



Triglyceride–Glucose Index as a Predictor of No-Reflow Phenomenon After Primary Percutaneous Coronary Intervention in ST-Elevation Myocardial Infarction: Systematic Review and Meta-Analysis

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ABSTRACT

Introduction: No-reflow phenomenon remains an important complication after percutaneous coronary intervention in ST-segment elevation myocardial infarction, reflecting impaired myocardial reperfusion despite successful epicardial vessel opening. The triglyceride–glucose index is a simple surrogate marker of insulin resistance and metabolic dysfunction, but its overall association with no-reflow after PCI remains incompletely established.

Objective: This systematic review and meta-analysis aimed to evaluate the predictive value of the triglyceride–glucose index for no-reflow or impaired microcirculatory reperfusion after PCI in patients with STEMI.

Methods: A systematic literature search was performed in PubMed, Cochrane Library, and ScienceDirect using terms related to triglyceride–glucose index, myocardial infarction, acute coronary syndrome, and percutaneous coronary intervention. Eligible studies included patients with STEMI or closely related AMI populations undergoing PCI, evaluated TyG index as a predictor, and reported no-reflow or impaired microcirculatory reperfusion outcomes. Odds ratios and 95% confidence intervals were pooled using a random-effects model.

Results: Five studies involving 2,007 patients were included. All studies were retrospective cohorts. Higher TyG index was consistently associated with increased risk of no-reflow or impaired microcirculatory reperfusion. The pooled analysis showed that elevated TyG index significantly increased the odds of no-reflow after PCI (OR 3.10, 95% CI 1.97–4.88; $p < 0.00001$). Substantial heterogeneity was observed across studies ($I^2 = 85\%$), likely due to differences in population characteristics, no-reflow definitions, TyG cut-off values, and adjustment models.

Discussion: The association between TyG index and no-reflow is biologically plausible because insulin resistance, hyperglycemia, and hypertriglyceridemia may promote endothelial dysfunction, oxidative stress, inflammation, platelet activation, and microvascular obstruction. These mechanisms overlap with the pathophysiology of no-reflow after PCI. The TyG index may therefore represent a practical and low-cost marker for identifying patients at increased risk of reperfusion failure.

Conclusion: Higher TyG index is significantly associated with increased odds of no-reflow or impaired microcirculatory reperfusion after PCI in patients with STEMI. The TyG index may

be useful for early risk stratification, although prospective validation is required before routine clinical implementation.

Keywords: Triglyceride–glucose index; TyG index; no-reflow phenomenon; ST-segment elevation myocardial infarction; percutaneous coronary intervention.

INTRODUCTION

ST-segment elevation myocardial infarction (STEMI) remains one of the most time-sensitive emergencies in cardiovascular medicine. Primary percutaneous coronary intervention (PCI) has become the preferred reperfusion strategy because it can rapidly restore epicardial coronary patency and limit infarct extension when performed within an appropriate therapeutic window. Nevertheless, successful opening of the infarct-related artery does not always translate into adequate myocardial tissue perfusion. A subset of patients continues to experience impaired downstream flow despite technically successful PCI, a condition commonly recognized as the no-reflow phenomenon. This complication is clinically important because it reflects microvascular reperfusion failure and has been associated with larger infarct size, poorer ventricular recovery, heart failure, malignant arrhythmias, and increased mortality.¹⁻³

The pathophysiology of no-reflow is complex and multifactorial. Distal embolization, ischemia-reperfusion injury, endothelial swelling, microvascular spasm, platelet activation, inflammation, oxidative stress, and intramyocardial hemorrhage may all contribute to impaired tissue-level perfusion after PCI. In STEMI, these processes are intensified by a large thrombus burden, prolonged ischemia, metabolic stress, and systemic inflammatory activation. Patients with diabetes mellitus or metabolic syndrome are particularly vulnerable because chronic metabolic dysregulation can impair endothelial function, reduce nitric oxide bioavailability, increase platelet reactivity, and promote microvascular dysfunction. These mechanisms suggest that readily available metabolic markers may help identify patients at higher risk for no-reflow before or around the time of PCI.⁴⁻⁶

The triglyceride–glucose (TyG) index, calculated from fasting triglyceride and fasting glucose levels, has emerged as a simple surrogate marker of insulin resistance. Compared with direct methods such as the hyperinsulinemic–euglycemic clamp or insulin-based indices, the TyG index is inexpensive, practical, and derived from routine laboratory parameters. Its biological relevance in STEMI is plausible because it captures the interaction between hyperglycemia and dyslipidemia, two metabolic abnormalities closely linked to endothelial dysfunction, inflammation, oxidative stress, thrombogenicity, and atherosclerotic plaque

instability. Previous cardiovascular studies have shown that a higher TyG index is associated with adverse outcomes after acute coronary syndrome and PCI, supporting its potential role as a risk marker in acute myocardial infarction.^{7,8}

In recent years, several observational studies have specifically examined the association between the TyG index and no-reflow or impaired coronary microcirculatory reperfusion after PCI. Ma et al. reported that a higher TyG index was independently associated with no-reflow in STEMI patients with type 2 diabetes mellitus after PCI. Kerkutluoglu et al. similarly found that STEMI patients who developed no-reflow had higher admission TyG index values than those with normal coronary flow. More recent studies by Qu et al. and Yang et al. further suggested that TyG-based risk stratification may predict no-reflow in metabolically high-risk STEMI populations, including patients with metabolic syndrome or type 2 diabetes.^{9,10}

Despite these findings, the available evidence remains fragmented. Existing studies differ in population characteristics, no-reflow definitions, TyG cut-off values, adjustment models, and whether no-reflow was assessed using TIMI flow alone, myocardial blush grade, or microcirculatory resistance indices. Some studies enrolled only diabetic patients, whereas others focused on metabolic syndrome or broader STEMI cohorts. These methodological differences make it difficult to determine the overall strength and consistency of the association between the TyG index and no-reflow after primary PCI. Therefore, this systematic review and meta-analysis aimed to synthesize the current evidence on the predictive value of the TyG index for no-reflow phenomenon after primary PCI in STEMI patients.

METHODS

Search Strategy

This systematic review and meta-analysis was conducted to evaluate the association between the triglyceride-glucose index and the occurrence of no-reflow phenomenon after percutaneous coronary intervention in patients with ST-segment elevation myocardial infarction. The literature search was performed using three electronic databases: PubMed, Cochrane Library, and ScienceDirect. The search strategy was developed using terms related to the

triglyceride-glucose index, myocardial infarction, acute coronary syndrome, and percutaneous coronary intervention.

The following search string was used in PubMed: (triglyceride-glucose index OR triglyceride glucose index OR TyG index OR TyG) AND (myocardial infarction OR acute myocardial infarction OR AMI OR STEMI OR ST-segment elevation myocardial infarction OR acute coronary syndrome OR ACS) AND (percutaneous coronary intervention OR PCI OR primary PCI OR PPCI).

The following search string was used in Cochrane Library: (triglyceride-glucose index OR triglyceride glucose index OR TyG index OR TyG) AND (myocardial infarction OR acute myocardial infarction OR STEMI OR acute coronary syndrome) AND (percutaneous coronary intervention OR PCI).

The following search string was used in ScienceDirect: (triglyceride-glucose index OR triglyceride glucose index OR TyG index OR TyG) AND (myocardial infarction OR acute myocardial infarction OR STEMI OR acute coronary syndrome) AND (percutaneous coronary intervention OR PCI).

All retrieved records were screened according to the predefined eligibility criteria. Duplicate records were removed before screening. Titles and abstracts were reviewed first, followed by full-text assessment of potentially relevant studies.

Eligibility Criteria

Studies were considered eligible if they included patients with acute ST-segment elevation myocardial infarction or closely related acute myocardial infarction populations undergoing percutaneous coronary intervention, evaluated the triglyceride-glucose index as the exposure or predictor, and reported no-reflow phenomenon or impaired coronary microcirculatory reperfusion as the outcome. Studies were eligible when they reported effect estimates such as odds ratios with confidence intervals, or provided sufficient information for outcome synthesis.

The population of interest was patients with STEMI undergoing primary PCI. However, studies involving clinically adjacent populations, such as STEMI patients with type 2 diabetes mellitus, STEMI patients with metabolic syndrome, or PCI-treated AMI cohorts, were considered when the study directly evaluated the TyG index in relation to no-reflow or impaired reperfusion. The exposure of interest was a higher TyG index, either analyzed as a continuous

variable, categorical cut-off, tertile, or quartile. The comparator was a lower TyG index category or lower TyG value. The primary outcome was no-reflow phenomenon after PCI, generally defined using post-procedural TIMI flow grade, myocardial blush grade, or another angiographic marker of microcirculatory impairment.

Studies were excluded if they did not evaluate the TyG index, did not involve PCI-treated myocardial infarction or acute coronary syndrome patients, did not report no-reflow or a relevant microcirculatory reperfusion outcome, used an inappropriate intervention regimen, were review articles, editorials, case reports, conference abstracts without extractable data, or lacked sufficient quantitative data for synthesis.

Study Selection

All records identified from the database search were imported and checked for duplicates. After duplicate removal, titles and abstracts were screened to identify potentially relevant studies. Full-text articles were then assessed against the eligibility criteria. Studies that fulfilled the inclusion criteria were included in the qualitative synthesis. Studies that reported extractable effect estimates for the association between TyG index and no-reflow or impaired microcirculatory reperfusion were included in the quantitative meta-analysis.

Data Extraction

Data extraction was performed using a standardized extraction table. The extracted study characteristics included first author, publication year, country, study design, study period, population characteristics, sample size, age, sex distribution, TyG index cut-off or grouping method, definition of high TyG index, definition of no-reflow phenomenon, timing of no-reflow assessment, PCI-related details, culprit vessel or lesion characteristics, baseline comorbidities, adjusted covariates, risk of bias, and summary of findings.

For the quantitative synthesis, the extracted effect-size data included study ID, outcome type, effect measure, comparison, number of events and total patients when available, reported odds ratio, 95% confidence interval, log odds ratio, standard error of the log odds ratio, adjustment status, adjusted covariates, TyG cut-off or category used, assessment timepoint, extraction method, and relevant notes. When multiple estimates were available, adjusted odds ratios from multivariable logistic regression were prioritized over unadjusted estimates. When

studies reported categorical and continuous TyG models, the most clinically appropriate and consistently reported adjusted estimate was selected for pooling.

Risk of Bias Assessment

The methodological quality and risk of bias of the included observational studies were assessed based on study design, population selection, exposure measurement, outcome definition, control of confounding, completeness of data, and appropriateness of statistical analysis. Particular attention was given to whether the TyG index was clearly calculated, whether no-reflow was defined using objective angiographic criteria, whether outcome assessment was performed consistently, and whether multivariable adjustment was applied. Risk of bias was categorized as low or moderate.

Outcome Definition

The primary outcome was the association between higher TyG index and no-reflow phenomenon after PCI. No-reflow was generally defined as impaired post-procedural coronary flow, most commonly TIMI flow grade ≤ 2 after PCI despite successful epicardial vessel opening and absence of mechanical obstruction. Studies that used related markers of impaired coronary microcirculation, such as high angiography-derived microcirculatory resistance, were included in the broader synthesis when they evaluated a closely related reperfusion failure endpoint.

Data Synthesis and Statistical Analysis

The primary quantitative analysis pooled the association between TyG index and no-reflow or impaired microcirculatory reperfusion using odds ratios and 95% confidence intervals. Reported odds ratios were transformed into log odds ratios, and standard errors were calculated from the corresponding 95% confidence intervals. A random-effects model was used because clinical and methodological heterogeneity was expected across studies, particularly in terms of patient population, TyG index cut-off, outcome definition, and covariate adjustment.

Heterogeneity was assessed using the Chi-square test, τ^2 , and I^2 statistic. An I^2 value above 50% was interpreted as substantial heterogeneity. The pooled effect was presented as an odds ratio with 95% confidence interval. A p-value below 0.05 was considered statistically significant. When appropriate, sensitivity considerations were made based on population eligibility and outcome definition, particularly for studies involving broader AMI populations or microcirculatory resistance rather than conventional no-reflow.

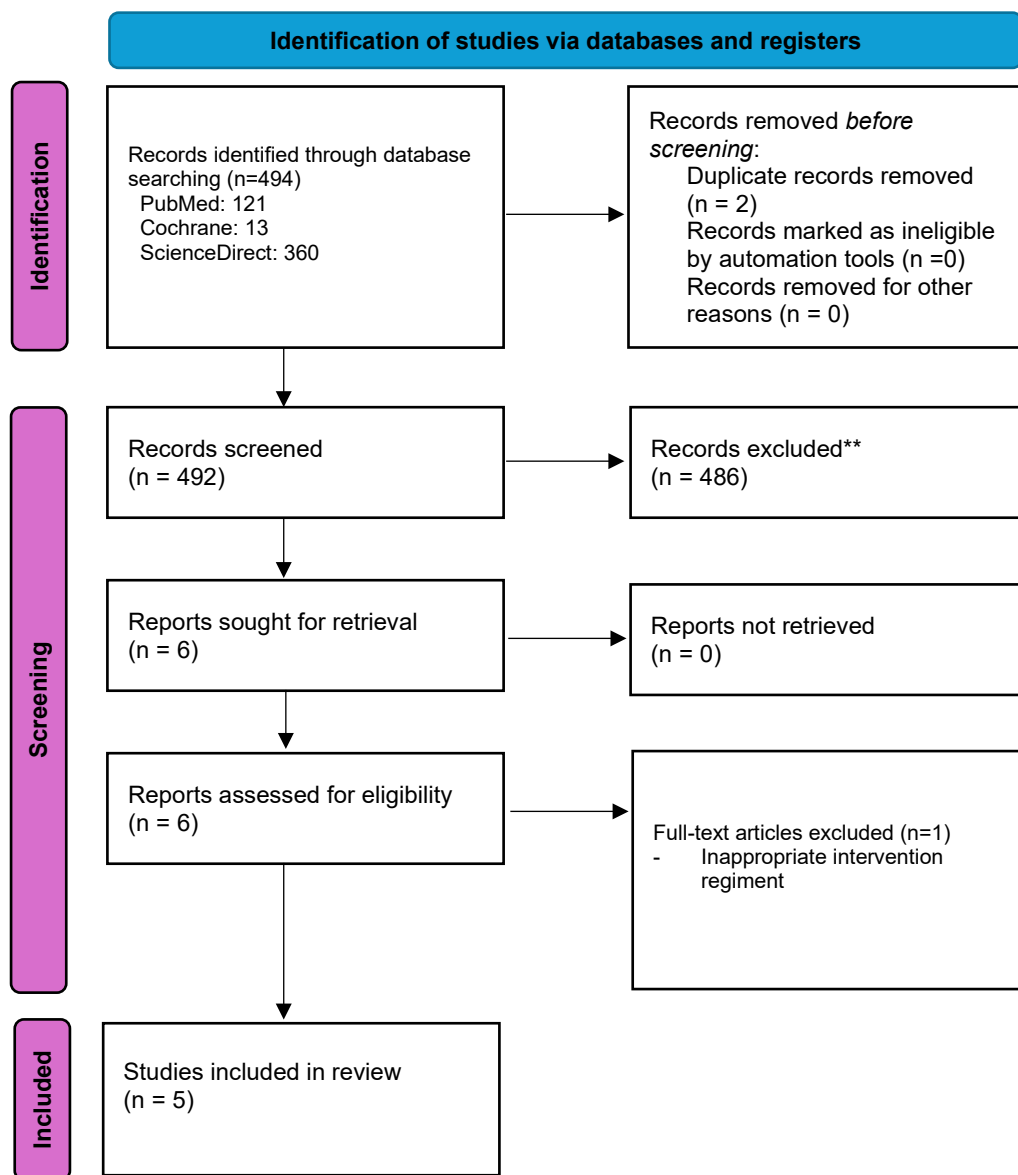


Figure 1. Flow Chart Diagram

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First Author, Year	Country	Study Design	Study Period	Population	Sample Size	Age, years	Male, n (%)	TyG Index Cut-off / Grouping	Definition of High TyG Index	Definition of No-Reflow Phenomenon	Timing of No-Reflow Assessment	Primary PCI Details	Culprit Vessel / Lesion Characteristics	Key Baseline Comorbidities	Adjusted Covariates	Risk of Bias	Summary of Findings
Wang, 2025	China, Taizhou People’s Hospital	Single-center retrospective cohort	January 2022 to December 2023	Patients with type 2 diabetes mellitus and STEMI undergoing primary PCI	168	Low	Low	ROC-	TyG index	Not reported as	During	STEMI patients received	LAD-related	All included	Multivariable	Low	TyG index was
	AMR: 59.41 ± 14.09; High					AMR: 65/81, 80.25%; High	derived TyG cut-off 9.57 for predicting high AMR	calculated as ln [triglycerides, mg/dL × fasting glucose, mg/dL / 2]; higher TyG analyzed as continuous predictor; ROC cut-off 9.57	no-reflow. Outcome was high AMR, defined as AMR ≥2.5; low AMR defined as AMR <2.5	retrospective angiographic assessment after pPCI using AngioPlus software	aspirin 300 mg, ticagrelor 180 mg, heparin 80–100 U/kg; thrombus aspiration and GP IIb/IIIa inhibitor use at operator discretion	infarction: low AMR 49/81, 60.49%; high AMR 47/87, 54.02%; 3-vessel disease: low AMR 33/81, 40.74%; high AMR 32/87, 36.78%; pre-PCI TIMI flow grade ≥3: low AMR 15/81, 18.52%; high AMR 8/87, 9.20%	patients had T2DM and STEMI; HTN: low AMR 42/81, 51.85%; high AMR 54/87, 62.07%; smoking: low AMR 59/81, 72.84%; high AMR 47/87, 54.02%; Killip class ≥II: low AMR 42/81, 51.85%; high	model retained age, hemoglobin, and TyG index as predictors of high AMR		significantly higher in the high AMR group. TyG independently predicted high AMR, OR 2.449, 95% CI 1.421– 4.220, p=0.001. ROC AUC was 0.650, 95% CI 0.57–0.73, with cut-off 9.57, sensitivity 0.644, specificity 0.654.	

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														AMR 55/87, 63.22%			
Yang, 2026	China, Second Hospital of Shandong University	Single-center retrospective cohort	June 2018 to December 2024	Patients with T2DM and STEMI undergoing PPCI within 12 hours of symptom onset	524	Normal reflow: 60.43 ± 11.72; no-reflow: 64.96 ± 10.56	Normal reflow: 353/477, 74.00%; no-reflow: 34/47, 72.34%	ROC-derived TyG cut-off ≥9.347; low TyG defined as TyG <9.347	High TyG defined as TyG ≥9.347; low TyG defined as TyG <9.347	Post-procedural TIMI flow grade ≤2; TIMI flow grade 3	Immediately after stent implantation during PPCI	Standard loading therapy with aspirin 300 mg, clopidogrel 300 mg or ticagrelor 180 mg, atorvastatin 40 mg, and unfractionated heparin 70 U/kg; stent selection and thrombus aspiration at operator discretion; tirofiban available if clinically indicated	Infarct-related artery: LAD 400/524, 76.34%; LCX 29/524, 5.53%; LM 4/524, 0.76%; RCA 91/524, 17.37%. LCX and LM lesions were more frequent in no-reflow patients	All patients had T2DM and STEMI; hypertension: 298/524, 56.87%; hyperlipidemia: 132/524, 25.19%; smoking: 184/524, 35.11%	Final model retained age, pain-to-balloon time, RBC, NLR, CRP, and TyG index; leukocytes, neutrophils, TG, and glucose excluded due to VIF >5	Low	No-reflow occurred in 47/524 patients, 8.97%. TyG index was higher in no-reflow patients, 9.51 ± 0.52 vs 9.12 ± 0.56, p<0.001. TyG independently predicted no-reflow, adjusted OR 2.98, 95% CI 1.69–5.27, p<0.001. TyG AUC was 0.70,

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																	95% CI 0.63–0.78, with cut-off 9.347.
Qu, 2024	China, Baoji People’s Hospital	Retrospective cohort	January 2023 to December 2023	STEMI patients with metabolic syndrome undergoing PCI	378	Normal reflow: 58.69 ± 3.57; no-reflow: 59.98 ± 3.45	Normal reflow: 200/311; no-reflow: 48/67	ROC-derived TyG cut-off ≥8.1	High TyG defined as TyG index ≥8.1	Post-PCI TIMI flow grade ≤2, or TIMI grade 3 with myocardial blush grade ≤2	Post-PCI coronary angiography	Emergency PCI after chest pain center diagnosis; medication/procedural variables included aspirin, clopidogrel, heparin, statins, beta-blockers, ACEI/ARB, thrombectomy, DES/BMS	Culprit lesion characteristics not deeply detailed; procedural variables included thrombectomy and stent type. Thrombectomy: normal reflow 25/311, 8.04%; no-reflow 8/67, 11.94%. DES/BMS: normal reflow 217/94; no-reflow 43/24	All patients had metabolic syndrome. Diabetes: normal reflow 94/311, 30.23%; no-reflow 26/67, 38.81%. Hypertension: normal reflow 140/311, 45.16%; no-reflow 36/67, 53.73%. Smoking: normal reflow 109/311, 35.05%; no-reflow 28/67,	Multivariable model included metabolic predictors selected after random forest analysis: fasting glucose, triglycerides, total cholesterol, LDL-C, non-HDL cholesterol, VLDL cholesterol, and TyG index.	Low	No-reflow occurred in 67/378 patients, 17.7%. TyG index was significantly higher in no-reflow patients, 8.97 ± 1.15 vs 7.49 ± 1.17, p<0.001. TyG index ≥8.1 was the strongest independent predictor of no-reflow, OR 9.591,

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41.79%

Methods also stated adjustment for age, sex, smoking, hypertension, diabetes, dyslipidemia, and CKD

95% CI 4.469–20.587, p<0.001. ROC AUC for TyG alone was 0.818, with sensitivity 0.806 and specificity 0.707.

Ma, 2024

China, General Hospital of Ningxia Medical University

Single-center retrospective cohort

January 2014 to December 2019

Patients with T2DM and STEMI undergoing primary PCI

695

Overall: 61.57 ± 10.61

Overall: 494/695, 71.08%

TyG quartiles: Q1 6.25–8.15, Q2 8.15–8.68, Q3 8.68–9.29, Q4 9.29–11.34; ROC cut-off 8.99

Highest TyG category represented by Q4, 9.29–11.34; ROC cut-off for no-reflow prediction was 8.99

TIMI flow grade ≤2 after coronary reopening

During PCI procedure after coronary reopening

Standard primary PCI with loading clopidogrel 300 mg, ticagrelor 180 mg, aspirin 300 mg, and total heparinization; radial access using Seldinger technique; adenosine, tirofiban, and other intracoronary drugs at operator discretion

IRA distribution by quartile: LAD 322/695, RCA 300/695, LCX 73/695, LM 2/695. No-reflow increased across TyG quartiles: Q1 5/174, Q2 9/173, Q3 13/174, Q4

All patients had T2DM and STEMI. Hypertension: 445/695, 64.03%; CKD: 32/695, 4.60%; stroke: 86/695, 12.37%; dyslipidemia: 295/695; current

Fully adjusted model adjusted for age, gender, BMI, hypertension, dyslipidemia, CKD, smoking status, HDL cholesterol, total cholesterol, and

Low

No-reflow occurred in 59/695 patients, 8.49%. TyG index was independently associated with no-reflow, adjusted OR 3.23, 95% CI 2.15–4.86, p<0.001.

2023	Kerkutluoglu, Turkey,	Single-center	June 2021	Patients	242	No-	No-	ROC-	High TyG	No-reflow	Post-	Patients received	PCI vessel: LAD	Diabetes mellitus:	Multivariate	Low	No-reflow
	Kahramanmaraş	retrospective	to June	treated with		reflow:	reflow:	derived	defined as TyG	defined as	procedural	acetylsalicylic acid,	no-reflow 15/40,	no-reflow 23/40,	model retained		occurred in
	Sutcu Imam	cohort	2022	primary PCI		67 ± 12;	28/40;	TyG cut-off	index >9.2 for	impaired post-	coronary	additional antiaggregant	37.5% vs normal	57.5% vs normal	TyG index,		40/242 patients,

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University Faculty of Medicine Hospital	for acute	normal	normal	>9.2	no-reflow	PCI TIMI flow,	angiography	loading with clopidogrel,	flow 96/202,	flow 57/202,	LVEF, BUN, and	16.5%. TyG index	
	STEMI	flow: 64	flow:		prediction	namely TIMI	after PCI	prasugrel, or ticagrelor,	47.5%; CX no-	28.2%;	MPV after	was significantly	
	according to	± 12	136/202			0–2, in the		and anticoagulant	reflow 10/40,	hypertension: no-	adjustment for	higher in the no-	
	abstract;					absence of		treatment with	25.0% vs normal	reflow 34/40,	variables	reflow group, 9.7	
	methods also					dissection and		unfractionated heparin or	flow 60/202,	85.0% vs normal	significant in	± 0.25 vs 8.9 ±	
		describe				thrombus;		low molecular weight	29.7%; RCA no-	flow 182/202,	univariate	0.5, p<0.001. TyG	
		AMI patients				normal		heparin before PCI	reflow 15/40,	90.0%; smoking:	analysis and	independently	
		undergoing				coronary flow			37.5% vs normal	no-reflow 19/40,	variables	predicted no-	
		PCI				defined as			flow 46/202,	47.5% vs normal	correlated with	reflow, adjusted	
						TIMI 3			22.7%	flow 88/202,	TyG index	OR 1.915,	
										43.5%		p<0.001. ROC	
												analysis showed	
												TyG cut-off >9.2	
												with AUC 0.884,	
												95% CI 0.842–	
												0.926, sensitivity	
												97.5%, and	
												specificity 72.8%.	

Table 1. Characteristics and results of the included

Study	Risk of bias			
	D1	D2	D3	Overall
	Wang, 2025	+	+	+
	Yang, 2026	+	+	+
	Qu, 2024	+	+	+
	Ma, 2024	+	+	+
	Kerkutluoglu, 2023	+	+	+
D1: Selection D2: Performance D3: Detection/Reporting				Judgement + Low

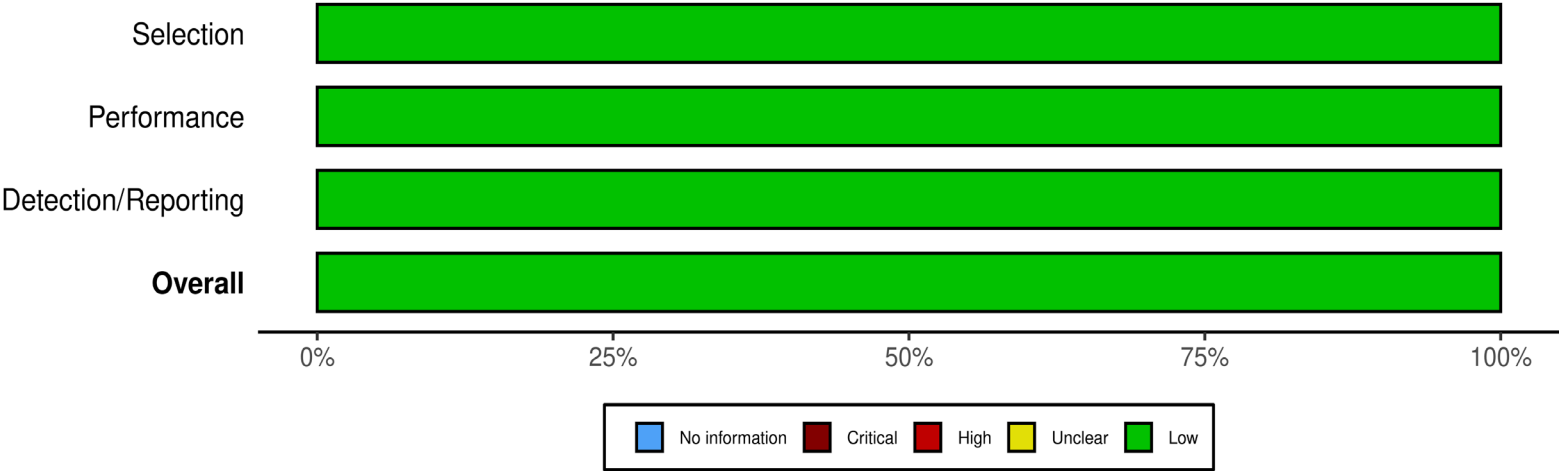


Figure 2. Risk of bias assessment result of the included studies

RESULTS

Study Selection

The database search identified 494 records, consisting of 121 records from PubMed, 13 from Cochrane Library, and 360 from ScienceDirect. After removal of 2 duplicate records, 492 records were screened by title and abstract. Of these, 486 records were excluded because they were not relevant to the study question, did not evaluate the TyG index, did not involve PCI-related reperfusion outcomes, or did not provide suitable clinical data.

Six full-text articles were retrieved and assessed for eligibility. One article was excluded after full-text review because of an inappropriate intervention regimen. Finally, 5 studies were included in the systematic review and meta-analysis.

Study Characteristics

The 5 included studies enrolled a total of 2,007 patients. Four studies were conducted in China and one study was conducted in Turkey. All included studies used a retrospective cohort design. The study periods ranged from 2014 to 2024. Most studies focused on patients with STEMI undergoing primary PCI, although the population criteria varied slightly across studies. Two studies specifically included STEMI patients with type 2 diabetes mellitus, one study included STEMI patients with metabolic syndrome, one study included acute STEMI patients undergoing primary PCI, and one study evaluated STEMI patients with type 2 diabetes mellitus using angiography-derived microcirculatory resistance as the reperfusion-related endpoint.

The sample size ranged from 168 to 695 patients. The reported incidence of no-reflow or impaired microcirculatory reperfusion varied across studies. Yang et al. reported no-reflow in 47 of 524 patients, Qu et al. reported no-reflow in 67 of 378 patients, Ma et al. reported no-reflow in 59 of 695 patients, and Kerkutluoglu et al. reported no-reflow in 40 of 242 patients. Wang et al. reported high angiography-derived microcirculatory resistance in 87 of 168 patients rather than conventional angiographic no-reflow.

The definition of no-reflow was broadly based on post-procedural TIMI flow grade, with most studies defining no-reflow as TIMI flow grade ≤ 2 after PCI. Qu et al. additionally incorporated myocardial blush grade, defining no-reflow as TIMI flow grade ≤ 2 or TIMI grade 3 with myocardial blush grade ≤ 2 . Wang et al. used high AMR, defined as AMR ≥ 2.5 , as a marker of impaired coronary microcirculation.

The TyG index was consistently calculated from fasting triglyceride and glucose values, although the cut-off values differed among studies. Reported TyG cut-offs included 8.1, 8.99, 9.2, 9.347, and 9.57. Several studies also analyzed the TyG index as a continuous predictor in multivariable logistic regression models.

Risk of Bias

Overall, the included studies were judged to have low risk of bias. All studies clearly described their population, exposure measurement, and angiographic outcome assessment. However, all studies were retrospective and single-center, which may introduce selection bias and limit generalizability. Differences in no-reflow definitions, TyG cut-off values, and adjustment models were also noted as potential sources of clinical and methodological heterogeneity.

Association Between TyG Index and No-Reflow or Impaired Microcirculatory Reperfusion

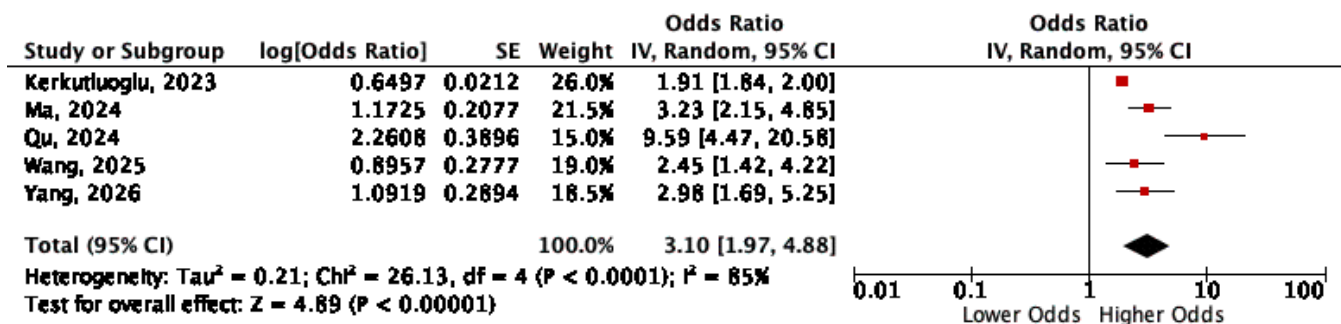


Figure 3. Forest plot result for Association Between TyG Index and No-Reflow or Impaired Microcirculatory Reperfusion

All included studies reported a positive association between higher TyG index and no-reflow or impaired microcirculatory reperfusion after PCI. The individual adjusted odds ratios ranged from 1.91 to 9.59. The strongest individual association was observed in Qu et al., where TyG index ≥ 8.1

was associated with markedly increased odds of no-reflow. Yang et al. and Ma et al. also showed significant independent associations between TyG index and no-reflow after primary PCI. Kerkutluoglu et al. reported a significant association, although the reported confidence interval was unusually narrow. Wang et al. showed that higher TyG index independently predicted high AMR, supporting the relationship between metabolic dysfunction and impaired coronary microcirculation.

The random-effects meta-analysis showed that higher TyG index was significantly associated with increased odds of no-reflow or impaired microcirculatory reperfusion after PCI. The pooled odds ratio was 3.10, with a 95% confidence interval of 1.97 to 4.88. The overall effect was statistically significant, with $Z = 4.89$ and $p < 0.00001$.

Substantial heterogeneity was observed across studies. The heterogeneity statistics were $\text{Tau}^2 = 0.21$, $\text{Chi}^2 = 26.13$, $\text{df} = 4$, $p < 0.0001$, and $I^2 = 85\%$. This high heterogeneity likely reflects differences in patient populations, TyG index cut-off values, adjustment models, and outcome definitions, particularly the inclusion of one study using high AMR rather than conventional no-reflow.

Predictive Performance of TyG Index

The included studies consistently reported that the TyG index had clinically meaningful predictive value for no-reflow or impaired microcirculatory reperfusion. Reported AUC values ranged from 0.650 to 0.884. Yang et al. reported an AUC of 0.70 using a TyG cut-off of 9.347. Qu et al. reported an AUC of 0.818 using a cut-off of 8.1. Ma et al. reported an AUC of 0.710 using a cut-off of 8.99. Kerkutluoglu et al. reported the highest AUC, 0.884, using a cut-off of >9.2 . Wang et al. reported an AUC of 0.650 for predicting high AMR using a cut-off of 9.57.

Overall, these findings suggest that the TyG index is not only associated with no-reflow risk but may also have practical value as a simple preprocedural or admission-based marker for identifying patients at higher risk of impaired reperfusion after PCI.

DISCUSSION

Principal Findings

This systematic review and meta-analysis found that a higher triglyceride–glucose index was significantly associated with an increased risk of no-reflow or impaired microcirculatory reperfusion after percutaneous coronary intervention in patients with acute myocardial infarction, particularly STEMI. Across five included studies, the pooled analysis demonstrated that patients with a higher TyG index had more than three-fold higher odds of developing no-reflow or microcirculatory impairment after PCI (OR 3.10, 95% CI 1.97–4.88; $p < 0.00001$). This association was consistent in direction across all included studies, although the magnitude of effect varied. The high heterogeneity observed in the analysis ($I^2 = 85\%$) suggests that differences in patient phenotype, no-reflow definition, TyG cut-off value, and adjustment strategy should be considered when interpreting the pooled result.

The clinical relevance of this finding lies in the persistent gap between successful epicardial reperfusion and adequate myocardial tissue perfusion after primary PCI. Although primary PCI remains the standard reperfusion strategy in STEMI, restoration of infarct-related artery patency does not always guarantee microvascular recovery. No-reflow represents a failure of tissue-level reperfusion and is associated with larger infarct size, impaired left ventricular recovery, adverse remodeling, heart failure, arrhythmia, and increased mortality.^{1–3} Therefore, identifying a simple and readily available predictor before or during PCI may help clinicians recognize patients at higher risk for poor reperfusion despite technically successful intervention.

Interpretation of the Association Between TyG Index and No-Reflow

The association between TyG index and no-reflow is biologically plausible. The TyG index reflects the combined burden of hyperglycemia and hypertriglyceridemia, both of which are closely linked to insulin resistance. Insulin resistance contributes to endothelial dysfunction, reduced nitric oxide bioavailability, oxidative stress, inflammatory activation, platelet hyperreactivity, and impaired fibrinolysis.^{4–6} These mechanisms overlap with the known pathophysiology of no-reflow, which includes microvascular obstruction, distal embolization, endothelial swelling, vasospasm, inflammation, reperfusion injury, and intramyocardial hemorrhage.⁶ In this context, a higher TyG index may not simply act as a metabolic marker, but may also reflect a systemic environment that predisposes the coronary microcirculation to reperfusion failure.

Hyperglycemia may worsen no-reflow through several pathways, including increased leukocyte adhesion, endothelial injury, oxidative stress, and microvascular plugging. Triglyceride-rich lipoproteins may further promote atherogenic plaque vulnerability and distal embolization during PCI. When these two abnormalities coexist, as captured by the TyG index, the resulting metabolic and inflammatory milieu may intensify microvascular dysfunction after coronary reperfusion. This may explain why TyG index performed better than isolated glucose or triglyceride values in several included studies and why its predictive value was observed across diabetic, metabolic syndrome, and broader STEMI populations.

Comparison With Previous Studies

The present findings are consistent with earlier cardiovascular literature showing that the TyG index is associated with adverse outcomes in patients with acute coronary syndrome and after PCI. Luo et al. reported that elevated TyG index was associated with poorer prognosis in patients with STEMI after PCI, supporting the relevance of insulin resistance-related markers in post-infarction risk stratification.⁸ Similarly, studies on coronary calcification and atherosclerotic cardiovascular disease have shown that the TyG index is associated with coronary atherosclerotic burden and vascular injury.⁷ These findings support the concept that TyG index is not only a metabolic indicator but also a vascular risk marker.

The included studies specifically extend this concept to the no-reflow setting. Ma et al. reported that the TyG index was independently associated with no-reflow in STEMI patients with type 2 diabetes mellitus after PCI, with a linear increase in no-reflow risk across higher TyG categories.¹⁰ Kerkutluoglu et al. similarly found that patients with no-reflow had significantly higher TyG values than those with normal coronary flow after primary PCI.⁹ The more recent studies by Qu et al. and Yang et al. further supported the predictive value of TyG index in metabolically vulnerable populations, including STEMI patients with metabolic syndrome and STEMI patients with type 2 diabetes mellitus.^{11,12} The study by Wang et al., although using angiography-derived microcirculatory resistance rather than classic angiographic no-reflow, also showed that TyG index was associated with impaired coronary microcirculatory function.¹³

Clinical Implications

The TyG index has several features that make it attractive for clinical use. It is calculated using fasting glucose and triglyceride levels, both of which are routinely available, inexpensive, and widely measured in patients admitted with acute coronary syndrome. Unlike more complex assessments of insulin resistance, such as the hyperinsulinemic–euglycemic clamp or HOMA-IR, the TyG index can be obtained without insulin measurement and without specialized testing.⁴ This practicality is important in STEMI care, where decision-making is time-sensitive and risk markers must be simple enough to integrate into real-world workflows.

In patients with elevated TyG index, clinicians may consider closer attention to microvascular protection strategies, thrombus burden, glycemic status, lipid abnormalities, and adjunctive pharmacological approaches during PCI. Although this meta-analysis does not prove that interventions guided by TyG index can reduce no-reflow, the findings suggest that TyG may help identify a higher-risk phenotype. These patients may benefit from more careful procedural planning, consideration of intracoronary vasodilators when appropriate, optimization of antithrombotic therapy, and more intensive post-PCI monitoring. Previous studies have shown that no-reflow management requires a combination of preventive and rescue strategies, including attention to thrombus burden, distal embolization, vasodilator therapy, and myocardial protection.^{13,14}

The finding may be especially relevant in patients with diabetes mellitus or metabolic syndrome. These populations often have baseline endothelial dysfunction, chronic inflammation, impaired microvascular reserve, and higher thrombotic tendency. Because several included studies focused on patients with type 2 diabetes or metabolic syndrome, the pooled result strongly suggests that the TyG index may be particularly informative in metabolically high-risk STEMI patients.

Heterogeneity and Methodological Considerations

The main limitation of the pooled evidence is substantial heterogeneity. This heterogeneity is expected because the included studies differed in several important aspects. First, the study populations were not identical. Some studies included STEMI patients with type 2 diabetes, one focused on metabolic syndrome, and one study used a broader AMI population. Second, the outcome definition varied. Most studies used TIMI flow-based definitions of no-reflow, while others incorporated myocardial blush grade or angiography-derived microcirculatory resistance.

Third, TyG index was modeled differently across studies, including continuous TyG index, ROC-derived cut-offs, and high-versus-low categorical comparisons. Fourth, adjustment models differed, with some studies adjusting for clinical factors such as age, diabetes, renal function, left ventricular function, lesion location, inflammatory markers, and procedural variables.

These variations may explain the wide range of reported odds ratios. The inclusion of Wang et al. also requires caution because the endpoint was high angiography-derived microcirculatory resistance rather than angiographic no-reflow.¹³ Although this outcome is mechanistically related to impaired reperfusion, it is not identical to conventional no-reflow. Therefore, the pooled result should be interpreted as an association between TyG index and impaired reperfusion or coronary microcirculatory dysfunction after PCI, rather than as a purely homogeneous no-reflow endpoint.^{13–}

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Strengths and Limitations

This meta-analysis has several strengths. It focuses on a clinically relevant and increasingly recognized metabolic marker in the setting of STEMI and PCI. It includes recent studies and synthesizes quantitative estimates using adjusted odds ratios whenever available. It also incorporates studies that assessed both angiographic no-reflow and related microcirculatory dysfunction, allowing a broader understanding of how TyG index may relate to reperfusion failure.

However, several limitations should be acknowledged. First, all included studies were observational and retrospective, which limits causal inference. Second, most studies were single-center cohorts, reducing generalizability. Third, the number of included studies was small, limiting the ability to perform robust subgroup analyses or meta-regression. Fourth, the definition of no-reflow was not fully uniform across studies. Fifth, the TyG index cut-off varied considerably, making it difficult to propose one universal threshold for clinical use. Sixth, residual confounding remains possible because important factors such as ischemic time, thrombus burden, Killip class, glycemic control, medication use, and procedural strategy were not consistently adjusted across studies. Finally, the high heterogeneity suggests that the pooled effect should be interpreted with caution.

Future Research

Future studies should aim to validate the predictive value of the TyG index in larger, multicenter prospective cohorts of STEMI patients undergoing primary PCI. Standardized definitions of no-reflow should be used, ideally combining TIMI flow, myocardial blush grade, ST-segment resolution, and microcirculatory indices when available. Studies should also evaluate whether TyG index adds incremental predictive value beyond established clinical and procedural predictors, such as ischemic time, thrombus burden, baseline TIMI flow, diabetes status, renal function, and inflammatory markers. In addition, future research should determine whether TyG-guided preventive strategies can reduce no-reflow incidence or improve clinical outcomes after PCI.

CONCLUSION

This systematic review and meta-analysis suggests that a higher triglyceride–glucose index is significantly associated with increased odds of no-reflow or impaired microcirculatory reperfusion after PCI in patients with STEMI. The pooled analysis showed that elevated TyG index was associated with more than three-fold higher odds of no-reflow, supporting its potential role as a simple metabolic risk marker in the acute reperfusion setting. Because the TyG index is derived from routinely available fasting glucose and triglyceride values, it may help identify patients at higher risk of microvascular reperfusion failure after PCI. However, the available evidence remains limited by retrospective study designs, small number of included studies, variable no-reflow definitions, different TyG cut-off values, and substantial heterogeneity. Further multicenter prospective studies are needed to validate the optimal TyG threshold, confirm its incremental predictive value, and determine whether TyG-guided risk stratification can improve clinical outcomes after primary PCI.

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