Impacts of triglycerides-glucose index on prognosis of patients with type 2 diabetes mellitus and non-ST-segment elevation acute coronary syndrome: results from an observational cohort study in China

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Abstract

Background

The relationship between triglycerides-glucose index (TyG index) and the prevalence and prognosis of cardiovascular disease has been confirmed by former studies. However, it remains uncertain whether TyG index has a prognostic impact in patients with type 2 diabetes mellitus (T2DM) and non-ST-segment elevation acute coronary syndrome (NSTE-ACS) undergoing percutaneous coronary intervention (PCI).

Methods

The study retrospectively enrolled 832 patients (mean age: 60.7 ± 8.4 years; 68.1% men) with T2DM and NSTE-ACS who underwent PCI at Beijing Anzhen Hospital from January to December 2015. TyG index was calculated as previously reported: \( \ln \left( \frac{\text{fasting TGs (mg/dL)} \times \text{FBG (mg/dL)}}{2} \right) \). The primary endpoint was a composite of adverse events as follows: all-cause death, non-fatal myocardial infarction (MI) and ischemia-driven revascularization.

Results

TyG index were significantly higher in patients with a primary endpoint event compared with those without. Multivariate Cox analysis showed that 1-unit increase of TyG index was independently associated with higher risk of primary endpoint, independent of other risk factors (hazard ratio (HR) 2.644 per 1-unit increase, 95% confidence interval (CI) 2.086–3.352, \( P < 0.001 \)). The addition of TyG index to a baseline risk model had an incremental effect on the predictive value for adverse prognosis [AUC: baseline risk model, 0.748 vs. baseline risk model + TyG index, 0.860, \( P \) for comparison < 0.001; category-free net reclassification improvement (NRI) 0.378, \( P < 0.001 \); integrated discrimination improvement (IDI) 0.139, \( P < 0.001 \)].

Conclusion

Increased TyG index is a significant predictor of adverse prognosis in patients with T2DM and NSTE-ACS undergoing PCI. Further studies need to be performed to determine whether interventions for TyG index have a positive impact on improving clinical prognosis.

Background

Coronary artery disease (CAD) has been recognized as the leading cause of disability and mortality in contemporary society. In recent years, in spite of superior evidence-based strategies including optimized drug therapy and revascularization having been widely developed and applied, the risk of recurrent adverse cardiovascular outcomes remains relatively high in patients with CAD, especially for those who have ever had an acute coronary syndrome (ACS) [1–3]. Previous studies have suggested that more than one-quarter of patients with ACS are combined with Type 2 Diabetes mellitus (T2DM), which has been widely proved to be one of the most significant risk factors for cardiovascular disease [4]. Certain studies have demonstrated that T2DM is significantly correlated with higher prevalence of CAD, more complex coronary lesions and worse prognosis [4–6]. Therefore, identification of the residual risk factors of diabetic patients with ACS is of great clinical importance if we are to develop new therapeutic targets and to tailor risk reduction strategies that match individual risk level.

Insulin resistance (IR), the critical mechanism of the pathogenesis of T2DM, has been extensively demonstrated to be significantly related to the development and progression of coronary atherosclerosis and an increased risk of adverse prognosis [7–9]. The triglyceride-glucose index (TyG index), which is derived from fasting triglycerides (TGs) and fasting blood glucose (FBG), has been proposed as a surrogate biomarker of IR and former studies have proved that it has high correlation with hyperinsulinaemic-euglycaemic clamp (the gold standard technique for assessing IR), either in individuals with or without T2DM [10–12]. Studies have shown that an increased level
of TyG index is closely related to higher incidence of diabetes and prediabetic status [13–15]. Furthermore, the association between TyG index and the prevalence and prognosis of cardiovascular disease has been confirmed by certain clinical researches, despite the existence of diabetes or not at baseline [16–20].

However, the prognostic significance of TyG index in patients with T2DM and non-ST-segment elevation acute coronary syndrome (NSTE-ACS) who were treated with percutaneous coronary intervention (PCI) has not been fully studied. Based on this, the present study was designed with the aim of: (1) identifying the potential association between IR quantified by TyG index and clinical prognosis; (2) determining whether TyG index has an incremental effect on risk stratification on the basis of traditional risk factors in participants with T2DM and NSTE-ACS undergoing PCI.

Methods

Study population

The present study is a single-center, observational, retrospective cohort study among patients with T2DM who were diagnosed with NSTE-ACS and treated with elective PCI at Beijing Anzhen Hospital between January and December 2015. The exclusion criteria were listed as follows: (1) missing clinical data; (2) PCI failure, PCI-related complications, and in-hospital death; (3) renal dysfunction with estimated glomerular filtration rate (eGFR) < 30 mL/(min * 1.73 m2), or treated with renal replacement therapy; (4) severe hepatic disease; (5) history of coronary artery bypass grafting (CABG), cardiogenic shock, chronic inflammatory disease, neoplasm, or other serious diseases. Ultimately, a cohort of 832 patients who met the enrollment principles were included for the present analyses.

Data collection and definitions

Data of demographic and clinical characteristics, including age, sex, weight, height, heart rate, blood pressure [systolic blood pressure (SBP) and diastolic blood pressure (DBP)], medical history, family history, and medical treatment were extracted from the medical information recording system of Beijing Anzhen Hospital. Body mass index (BMI) was calculated as follows: BMI = weight (kg) / [height (m)]². Criteria for diabetes include: (1) previously diagnosed diabetes under treatment of antidiabetic medication (diet, oral agents, and/or insulin); (2) the typical symptoms of diabetes with a random blood glucose ≥ 11.1 mmol/L, and/or FBG ≥ 7.0 mmol/L, and/or 2-h blood glucose after oral glucose tolerance test (OGTT) ≥ 11.1 mmol/L [21]; (3) glycosylated hemoglobin A1c (HbA1c) level ≥ 6.5% on admission [22]. NSTE-ACS was composed of non-ST-segment elevation myocardial infarction (NSTEMI) and unstable angina (UA), definitions of which were determined by appropriate guidelines [23]. NSTEMI was defined as having symptoms of ischemia and elevated cardiac troponin I (cTnI), and without an elevation of ST-segment. UA was diagnosed as ischemic symptoms at rest, or exacerbated or new-onset symptoms with transient ischemic ST-segment shifts, and without release of myocardial enzymes related to myocardial necrosis. Patients with SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg, or those receiving anti-hypertensive treatments were considered having hypertension. Peripheral vascular disease (PVD) was defined as aorta and other arteries than coronary arteries, with exercise related claudication, or reduced or absent pulsation, or angiographic stenosis of more than 50%.

Venous blood samples were collected after an overnight fasting on the day of the baseline coronary procedure. The routine hematological and biochemical parameters, including lipid profiles [TGs, total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C)], creatinine, uric acid, FBG, HbA1c, high-sensitivity C-reactive protein (hs-CRP), and other biomarkers, were determined by standard laboratory methods in central lab of Beijing Anzhen Hospital. Patients with fasting TC > 200 mg/dL, and/or LDL-C > 130 mg/dL, and/or TGs > 150 mg/dL, and/or HDL-C < 40 mg/dL, and/or long-term use of lipid-lowering drugs were considered having dyslipidemia. The eGFR was calculated as previously described: eGFR [mL/(min * 1.73 m²)] = 186 * serum creatinine (mg/dL)−1.154 * age−0.203 (* 0.742 if female) [24]. Baseline TyG index was calculated based on fasting TGs and FBG values obtained at admission as previously reported: ln [fasting TGs (mg/dL) * FBG (mg/dL) / 2] [10]. Left ventricular ejection fraction (LVEF) was evaluated by two-dimensional
modified Simpson's method using an ultrasonic cardiogram (Philips Company, Eindhoven, The Netherlands).

Coronary angiography data were analyzed and recorded by at least two experienced cardiologists, and measurements of coronary artery lesion characteristics were obtained. The lesion characteristics were defined as follows: (1) multi-vessel lesion: more than two main coronary branches (vessel diameter ≥ 2 mm) with extent of stenosis ≥ 50%. (2) chronic total occlusion lesion: lesion with complete obstruction [thrombolysis in myocardial infarction (TIMI) flow grade 0] lasting longer than 3 months, which was judged from the previous medical history or coronary angiogram results. (3) diffuse lesion: a single stenotic lesion with a length of ≥ 20 mm. (4) bifurcation lesion: stenosis occurred adjacent to and/or involving the origin of a significant side branch that has too much functional value and so cannot be lost during the interventional procedure. (5) in-stent restenosis: stenosis of ≥ 50% occurring in the segment inside the stent, 5 mm proximal or distal to the stent [25]. The severity of coronary artery lesions was quantified by the synergy between PCI with taxus and cardiac surgery (SYNTAX) score. The SYNTAX score was calculated for each participant using the online calculator (www.syntaxscore.com). PCI was performed in accordance with current practice guidelines in China, and detailed strategies were determined by experienced interventional cardiologists.

**Follow-up**

After baseline PCI, all patients were followed up by trained professionals who were blinded to the baseline information at 3, 6, and 12 months and then annually for up to 36 months. The information about adverse prognostic events was obtained from patients or their family members by telephone questionnaire. The information was further confirmed by careful verification of corresponding medical records if necessary. The primary observational endpoint was defined as a composite of events including all-cause death, non-fatal myocardial infarction (MI) and ischemia-driven revascularization. The secondary observational endpoints are each component of the composite primary endpoint. For patients who had multiple adverse outcomes during the follow-up, only the most severe event (all-cause death > non-fatal MI > ischemia-driven revascularization) was selected to perform our analyses. If the same event occurs multiple times, only the first occurrence was used for analysis.

**Statistical analysis**

Continuous variables were presented as mean ± standard deviation (SD) or median (25th and 75th percentiles: P25, P75) in the case of normal or non-normal distribution, and differences between the two groups were examined by independent-sample t-test or Mann-Whitney U test correspondingly. Categorical variables were described as counts (percentages) and compared by Pearson chi-square test (Pearson χ² test) or Fisher’s exact test appropriately. The Spearman’s rank correlation test was used for evaluating the correlations between the TyG index and cardiovascular risk factors. The Kaplan-Meier survival analyses were performed to evaluate the incidence rate of adverse events between groups according to the median of TyG index, and discrepancies between groups were evaluated by log-rank test. The predictive value of the variables for primary endpoint was evaluated by univariate and multivariate Cox proportional hazards analyses. The TyG index was analyzed in two ways: (1) as a categorical variable; and (2) as a continuous variable. In multivariate Cox proportional hazards analyses, 4 models were established to evaluate the predictive value of TyG index for primary endpoint, among which confounders were selected according to statistical significance (P < 0.2) in univariate analysis and clinical importance: (1) Model 1: adjusted for age, sex, BMI, SBP, DBP, smoking, drinking, dyslipidemia, prior MI, prior PCI, stroke and PVD; (2) Model 2: adjusted for variables included in Model 1 and diagnosis (NSTEMI), TC, HDL-C, eGFR, HbA1c, LVEF; (3) Model 3: adjusted for variables included in Model 2 and SYNTAX score and number of stent; (4) Model 4: adjusted for variables included in Model 3 and discharge medication including statins, oral hypoglycemic agents and insulin. The prognostic impact of TyG index for each component of primary endpoint was also assessed by using model 4. FBG and TGs were not introduced into multivariate analysis since the TyG index was calculated from them. Results of Cox proportional hazards analyses were presented as hazard ratio (HR) and 95% confidence intervals (CI). Further subgroup analyses stratified by age, sex, BMI, hypertension, initial diagnosis, HbA1c or LDL-C were employed to examine the consistency of the prognostic impact of TyG index for primary endpoint. The model used in the subgroup analyses consisted of all covariates used in Model 4 except for the variables that were used for stratification.
C-statistics including receiver-operating characteristic (ROC) curve analysis were performed to examine the incremental effects of TyG index on the predictive potential of the baseline risk model that including traditional risk factors. DeLong’s test was used to compare the area under the curve (AUC) from each of the models. We also calculated category-free net reclassification improvement (NRI) and integrated discrimination improvement (IDI) to determine the extent to which the addition of TyG index improves the predictive power of existing baseline risk model.

Statistical tests were performed with SPSS 23.0 (SPSS Inc., Chicago, Illinois, USA), the R Programming Language (version 3.5.1) and MedCalc version 19.1 (MedCalc Software, Belgium). A two-tail P value < 0.05 was regarded as statistically significant.

### Results

A total of 832 patients (mean age: 60.7 ± 8.4 years; 68.1% men) were finally enrolled in present study. During the 36-month follow-up period, seventeen patients (2.0% of total population) were lost to follow-up. Among the 832 participants, 207 (24.9%) experienced primary endpoint events, which consisted of 14 (1.7%) all-cause death, 44 (5.3%) non-fatal MI, and 149 (17.9%) ischemia-driven revascularization.

#### Baseline characteristic of study population

Baseline characteristics of the total population and groups stratified by the occurrence of primary endpoint events were presented in Table 1. TyG index was significantly higher in patients with primary endpoint event compared with those without. Patients with a primary endpoint event showed higher age, SBP, DBP, and higher prevalence of dyslipidemia, previous MI and previous PCI history. In terms of laboratory indicators, participants with endpoint event had higher levels of TGs, TC, hs-CRP, FBG and HbA1c, but lower levels of HDL-C, eGFR and LVEF. As for the angiographic findings, those with an endpoint event showed higher proportions of left main artery (LM) disease, multi-vessel disease and other characteristics of complex coronary artery lesion. The SYNTAX score was significantly higher in subset with adverse prognosis. Correspondingly, more coronary artery stents were implanted in patients with endpoint event.

| Table 1 | Baseline clinical characteristics of patients with and without adverse event. |
|---------|--------------------------------------------------------------------------------|
|         | Total population (n = 832) | Without event (n = 625) | With event (n = 207) | P value |
| Age, years | 60.7 ± 8.4 | 60.2 ± 8.2 | 62.3 ± 8.9 | 0.002 |
| Sex, male, n (%) | 567 (68.1) | 435 (69.6) | 132 (63.8) | 0.119 |
| BMI, kg/m² | 26.7 ± 3.3 | 26.7 ± 3.2 | 26.9 ± 3.5 | 0.563 |
| Heart rate, bpm | 71.8 ± 10.1 | 71.6 ± 9.7 | 72.6 ± 11.2 | 0.259 |
| SBP, mmHg | 131.8 ± 17.2 | 130.9 ± 16.2 | 134.8 ± 19.5 | 0.010 |
| DBP, mmHg | 77.0 ± 10.2 | 76.5 ± 9.9 | 78.3 ± 11.2 | 0.037 |
| Smoking, n (%) | 437 (52.5) | 336 (53.8) | 101 (48.8) | 0.215 |
| Drinking, n (%) | 190 (22.8) | 150 (24.0) | 40 (19.3) | 0.165 |
|-----------------|------------|------------|-----------|-------|
| Family history of CAD, n (%) | 96 (11.5) | 73 (11.7) | 23 (11.1) | 0.824 |
| Medical history, n (%) | | | | |
| Hypertension | 595 (71.5) | 453 (72.5) | 142 (68.6) | 0.284 |
| Dyslipidemia | 744 (89.4) | 544 (87.0) | 200 (96.6) | \(< 0.001\) |
| Prior MI | 188 (22.6) | 120 (19.2) | 68 (32.9) | \(< 0.001\) |
| Prior PCI | 163 (19.6) | 107 (17.1) | 56 (27.1) | \(0.002\) |
| Prior stroke | 111 (13.3) | 80 (12.8) | 31 (15.0) | 0.425 |
| Prior PVD | 129 (15.5) | 93 (14.9) | 36 (17.4) | 0.387 |
| Laboratory results | | | | |
| TGs, mg/dL | 142.6 (98.6, 211.5) | 128.5 (91.3, 177.2) | 225.9 (147.1, 344.7) | \(< 0.001\) |
| TC, mg/dL | 159.3 ± 41.0 | 154.1 ± 39.9 | 174.9 ± 40.3 | \(< 0.001\) |
| LDL-C, mg/dL | 93.9 ± 32.9 | 93.2 ± 33.9 | 95.9 ± 29.9 | 0.304 |
| HDL-C, mg/dL | 36.6 ± 8.7 | 37.2 ± 8.8 | 34.6 ± 7.8 | \(< 0.001\) |
| hs-CRP, mg/L | 1.7 (0.7, 4.1) | 1.5 (0.7, 3.9) | 2.2 (1.0, 4.7) | \(0.002\) |
| Creatinine, mg/dL | 0.8 ± 0.2 | 0.8 ± 0.2 | 0.9 ± 0.2 | 0.111 |
| eGFR, mL/ (min * 1.73 m²) | 96.4 ± 22.1 | 97.6 ± 21.9 | 93.1 ± 22.6 | \(0.012\) |
| Uric acid, µmol/L | 330.3 ± 76.9 | 329.3 ± 76.3 | 333.3 ± 78.5 | 0.509 |
| FBG, mg/dL | 128.5 (110.2, 158.4) | 125.3 (108.2, 148.5) | 148.0 (119.3, 177.7) | \(< 0.001\) |
| HbA1c, % | 7.5 ± 1.3 | 7.3 ± 1.2 | 8.1 ± 1.4 | \(< 0.001\) |
| TyG index | 9.2 ± 0.7 | 9.0 ± 0.6 | 9.7 ± 0.8 | \(< 0.001\) |
| LVEF, % | 63.9 ± 6.6 | 64.3 ± 6.3 | 62.7 ± 7.4 | \(0.005\) |
| Initial diagnosis, n (%) |   |   | 0.219 |
|-------------------------|---|---|-------|
| UA                      | 679 (81.6) | 516 (82.6) | 163 (78.7) |
| NSTEMI                  | 153 (18.4) | 109 (17.4) | 44 (21.3) |

| Pre-admission medication, n (%) |   |   |       |
|--------------------------------|---|---|-------|
| ACEI                           | 81 (9.7) | 63 (10.1) | 18 (8.7) |
| ARB                            | 133 (16.0) | 102 (16.3) | 31 (15.0) |
| Aspirin                        | 446 (53.6) | 328 (52.5) | 118 (57.0) |
| Clopidogrel                    | 278 (33.4) | 205 (32.8) | 73 (35.3) |
| β-Blocker                      | 171 (20.6) | 128 (20.5) | 43 (20.8) |
| Statins                        | 239 (28.7) | 190 (30.4) | 49 (23.7) |
| Oral hypoglycemic agents       | 428 (51.4) | 328 (52.5) | 100 (48.3) |
| Insulin                        | 236 (28.4) | 164 (26.2) | 72 (34.8) |

| Post-discharge medication, n (%) |   |   |       |
|--------------------------------|---|---|-------|
| ACEI                           | 243 (29.2) | 178 (28.5) | 65 (31.4) |
| ARB                            | 400 (48.1) | 298 (47.7) | 102 (49.3) |
| Aspirin                        | 831 (99.9) | 624 (99.8) | 207 (100.0) |
| Clopidogrel                    | 831 (99.9) | 625 (100.0) | 206 (99.5) |
| β-Blocker                      | 778 (93.5) | 586 (93.8) | 192 (92.8) |
| Statins                        | 821 (98.7) | 618 (98.9) | 203 (98.1) |
| Oral hypoglycemic agents       | 424 (51.0) | 325 (52.0) | 99 (47.8) |
| Insulin                        | 227 (27.3) | 157 (25.1) | 70 (33.8) |

0.015
Baseline characteristics of groups according to the median of TyG index were summarized in Table 2. Compared with patients in lower TyG index group, those with higher TyG index levels seemed to be younger and have higher levels of BMI, heart rate, DBP. Laboratory indexes including TGs, TC, LDL-C, hs-CRP, uric acid, FBG and HbA1c were significantly higher in patients with higher TyG index, while HDL-C levels were relatively lower. In higher TyG index group, more patients were diagnosed as NSTEMI and prescribed angiotensin converting enzyme inhibitor (ACEI) or insulin for treatment. Participants with higher TyG index also showed a higher proportion of chronic total occlusion disease and higher SYNTAX score.
|                          | Group 1            | Group 2            | Group 3            | p-value |
|--------------------------|--------------------|--------------------|--------------------|---------|
| Heart rate, bpm          | 71.8 ± 10.1        | 71.0 ± 9.6         | 72.7 ± 10.6        | 0.014   |
| SBP, mmHg                | 131.8 ± 17.2       | 131.3 ± 16.9       | 132.4 ± 17.5       | 0.343   |
| DBP, mmHg                | 77.0 ± 10.2        | 76.2 ± 10.1        | 77.8 ± 10.3        | 0.029   |
| Smoking, n (%)           | 437 (52.5)         | 222 (53.0)         | 215 (52.1)         | 0.789   |
| Drinking, n (%)          | 190 (22.8)         | 104 (24.8)         | 86 (20.8)          | 0.170   |
| Family history of CAD, n (%) | 96 (11.5)         | 43 (10.3)          | 53 (12.8)          | 0.246   |
| Hypertension             | 595 (71.5)         | 295 (70.4)         | 300 (72.6)         | 0.475   |
| Dyslipidemia             | 744 (89.4)         | 340 (81.1)         | 404 (97.8)         | < 0.001 |
| Prior MI                 | 188 (22.6)         | 90 (21.5)          | 98 (23.7)          | 0.438   |
| Prior PCI                | 163 (19.6)         | 80 (19.1)          | 83 (20.1)          | 0.715   |
| Prior stroke             | 111 (13.3)         | 58 (13.8)          | 53 (12.8)          | 0.669   |
| Prior PVD                | 129 (15.5)         | 71 (16.9)          | 58 (14.0)          | 0.248   |
| TGs, mg/dL               | 142.6 (98.6, 211.5)| 99.2 (78.0, 125.8)| 211.8 (167.5, 299.0)| < 0.001 |
| TC, mg/dL                | 159.3 ± 41.0       | 145.8 ± 35.2       | 173.0 ± 42.0       | < 0.001 |
| LDL-C, mg/dL             | 93.9 ± 32.9        | 88.3 ± 30.6        | 99.6 ± 34.3        | < 0.001 |
| HDL-C, mg/dL             | 36.6 ± 8.7         | 38.7 ± 9.4         | 34.5 ± 7.3         | < 0.001 |
| hs-CRP, mg/L             | 1.7 (0.7, 4.1)     | 1.3 (0.6, 4.4)     | 1.9 (0.9, 3.9)     | 0.004   |
| Creatinine, mg/dL        | 0.8 ± 0.2          | 0.8 ± 0.2          | 0.8 ± 0.2          | 0.869   |
| eGFR, mL/ (min * 1.73 m²)| 96.4 ± 22.1        | 96.7 ± 21.4        | 96.2 ± 22.9        | 0.737   |
| Uric acid, µmol/L        | 330.3 ± 76.9       | 321.8 ± 74.8       | 338.8 ± 78.0       | 0.001   |
|                   | FBG, mg/dL | HbA1c, % | TyG index | LVEF, % | Initial diagnosis, n (%) | UA | NSTEMI | Pre-admission medication, n (%) |
|------------------|-----------|----------|------------|--------|--------------------------|----|--------|--------------------------------|
| FBG, mg/dL       | 128.5 (110.2, 158.4) | 115.4 (102.2, 132.8) | 150.8 (124.8, 179.0) | < 0.001 |
| HbA1c, %         | 7.5 ± 1.3 | 7.1 ± 1.2 | 7.9 ± 1.3 | < 0.001 |
| TyG index        | 9.2 ± 0.7 | 8.6 ± 0.4 | 9.8 ± 0.5 | < 0.001 |
| LVEF, %          | 63.9 ± 6.6 | 64.0 ± 6.7 | 64.0 ± 6.5 | 0.894 |

|                   |           |          |            |        |                          |    |        |                                |
| Initial diagnosis, n (%) |          |          |            |        |                          |    |        |                                |
| UA                | 679 (81.6) | 353 (84.2) | 326 (78.9) |        |
| NSTEMI            | 153 (18.4) | 66 (15.8)  | 87 (21.1)  |        |

| Pre-admission medication, n (%) |          |          |            |        |                          |    |        |                                |
| ACEI              | 81 (9.7)  | 41 (9.8)  | 40 (9.7)   | 0.961  |
| ARB               | 133 (16.0) | 64 (15.3) | 69 (16.7) | 0.573  |
| Aspirin           | 446 (53.6) | 219 (52.3) | 227 (55.0) | 0.436  |
| Clopidogrel       | 278 (33.4) | 135 (32.2) | 143 (34.6) | 0.462  |
| -Blocker         | 171 (20.6) | 89 (21.2)  | 82 (19.9)  | 0.621  |
| Statins           | 239 (28.7) | 123 (29.4) | 116 (28.1) | 0.686  |
| Oral hypoglycemic agents | 428 (51.4) | 215 (51.3) | 213 (51.6) | 0.940  |
| Insulin           | 236 (28.4) | 106 (25.3) | 130 (31.5) | 0.048  |

| Post-discharge medication, n (%) |          |          |            |        |                          |    |        |                                |
| ACEI              | 243 (29.2) | 109 (26.0) | 134 (32.4) | 0.041  |
| ARB               | 400 (48.1) | 201 (48.0) | 199 (48.2) | 0.951  |
| Aspirin           | 831 (99.9) | 419 (100.0) | 412 (99.8) | 0.496  |
| Clopidogrel       | 831 (99.9) | 419 (100.0) | 412 (99.8) | 0.496  |
### β-Blocker

|     |    |    |    |      |
|-----|----|----|----|------|
|     | 778 (93.5) | 391 (93.3) | 387 (93.7) | 0.821 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Statins | 821 (98.7) | 413 (98.6) | 408 (98.8) | 0.780 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Oral hypoglycemic agents | 424 (51.0) | 212 (50.6) | 212 (51.3) | 0.832 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Insulin | 227 (27.3) | 101 (24.1) | 126 (30.5) | 0.038 |

### Angiographic data, n (%)

|     |    |    |    |      |
|-----|----|----|----|------|
| LM disease | 44 (5.3) | 19 (4.5) | 25 (6.1) | 0.328 |

|     |    |    |    |      |
|-----|----|----|----|------|
| One-vessel disease | 174 (20.9) | 90 (21.5) | 84 (20.3) | 0.686 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Two-vessel disease | 298 (35.8) | 160 (38.2) | 138 (33.4) | 0.151 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Three-vessel disease | 360 (43.3) | 169 (40.3) | 191 (46.2) | 0.085 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Chronic total occlusion | 127 (15.3) | 53 (12.6) | 74 (17.9) | 0.035 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Diffuse lesion | 253 (30.4) | 120 (28.6) | 133 (32.2) | 0.264 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Bifurcation lesion | 193 (23.2) | 90 (21.5) | 103 (24.9) | 0.237 |

|     |    |    |    |      |
|-----|----|----|----|------|
| In-stent restenosis | 62 (7.5) | 26 (6.2) | 36 (8.7) | 0.168 |

|     |    |    |    |      |
|-----|----|----|----|------|
| SYNTAX score | 12.1 ± 5.6 | 11.6 ± 5.5 | 12.6 ± 5.6 | 0.007 |

|     |    |    |    |      |
|-----|----|----|----|------|
| Number of stents | 2.1 ± 1.3 | 2.1 ± 1.3 | 2.1 ± 1.4 | 0.824 |

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; CAD, coronary artery disease; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease; COPD, chronic obstructive pulmonary disease; TGs, triglycerides; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; hs-CRP, high-sensitivity C-reactive protein; eGFR, estimated glomerular filtration rate; FBG, fasting blood glucose; HbA1c, glycated hemoglobin A1c; TyG, triglyceride glucose; LVEF, left ventricular ejection fraction; UA, unstable angina; NSTEMI, non-ST-segment elevation myocardial infarction; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin receptor blocker; LM, left main artery; SYNTAX, synergy between PCI with taxus and cardiac surgery.

### Correlation between the TyG index and cardiovascular risk factors

The Spearman rank correlation analysis was performed to determine the correlation between the TyG index and traditional or commonly-used risk factors for cardiovascular disease. The TyG index was positively correlated with BMI, FBG, HbA1c, TGs, TC, LDL-C, uric acid, hs-CRP and SYNTAX score, while negatively correlated with age and HDL-C (Table 3).
### Correlations between the TyG index and traditional cardiovascular risk factors.

|                  | Spearman R | P value |
|------------------|------------|---------|
| Age              | -0.200     | < 0.001 |
| Sex, female      | 0.067      | 0.053   |
| BMI              | 0.194      | < 0.001 |
| FBG              | 0.588      | < 0.001 |
| HbA1c            | 0.368      | < 0.001 |
| TGs              | 0.917      | < 0.001 |
| TC               | 0.398      | < 0.001 |
| LDL-C            | 0.187      | < 0.001 |
| HDL-C            | -0.281     | < 0.001 |
| Uric acid        | 0.123      | < 0.001 |
| eGFR             | 0.004      | 0.907   |
| hs-CRP           | 0.136      | < 0.001 |
| LVEF             | -0.031     | 0.377   |
| SYNTAX score     | 0.071      | 0.040   |

BMI, body mass index; FBG, fasting blood glucose; HbA1c, glycated hemoglobin A1c; TGs, triglycerides; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; eGFR, estimated glomerular filtration rate; hs-CRP, high-sensitivity C-reactive protein; LVEF, left ventricular ejection fraction; SYNTAX, synergy between PCI with taxus and cardiac surgery.

### Clinical outcomes and Kaplan-Meier analysis

During the 36-month follow-up period, 207 (24.9%) endpoint events including 14 (1.7%) all-cause death, 44 (5.3%) non-fatal MI, and 149 (17.9%) ischemia-driven revascularization were documented to perform the present analyses. The incidence of primary endpoint, non-fatal MI and ischemia-driven revascularization increased significantly in patients with higher median of TyG index compared with those with lower median (all Chi-square P < 0.001). However, the all-cause death rate was similar between the two groups (Chi-square P = 0.269) (Table 4).
Table 4

Primary endpoint event rate according to the median of TyG index.

|                          | Lower TyG index (≤ 9.17; n = 419) | Higher TyG index (≥ 9.17; n = 413) | P value |
|--------------------------|-----------------------------------|-----------------------------------|---------|
| Primary endpoint, n (%)  | 40 (9.5)                          | 167 (40.4)                        | < 0.001 |
| All-cause death, n (%)   | 5 (1.2)                           | 9 (2.2)                           | 0.269   |
| Non-fatal MI, n (%)      | 9 (2.1)                           | 35 (8.5)                          | < 0.001 |
| Ischemia-driven revascularization, n (%) | 26 (6.2) | 123 (29.8)                        | < 0.001 |

TyG, triglyceride glucose; MI, myocardial infarction.

Kaplan–Meier curves for incidence of primary endpoint and each component of it according to the median of TyG index were shown in Fig. 1. Kaplan–Meier curves for primary endpoint showed a significant difference between the lower and higher median of TyG index group (Fig. 1(A), Log-rank P < 0.001). The difference was mainly driven by the increased incidence of non-fatal MI and ischemia-driven revascularization (Fig. 1(C) and (D), both Log-rank P < 0.001). Kaplan–Meier curves for all-cause death between the lower and higher TyG index group failed to reach statistical significance (Fig. 1(B), Log-rank P = 0.271).

Cox proportional hazard analyses to evaluate the prognostic implication of TyG index

In multivariate Cox proportional hazard analysis, four models (Model 1–4 as described above) including variables that had statistical significance (P < 0.2) and/or clinical importance were constructed to evaluate the predictive potential of TyG index for primary endpoint. After adjusting for confounding variables, higher TyG index levels remained to be an independent risk predictor of primary endpoint, despite of regarding TyG index as nominal variable or continuous variable (all P < 0.001 in Model 1–4) (Table 5). The detailed information of Model 4 was shown in Table S1.
Table 5
Predictive value of TyG index for primary endpoint in different Cox proportional hazards models.

| Model          | TyG index as a nominal variable* | TyG index as a continuous variable** |
|----------------|----------------------------------|-------------------------------------|
|                | HR  | 95% CI | P value | HR  | 95% CI | P value |
| Crude model    | 5.040 | 3.568–7.119 | < 0.001 | 2.933 | 2.488–3.457 | < 0.001 |
| Model 1        | 5.291 | 3.692–7.581 | < 0.001 | 2.918 | 2.452–3.472 | < 0.001 |
| Model 2        | 3.755 | 2.553–5.522 | < 0.001 | 2.453 | 1.951–3.086 | < 0.001 |
| Model 3        | 3.764 | 2.560–5.533 | < 0.001 | 2.555 | 2.024–3.226 | < 0.001 |
| Model 4        | 3.906 | 2.650–5.756 | < 0.001 | 2.644 | 2.086–3.352 | < 0.001 |

Model 1: adjusted for age, sex (female), BMI, SBP, DBP, smoking, drinking, dyslipidemia, prior MI, prior PCI, stroke and PVD.

Model 2: adjusted for variables included in Model 1 and diagnosis (NSTEMI), TC, HDL-C, eGFR, HbA1c, LVEF.

Model 3: adjusted for variables included in Model 2 and SYNTAX score and number of stents.

Model 4: adjusted for variables included in Model 3 and discharge medication including statins, oral hypoglycemic agents and insulin.

* The HR was examined regarding lower median of TyG index as reference.

** The HR was examined by per 1-unit increase of TyG index.

TyG, triglyceride glucose; HR, hazard ratio; CI, confidence interval.

The predictive value of TyG index for each component of primary endpoint was also evaluated by using model 4. The results showed that a 1-unit increase of TyG index was independently associated with higher risk of non-fatal MI and ischemia-driven revascularization [HR (95% CI) for non-fatal MI: 2.043 (1.224–3.411), P = 0.006; HR (95% CI) for ischemia-driven revascularization: 2.837 (2.150–3.743), P < 0.001]. However, higher TyG index levels failed to be a predictor of all-cause death, which was consistent with the results of Kaplan-Meier curves (Table 6).
Table 6
Cox proportional hazards analysis evaluating predictive value of TyG index for primary endpoint and each component.

|                     | Univariate analysis |                      | Multivariate analysis*** |
|---------------------|---------------------|----------------------|--------------------------|
|                     | HR                  | 95% CI               | P value                  | HR          | 95% CI               | P value                  |
| TyG index as a nominal variable* |                      |                      |                          |             |                      |                          |
| Primary endpoint    | 5.040               | 3.568–7.119          | < 0.001                  | 3.906       | 2.650–5.756          | < 0.001                  |
| All-cause death     | 1.830               | 0.613–5.461          | 0.279                    | 1.152       | 0.291–4.556          | 0.840                    |
| Non-fatal MI        | 4.089               | 1.966–8.507          | < 0.001                  | 2.219       | 0.923–5.337          | 0.075                    |
| Ischemia-driven revascularization | 5.437               | 3.561–8.302          | < 0.001                  | 4.823       | 3.018–7.709          | < 0.001                  |
| TyG index as a continuous variable** |                      |                      |                          |             |                      |                          |
| Primary endpoint    | 2.933               | 2.488–3.457          | < 0.001                  | 2.644       | 2.086–3.352          | < 0.001                  |
| All-cause death     | 1.107               | 0.550–2.226          | 0.776                    | 0.574       | 0.207–1.592          | 0.286                    |
| Non-fatal MI        | 3.019               | 2.165–4.209          | < 0.001                  | 2.043       | 1.224–3.411          | 0.006                    |
| Ischemia-driven revascularization | 2.697               | 2.224–3.269          | < 0.001                  | 2.837       | 2.150–3.743          | < 0.001                  |

* The HR was examined regarding lower median of TyG index as reference.
** The HR was examined by per 1-unit increase of TyG index.
*** The multivariate analysis was performed by using Model 4.

Further evaluation of risk stratification value of TyG index for primary endpoint was performed in various subclasses of the study population. Increased TyG index (per 1-unit) was consistently related to primary endpoint in various subgroups, including age > 65 or ≤ 65 years, female or male, BMI > 28 or ≤ 28 kg/m², with or without hypertension, NSTEMI or UA, HbA1c > 7.0 or ≤ 7.0% and LDL-C > 70 or ≤ 70 mg/dL. Interestingly, the predictive value of TyG index seemed to be more prominent in patients BMI > 28 kg/m² [HR (95% CI): BMI > 28 kg/m² 4.625 (2.863–7.471) vs. BMI ≤ 28 kg/m² 2.355 (1.749–3.170), P for interaction = 0.044] (Fig. 2).

ROC curve analysis evaluating predictive value of TyG index

The predictive potential of TyG index for primary endpoint was further examined by ROC curve analysis. ROC
curve analysis showed that the AUC was 0.770 (95% CI 0.730–0.809, P < 0.001), which indicated good predictive ability of TyG index for the risk of poor prognosis in the study population. The TyG index level of 9.18, which was close to the median of TyG index, was determined as the optimal cutoff point for predicting the risk of adverse events, with a sensitivity of 80.2% and a specificity of 62.1%.

**Incremental effect of TyG index on predictive value for adverse prognosis**

The addition of TyG index had a significant incremental effect on the AUC obtained with baseline risk model that consisted of risk factors including age, sex (female), smoking, hypertension, dyslipidemia, prior MI, prior PCI, eGFR, LVEF, SYNTAX score and statins at discharge (AUC: baseline risk model, 0.748 vs. baseline risk model + TyG index, 0.860, P for comparison < 0.001). However, the addition of glycemic index including FBG or HbA1c did not have a significant incremental effect on the AUC of the baseline risk model (Table 7, Fig. 3). The addition of TyG index significantly improved the reclassification and discrimination ability beyond the baseline risk model with a category-free NRI of 0.378 and an IDI of 0.139 (both P < 0.001). FBG and HbA1c also had a significant but relatively minor incremental effect compared with TyG index (Table 8).

**Table 7**

C-statistics for discrimination ability of TyG index, HbA1c and FBG in combination with baseline risk factors to predict adverse prognosis.

|                  | AUC   | 95% CI      | P value | Z value | P for comparison |
|------------------|-------|-------------|---------|---------|-----------------|
| Baseline risk model* | 0.748 | 0.710–0.787 | < 0.001 | Reference | Reference       |
| + FBG            | 0.767 | 0.731–0.804 | < 0.001 | 0.689   | 0.491           |
| + HbA1c          | 0.776 | 0.739–0.813 | < 0.001 | 1.015   | 0.310           |
| + TyG index      | 0.860 | 0.831–0.888 | < 0.001 | 4.480   | < 0.001         |

* The baseline risk model includes age, sex (female), smoking, hypertension, dyslipidemia, prior MI, prior PCI, eGFR, LVEF, SYNTAX score and statins at discharge.

FBG, fasting blood glucose; HbA1c, glycated hemoglobin A1c; TyG, triglyceride glucose; AUC, area under the curve; CI, confidence interval.
### Table 8
Category-free NRI and IDI for the incremental predictive values of various predictive model for adverse events.

|                         | Category-free NRI | IDI |
|-------------------------|-------------------|-----|
|                         | Index             | 95% CI | P value | Index             | 95% CI | P value |
| Baseline risk model*    | -                 | Reference | - | Reference | - | - |
| + FBG                   | 0.188             | 0.058–0.281 | 0.020 | 0.016 | 0.000-0.031 | 0.040 |
| + HbA1c                 | 0.198             | 0.134–0.282 | < 0.001 | 0.030 | 0.011–0.063 | < 0.001 |
| + TyG index             | 0.378             | 0.257–0.472 | < 0.001 | 0.139 | 0.082–0.193 | < 0.001 |

* The baseline risk model includes age, sex (female), smoking, hypertension, dyslipidemia, prior MI, prior PCI, eGFR, LVEF, SYNTAX score and statins at discharge.

FBG, fasting blood glucose; HbA1c, glycated hemoglobin A1c; TyG, triglyceride glucose; NRI, net reclassification improvement; IDI, integrated discrimination improvement; CI, 95% confidence interval.

### Discussion

In our present study, we retrospectively investigated the predictive significance of IR assessed by TyG index for adverse prognosis in patients with T2DM and NSTE-ACS who were treated with PCI. The major findings are listed as follows: (1) the TyG index was significantly correlated with variety of risk factors for cardiovascular disease; (2) compared to participants with lower TyG index, those with higher TyG index had an apparently higher incidence of primary endpoint.; (3) the increased level of TyG index was a strong indicator of worse prognosis in the study population, even after adjustment of confounding risk factors; (4) the addition of TyG index to the baseline risk model including traditional risk factors significantly promoted the ability of risk stratification.

T2DM has been widely recognized as the most significant risk factors for cardiovascular disease and it is very common for patients with ACS combined with T2DM. Certain studies have demonstrated that T2DM is significantly associated with higher prevalence of CAD, more complex coronary lesions and adverse prognosis [4–6] and the association has been shown to be mediated primarily by IR [26]. It has been proved that IR is significantly related to the development and progression of coronary atherosclerosis [7, 8]. Therefore, for patients with or at high risk of CAD, quantitative assessment of the extent of IR is of great clinical importance for risk stratification and prognosis prediction. The euglycemic-hyperinsulinemic clamp has been acknowledged as the gold standard method for the diagnosis of IR by previous studies [27]. However, this method is relatively time-consuming, expensive and complicated to operate, which makes it comparatively difficult to be applied in real-world clinical practice. Homeostasis model assessment of IR (HOMA-IR), which is calculated by fasting insulin and glucose, has been one of the commonly used method for the assessment of IR in current clinical applications [27]. However, the insulin concentration is not routinely measured in clinical practice, which makes HOMA-IR inappropriate for extensive clinical application. Based on these, a surrogate marker of IR named TyG index derived from commonly used clinical indicators (fasting TGs and glucose) has been proposed and showed to be well related to the euglycemic-hyperinsulinemic clamp and HOMA-IR [10, 28, 29]. And studies even showed that the TyG index may have a better performance on the prediction of IR and atherosclerosis compared with HOMA-IR [30, 31].
Previous studies have demonstrated that IR evaluated by TyG index is strongly related to the incidence of diabetes and prediabetic status, suggesting that TyG index may be a considerable predictor for early identifying individuals at high risk of developing diabetes and prediabetes, even performs better than other risk factors such as FBG and weight gain [13–15, 32, 33]. Studies also showed that elevated level of TyG index is prominently associated with an increased risk of developing cardiovascular disease including CAD and ischemic stroke, which suggests evaluation of TyG index might be helpful for identifying people who is susceptible to cardiovascular disease, despite existence of traditional cardiovascular risk factors or not [16, 17, 34–36]. And for patients with stable CAD, TyG index has been demonstrated to be positively related to future adverse clinical outcomes, indicating that TyG index may play an important role in the prediction of clinical prognosis in patients with stable CAD [37, 38]. The clinical significance of TyG index has been increasing as the adverse effects of it on individuals with or at high risk of cardiovascular disease have been elucidated. Evaluation of TyG index may have great clinical importance on risk stratification and therapeutic individuation for these patients.

Several studies have shown that there is an important correlation between TyG index and clinical prognosis in patients with ACS. Study from Mao et al [39] revealed that the level of TyG index is strongly associated with the complexity of coronary lesions and the incidence of future adverse cardiovascular event during a 12-month of follow-up in patients diagnosed with NSTE-ACS. Another observational study from Luo et al [40] assessing the predictive potential of TyG index for 1-year prognosis suggested that the increased TyG index might be an effective indicator of worse prognosis in patients with ST-segment elevation myocardial infarction (STEMI) who were treated with PCI. However, no adjustment was made for the presence of diabetes or not in multivariate analysis in both of the former studies, and neither of them evaluate whether the prognostic impact of TyG index varied among different glycometabolic status. What’s more, the former studies only confirmed the effect of TyG index on poor prognosis from a 12-month follow-up, which is relatively insufficient to evaluate the long-term prognostic impact of TyG index. Ma et al [41] evaluated the predictive significance of TyG index in participants with T2DM and ACS undergoing PCI and showed that the TyG index was the independent predictor of adverse clinical outcomes. However, whether the addition of TyG index has an incremental effect on predicting adverse cardiovascular prognosis on the basis of traditional risk factors is not confirmed. Our present study revealed the significant prognostic impact of TyG index and its incremental effect on risk stratification in diabetic patients with NSTE-ACS undergoing PCI, which makes the study be great agreement and complement to previous literatures.

The potential mechanism inducing the association of IR presented by TyG index with development and progression of cardiovascular disease remains uncertain, several speculations summarize as follows. (1) It has been demonstrated that TyG index is closely related to traditional risk factors for cardiovascular disease such as hypertension [42] and renal insufficiency [43]. In the present study, participants with higher TyG index exactly tended to combine with more severe and complex clinical conditions in terms of BMI, blood pressure, lipid profiles and coronary lesions, and correlation analysis also showed that TyG index is positively related to multiple risk factors for cardiovascular disease. (2) Study have shown that FBG mainly reflects IR from liver, whereas fasting TGS mainly reflects IR from adipose cell [44]. Therefore, it can be concluded that TyG index may reflect IR from two aspects and thus be closely related to IR, which has been widely demonstrated to have significant relationship with endothelial dysfunction, oxidative stress, cardio-vascular remodeling, coagulation imbalance and inflammation response [45, 46]. Indeed, a positive association between TyG index and hs-CRP levels was confirmed in the present study. (3) Certain studies have also identified an important correlation between TyG index and coronary artery calcification [47], which may be another potential mechanism.

Since adverse prognostic impacts of IR on individuals with CAD have been elucidated by previous studies, taking assessment and intervention of IR into long-term management strategies may be beneficial for patients with CAD. However, the relative lack of research about intervention on IR in patients with CAD makes it uncertain whether intervention of IR is necessary for the management of such patients. Former studies have shown that whole-grain consumption plays a significant protective role on IR and inflammatory markers [48, 49]. However, a recent systematic review of 9 RCTs indicated that there is insufficient evidence on the effect of whole-grain diets on cardiovascular outcomes or major cardiovascular disease risk factors [50]. This may be partly attributed to the fact that the association between whole-grain consumption and IR is partially mediated by adiposity [49]. Our present study also revealed that the predictive value of IR presented by TyG index seemed to be more prominent in patients BMI > 28 kg/m² [HR (95% CI): BMI > 28 kg/m² 4.625 (2.863–7.471) vs. BMI ≤ 28 kg/m² 2.355 (1.749–
Further specific-designed studies are required to determine whether interventions of IR assessed by TyG index have a positive impact on improving clinical prognosis in this population.

This study confirmed the predictive value of IR presented by TyG index for adverse prognosis in a cohort including patients with T2DM and NSTE-ACS who were treated with PCI, which indicates that TyG index can be an available predictor in clinical practice and has a positive effect on more comprehensive risk evaluation and stratification on the basis of traditional risk factors in this selected population. Meanwhile, some limitations of the study should be recognized. (1) This study is a single-center, retrospective, observational study, which may weaken the power of the results. (2) The TyG index was assessed only once at admission. The changes of TyG index during the follow-up period, which may have better prediction value for adverse prognosis, were not assessed in our study. (3) A large proportion of participants received lipid-lowering therapy, which may have potential impact on the TyG index and the study results. (4) Nearly all of the study population is Chinese patients. The results should be cautiously interpreted and expanded to Western population as differences in metabolic levels exist among different races. (5) It is hard to rule out that some patients may be complicated with undiagnosed systemic diseases, such as occult malignancies, which may have impact on the assessment of prognosis. (6) The HOMA-IR was not calculated in the present study, so the comparison between TyG index and HOMA-IR is lacking.

Conclusion

Increased IR extent presented by TyG index is a prominent risk predictor of adverse prognosis in patients with T2DM and NSTE-ACS who were treated with PCI. The addition of the TyG index to a baseline risk model has a strong incremental effect on the predictive potential for adverse prognosis. Further prospective, randomized studies need to be performed to determine whether interventions for IR have a positive impact on improving clinical prognosis.

Abbreviations

CAD, coronary artery disease; ACS, acute coronary syndrome; T2DM, type 2 diabetes mellitus; IR, insulin resistance; TyG index, triglyceride glucose index; NSTE-ACS, non-ST-segment elevation acute coronary syndrome; PCI, percutaneous coronary intervention; BMI, body mass index; FBG, fasting blood glucose; NSTEMI, non-ST-segment elevation myocardial infarction; UA, unstable angina; SBP, systolic blood pressure; DBP, diastolic blood pressure; TGs, triglycerides; HbA1c, glycosylated hemoglobin A1c; TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; eGFR, estimated glomerular filtration rate; SYNTAX, the synergy between PCI with taxus and cardiac surgery; MI, myocardial infarction; PVD, peripheral vascular disease; LVEF, Left ventricular ejection fraction; hs-CRP, high-sensitivity C-reactive protein; HR, hazard ratio; CI, confidence interval; ROC, receiver operating characteristics; AUC, area under the curve; NRI, net reclassification improvement; IDI, integrated discrimination improvement; HOMA-IR, homeostasis model assessment of insulin resistance.

Declarations

Ethics approval and consent to participate

Written or oral informed consent was obtained from each participant, and the study protocol was approved by the Clinical Research Ethics Committee of Beijing Anzhen Hospital, Capital Medical University.

Consent for publication

Not applicable.
Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

QZ (first author) and TYZ (co-first author) made substantial contributions to study design, data collection, data analysis and manuscript writing. YJZ (corresponding author) made substantial contributions to study design and intellectual direction. They contributed equally to this work. YJC, YM, YKX, JQY made contributions to data collection and analysis. All authors read and approved the final manuscript.

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Figure 1
Kaplan-Meier curves for accumulative event rate according to the median of TyG index. (A) Kaplan-Meier curves for primary endpoint. (B) Kaplan-Meier curves for all-cause death. (C) Kaplan-Meier curves for non-fatal MI. (D) Kaplan-Meier curves for ischemia-driven revascularization. TyG, triglyceride glucose; MI, myocardial infarction; PCI, percutaneous coronary intervention; HR, hazard ratio; CI, confidence interval.
Cox proportional hazards analysis of adverse prognosis in various subgroups. HR was evaluated by 1-unit.
increase of TyG index. BMI, body mass index; UA, unstable angina; NSTEMI, non-ST-segment elevation myocardial infarction; HbA1c, glycated hemoglobin A1c; LDL-C, low-density lipoprotein cholesterol; HR, hazard ratio; 95% CI, 95% confidence interval.
Figure 3

C-statistics evaluating incremental effect of TyG index, FBG or HbA1c on predictive value of baseline risk model for adverse prognosis. The baseline risk model includes age, sex (female), smoking, hypertension, dyslipidemia, prior MI, prior PCI, eGFR, LVEF, SYNTAX score and statins at discharge. FBG, fasting blood glucose; HbA1c, glycated hemoglobin A1c; TyG, triglyceride glucose.

Supplementary Files

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