observational studies in a Chinese population have shown an association between an elevated TyG index and the prevalence of CKD [20,22]. An assessment of NHANES data revealed a positive correlation with the prevalence of CKD [15]. Okamura et al. [23] also found in a Japanese Cohort an association of higher TyG index and incident CKD. The PURE study, conducted across five continents, did not address associations with chronic kidney disease but identified a higher risk of diabetes mellitus in both high-income and low-income countries [24].

3. The TyG Index and CKD Progression

Prospective Cohort studies within established CKD populations consistently link higher baseline TyG levels with adverse renal outcomes, including a more rapid decline in estimated glomerular filtration rate (eGFR) [25,26] and an increased long-term risk of progressing to end-stage renal disease (ESRD) [27]. A meta-analysis in patients with established CKD demonstrates that elevated TyG levels significantly predict accelerated CKD progression [13], reporting a pooled Hazard Ratio of 1.52 (95% CI: 1.36–1.70).

Studies also indicate that dynamic changes in the TyG index over time may provide prognostic information regarding CKD progression. For example, in hypertensive CKD patients, a decrease in TyG over the follow-up period was associated with a reduced likelihood of progression (HR 0.87) [17]. Although some studies comparing TyG to other IR or composite indices show variations in predictive performance for renal function decline [15], the overall evidence supports TyG as a relevant predictor.

4. The TyG Index in Diabetic Kidney Disease (DKD)

Longitudinal evidence has shown that higher baseline TyG levels can predict future risk of CKD in T2DM cohorts [25,28] and correlate with increased long-term risk of disease progression to ESRD [27]. The Odds Ratios (ORs) for the prevalent albuminuria or reduced eGFR often range from 1.6 to over 2.3 for individuals with high TyG levels compared to those with lower levels [29,30]. A meta-analysis of observational studies further validated the association between higher TyG and increased risk of DKD [31]. Associations with composite indices have also been observed within T2DM populations; for example, TyG-BMI was found to be significantly linked to the

prevalent of albuminuria and CKD in T2DM [19], while TyG-BRI was associated with prevalent CKD in this cohort (OR ~1.57) [32].

Meta-analyses focusing on individuals with T2DM demonstrate that a higher TyG index is significantly associated with an increased risk of Diabetic Nephropathy. Cross-sectional studies consistently report positive associations between elevated TyG and the presence of prevalent albuminuria (both micro- and macroalbuminuria) and reduced eGFR [29,33].

Various studies have proposed specific TyG thresholds aimed at identifying individuals within T2DM populations at significantly elevated risk for DKD (e.g., thresholds around 9.0–9.7 were suggested for predicting incident DKD in some cohorts) [30,31]. However, as noted earlier, these thresholds lack universal validation and are subject to variability based on calculation methods and study populations, hindering their immediate clinical application.

5. General Cardiovascular Risk Assessment (Including Mortality) in the CKD Population

Individuals with CKD are at significantly higher risk of cardiovascular disease (CVD) and mortality, which is due to the systemic nature of CMKD [3,13,34]. Therefore, identifying accessible markers that can help to stratify this already high-risk population. The metabolic dysregulation reflected by the TyG index, known to contribute to both kidney damage and systemic vascular pathology central to CMKD, makes it a plausible candidate for comprehensive cardiometabolic risk assessment within the CKD context.

Meta-analyses evaluating the association between TyG and cardiovascular outcomes in CKD patients consistently demonstrate a strong positive link [13]. Elevated TyG index levels are significantly associated with an increased risk for major adverse cardiovascular events (MACE) in this vulnerable population. For instance, a meta-analysis reported an Odds Ratio of 1.68 (95% CI: 1.11–2.54, P = 0.014) for MACE associated with higher TyG levels in CKD patients [13].

Prospective cohort studies conducted within established CKD populations generally corroborate these findings. Higher baseline TyG levels have been independently associated with increased incidence of specific cardiovascular endpoints, including myocardial infarction (MI), stroke, heart failure, and overall MACE [13,35–37]. The association is also consistently observed with both cardiovascular mortality and all-cause mortality in CKD patients [13,35–37]. Hazard Ratios for these outcomes in individuals with higher TyG typically range from 1.19 to 1.68, depending on the specific endpoint examined [13,35–37].

Composite indices combining TyG with anthropometric parameters, such as TyG-BMI and other body composition measures, have also been shown to be associated with increased risk in CKD populations [15,20,32]. Some studies suggest these composite measures might potentially improve predictive performance compared to TyG alone [32].

These findings indicate that the TyG index serves as a readily available and significant predictor of cardiovascular events and mortality, providing valuable complementary information for risk stratification in chronic kidney disease populations.

6. Practical Considerations, Limitations, and Future Directions for the TyG Index in CKD

As illustrated by the findings summarized in Tables 1–3, elevated TyG index levels have been consistently linked to increased risk across multiple key outcomes in CKD, including its incidence, progression, the development of diabetic kidney disease, and significant cardiovascular events and all-cause mortality. While this widespread predictive association underscores the index's potential utility, it is imperative to examine the practical viability and inherent limitations that impact its clinical application.

A critical limitation is the lack of methodological standardization and the absence of universally validated, clinically actionable risk thresholds, not only across different CKD populations but also across various populations in general [7,9,29–31,38–45]. Inconsistent formulas, variable units, and non-uniform logging transformations yield dramatically inconsistent TyG values across studies, crippling the ability to compare findings or confidently apply proposed thresholds to individual patients [7,9,29,39–44]. This methodological heterogeneity is evident across studies in CKD populations [13,30,31,38]. Furthermore, the frequent reporting of complex, often non-linear associations, including concerning U-shaped relationships between TyG and outcomes [46], complicates the clinical application of proposed risk thresholds.

Critically, the most significant impediment preventing direct clinical utility is the complete absence of evidence from randomized controlled trials (RCTs). There are simply no data demonstrating that interventions triggered by TyG levels, or targeting the metabolic state they reflect more aggressively, translate into improved 'hard' renal or cardiovascular outcomes compared to current standard care in CKD patients. Currently, TyG functions solely as an associative research marker, not a validated determinant of specific therapeutic action.

In conclusion, while the TyG index has high clinical utility as a critical metabolic driver of cardiorenal disease owing to its easy accessibility, there are limitations that prevents its routine widespread clinical application. Therefore, high-quality research is needed to transform its clinical utility in contemporary nephrology practice.

Table 1. Key Meta-Analyses and Umbrella Reviews on TyG Index and Chronic Kidney Disease (CKD)-Related Outcomes.

Study Design & Focus	Author, Year [Ref.]	Population/Context	Key Finding	Statistical Result
Meta-Analysis	Tuo J et al., 2025 [13]	CKD patients	TyG predicts CKD progression, ESRD, and mortality	HR 1.52 (95% CI: 1.36–1.70) for CKD progression
Meta-Analysis	Deng S& Peng L, 2025 [31]	T2DM patients	Elevated TyG increases DN risk	Pooled RR 1.53 (95% CI: 1.37–1.71)
Meta-Analysis	Ren X et al., 2023 [21]	General population	TyG is associated with incident CKD	Pooled RR 1.47 (95% CI: 1.32–1.63)
Umbrella Review (Meta-analysis of meta-analyses)	Nayak SS et al., 2024 [47]	Various (Includes CKD, CIN, T2DM, CVD, etc.)	Higher TyG is associated with increased risk of CKD (among other outcomes)	Pooled RR 1.46 (95% CI: 1.32–1.63) for CKD; OR 2.24 (95% CI: 1.82–2.77) for CIN

Abbreviations: CKD: Chronic Kidney Disease; T2DM: Type 2 Diabetes Mellitus; ESRD: End-Stage Renal Disease; CVD: Cardiovascular Disease; HR: Hazard Ratio; OR: Odds Ratio; RR: Relative Risk; CI: Confidence Interval; CIN: Contrast-Induced Nephropathy.

Table 2. Key Prospective Cohort Studies on TyG Index and Chronic Kidney Disease (CKD)-Related Outcomes.

Study Design & Focus	Author, Year [Ref.]	Population/Context	Key Finding	Statistical Result
Prospective Cohort	Chen N et al., 2024 [14]	Non-diabetic adults	Long-term high TyG increases CKD risk	HR 1.77 (95% CI: 1.45–2.16) for highest vs. lowest quartile
Prospective Cohort	Kunutsor SK et al., 2024 [18]	Middle-aged men	TyG predicts new CKD cases	HR 1.59 (95% CI: 1.24–2.05) per unit increase
Prospective Cohort	Yu C et al., 2024 [17]	Hypertensive CKD patients	TyG decrease reduces progression	HR 0.87 (95% CI: 0.76–0.98) for TyG decrease
Prospective Cohort	Low S et al., 2022 [25]	T2DM patients	TyG predicts CKD progression	HR 1.21 (95% CI: 1.06–1.37) per unit increase
Prospective Cohort	Wang X et al., 2025 [48]	T2DM patients (ACCORD Trial)	Higher TyG linked to increased CKD risk, faster eGFR decline	HR 1.46 (95% CI: 1.13–1.88) for tertile 3 vs. 1 in women; p-interaction = 0.03
Prospective Cohort	Yoshida D et al., 2024 [26]	General population	Elevated TyG is associated with future renal function decline	HR 2.25 (95% CI: 1.40–3.60)
Prospective Cohort	Li Z et al., 2024 [49]	NHANES participants	TyG is associated with incident CKD and mortality in CKD (compared to other indices)	HR 1.21 (95% CI: 1.07–1.37) for incident CKD (TyG highest vs. lowest quartile)
Prospective Cohort (Nested Case-Control Component in Abstract)	Shen R et al., 2024 [46]	NHANES participants (TyG & other IR indices vs. CKD/mortality)	TyG associated non-linearly with prevalent CKD; TyG-WHtR better predictor for CKD prevalence and mortality	OR 1.77 (95% CI 1.44–2.18) for prevalent CKD when TyG > 9.05; HR 1.34 (95% CI 1.14–1.58) for all-cause mortality in CKD (TyG-WHtR)

Abbreviations: CKD: Chronic Kidney Disease; T2DM: Type 2 Diabetes Mellitus; HR: Hazard Ratio; OR: Odds Ratio; CI: Confidence Interval; eGFR: estimated Glomerular Filtration Rate; IR: Insulin Resistance; TyG-WHtR: Triglyceride-Glucose × Waist-to-Height Ratio.

Table 3. Key Retrospective Cohort, Cross-sectional, and Case-Control Studies on TyG Index and Chronic Kidney Disease (CKD)-Related Outcomes.

Study Design & Focus	Author, Year [Ref]	Population/Context	Key Finding	Statistical Result
Retrospective Cohort Studies				
Retrospective Cohort	Wei S et al., 2024 [50]	MAFLD patients	TyG predicts CKD in MAFLD	HR 1.19 (95% CI: 1.09–1.29) per unit increase
Observational/Retrospective	Tatli E., 2025 [33]	T2DM patients	TyG is associated with prevalent microalbuminuria	OR 3.35 (95% CI: 1.778–6.32) for microalbuminuria
Retrospective Cohort	Chi X et al., 2025 [51]	Maintenance of HD patients	TyG predicts all-cause and cardiovascular mortality in MHD patients	HR 1.790 ($p = 0.006$) for all-cause mortality (high vs. low TyG); HR 1.735 ($p = 0.022$) for CV mortality (high vs. low TyG)
Cross-sectional & Case-Control Studies				
Cross-sectional	Lv L et al., 2021 [29]	T2DM patients	TyG predicts DKD	OR 2.34 (95% CI: 1.74–3.14) for albuminuria
Cross-sectional	Liu L et al., 2021 [30]	Hospitalized T2DM patients	TyG is independently associated with DN	OR 1.91 (95% CI: 1.29–2.82); AUC 0.67
Cross-sectional	Shi Y et al., 2022 [22]	Hypertensive patients	TyG is associated with CKD prevalence (compared to other IR indices)	OR 1.48 (95% CI: 1.21, 1.81) for highest vs. lowest TyG tertile
Nested Case-Control	Shang J et al., 2019 [38]	Treated T2DM patients	TyG predicts biopsy-proven DN	Non-linear relationship with TyG threshold 9.05–9.09
Cross-sectional	Wu Y et al., 2025 [15]	NHANES participants	TyG and composites linked to CKD/CVD/CRS prevalence	OR 1.42 for CKD (95% CI: 1.11–1.82); non-linear association
Cross-sectional	Nabipoorashrafi et al., 2023 [52]	T2DM patients	TyG index exhibited the highest association with the incidence of albuminuria (compared to other IR indices)	OR 1.67 for prevalent albuminuria (95% CI 1.37–2.0); AUC 0.62 (TyG vs. albuminuria)
Cross-sectional	Chen T et al., 2024 [20]	Chinese adults	Compares TyG & composites for CKD detection; TyG-WHtR best AUC, but TyG highest OR for reduced eGFR	OR 2.713 (95% CI 1.446–5.090) for reduced eGFR (TyG); AUC 0.687 (TyG-WHtR)
Population-Based Study (Cross-sectional)	Liu L et al., 2024 [53]	NHANES participants with CKD	TyG is associated with CVD risk in CKD, which is stronger in later stages; suggesting a non-linear relationship	OR 1.213 (95% CI 1.059, 1.389) for CVD in CKD; OR 2.131 (95% CI 1.224–3.709) in CKD stages 4–5 (TyG vs. CVD)

Abbreviations: CKD: Chronic Kidney Disease; T2DM: Type 2 Diabetes Mellitus; DN: Diabetic Nephropathy; ESRD: End-Stage Renal Disease; CV: Cardiovascular; CVD: Cardiovascular Disease; MAFLD: Metabolic Associated Fatty Liver Disease; HR: Hazard Ratio; OR: Odds Ratio; CI: Confidence Interval; eGFR: estimated Glomerular Filtration Rate; CRS: Cardiorenal Syndrome; IR: Insulin Resistance; ROC: Receiver Operating Characteristic; AUC: Area Under the Curve; MHD: Maintenance Hemodialysis; TyG-WHtR: Triglyceride-Glucose × Waist-to-Height Ratio.

Author Contributions

H.T.: Conceptualization, Methodology, Investigation, Writing—original draft preparation, Visualization. B.N.: Conceptualization, Methodology, Writing—reviewing and editing. P.T.: Conceptualization, Writing—reviewing and editing, Project administration. All authors have read and agreed to the published version of the manuscript.

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