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Research Article

Relationship between Glycemic Control and Severity of Coronary Artery Disease in Patients Undergoing Coronary Angiography

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ABSTRACT
Background: Coronary artery disease (CAD) is a major cause of cardiovascular morbidity and mortality worldwide. Diabetes mellitus and chronic hyperglycaemia contribute to accelerated atherosclerosis and increased coronary disease burden. Glycated haemoglobin (HbA1c), a marker of long-term glycaemic control, may provide useful information regarding the severity of coronary artery disease.
Aim: To evaluate the relationship between glycaemic control and the severity of coronary artery disease in patients undergoing coronary angiography.
Materials and Methods: This hospital-based observational study included 100 consecutive patients undergoing coronary angiography for evaluation of suspected or established coronary artery disease. Baseline demographic and clinical parameters were recorded, and glycaemic status was assessed by HbA1c levels. Coronary angiographic severity was evaluated using the Gensini scoring system. The association between HbA1c levels and angiographic severity of CAD was assessed using correlation analysis and multivariable logistic regression.
Results: The mean age of the study population was 56.8 ± 10.4 years, with males comprising 72% of participants. Poor glycaemic control (HbA1c ≥7%) was observed in 54% of patients. Patients with poor glycaemic control had significantly higher mean Gensini scores compared with those with HbA1c <7% (55.8 ± 26.4 vs 27.1 ± 18.7; p<0.001). Multivessel coronary artery disease was more frequent among patients with HbA1c ≥7% (79.6% vs 54.3%; p=0.009). HbA1c showed a significant positive correlation with Gensini score (r=0.62; p<0.001). On multivariable logistic regression analysis, HbA1c ≥7% was an independent predictor of severe coronary artery disease (OR 3.4, 95% CI 1.6–7.1; p=0.001).
Conclusion: Poor glycaemic control was significantly associated with increased angiographic severity of coronary artery disease. HbA1c may serve as a simple and valuable marker for identifying patients at higher risk of severe coronary atherosclerotic burden and may assist in cardiovascular risk stratification.

Keywords: Glycated Haemoglobin, Hba1c, Coronary Artery Disease, Coronary Angiography, Gensini Score, Diabetes Mellitus, Glycaemic Control, Atherosclerosis.

INTRODUCTION

Coronary artery disease (CAD) remains one of the leading causes of morbidity and mortality worldwide, contributing substantially to the global burden of cardiovascular disease[1]. Despite advances in prevention, diagnosis, and treatment strategies, CAD continues to be responsible for a significant proportion of premature deaths, particularly in low- and middle-income countries. The increasing prevalence of metabolic disorders, especially diabetes mellitus, obesity, and sedentary lifestyle, has further accelerated the incidence and progression of atherosclerotic cardiovascular disease. [2]Diabetes mellitus is a well-established independent risk factor for the development and progression of CAD. Chronic hyperglycaemia promotes endothelial dysfunction, oxidative stress, inflammation, and accelerated atherosclerotic plaque formation through multiple metabolic pathways. Persistent elevation of blood glucose levels leads to advanced glycation end-product formation, increased vascular stiffness, and impaired nitric oxide-mediated vasodilatation, thereby contributing to coronary artery

endothelial injury and progression of obstructive coronary lesions. [3,4]Glycated haemoglobin (HbA1c) is widely used as an indicator of long-term glycaemic control, reflecting average blood glucose levels over the preceding 2–3 months. Apart from its role in diagnosing and monitoring diabetes, HbA1c has been increasingly recognized as a potential predictor of cardiovascular risk. Poor glycaemic control has been associated with increased incidence of myocardial infarction, multivessel coronary involvement, and adverse cardiovascular outcomes. [5,6] However, the relationship between HbA1c levels and the anatomical severity of CAD remains an area of ongoing investigation.Coronary angiography remains the gold standard for assessing the extent and severity of coronary artery stenosis and plays a central role in guiding revascularization decisions. Various angiographic scoring systems, including the Gensini score and SYNTAX score, provide quantitative assessment of coronary atherosclerotic burden by considering the severity, location, and complexity of coronary lesions. Understanding the association between glycaemic status and angiographic severity may help in early risk stratification and individualized management of patients undergoing coronary evaluation. [7,8]Previous studies have demonstrated a positive association between poor glycaemic control and increased coronary lesion complexity. Elevated HbA1c levels have been correlated with higher angiographic disease burden, greater prevalence of multivessel coronary artery disease, and increased severity scores among patients undergoing coronary angiography. [9,10] However, findings have been inconsistent, particularly among patients without previously diagnosed diabetes and across different clinical populations. Furthermore, data from Indian patients undergoing coronary angiography remain limited, despite the high prevalence of diabetes and premature CAD in this population. [11]The identification of simple biochemical markers that can predict the severity of CAD may improve early risk stratification and assist clinicians in optimizing preventive and therapeutic strategies. HbA1c, being an easily available and routinely measured parameter, may serve as a useful marker for predicting coronary atherosclerotic burden beyond conventional cardiovascular risk factors. [12-14].Therefore, the present study was undertaken to evaluate the relationship between glycaemic control, assessed by HbA1c levels, and the severity of coronary artery disease in patients undergoing coronary angiography. Establishing this association may provide valuable insights into cardiovascular risk assessment and facilitate individualized management approaches for patients with varying degrees of glycaemic control.

MATERIALS AND METHODS

This was a hospital-based observational cross-sectional study conducted to evaluate the relationship between glycaemic control and the severity of coronary artery disease in patients undergoing coronary angiography. The study was conducted in the Department of Cardiology and medicineA total of 100 consecutive patients undergoing coronary angiography for evaluation of suspected or established coronary artery disease were included in the study. Patients fulfilling the predefined eligibility criteria were enrolled.

Study Participants

Adult patients aged ≥18 years who underwent coronary angiography for assessment of coronary artery disease were included. The study population consisted of patients with and without diabetes mellitus to evaluate the association between glycaemic status and angiographic severity of coronary artery disease.

Inclusion Criteria

Patients were included if they fulfilled the following criteria:

- Age ≥18 years.
- Patients undergoing coronary angiography for evaluation of suspected or established coronary artery disease.
- Patients willing to participate and provide written informed consent.
- Availability of HbA1c estimation and complete angiographic assessment.

Exclusion Criteria

Patients were excluded if they had:

- Acute or chronic infectious or inflammatory disorders.
- Known malignancy.
- Chronic kidney disease requiring dialysis.
- Recent blood transfusion within the preceding 3 months.
- Haematological disorders affecting HbA1c interpretation.
- Incomplete clinical, laboratory, or angiographic records.
- Refusal to participate in the study.

Data Collection and Clinical Assessment

Baseline demographic and clinical data were collected using a structured proforma. Variables including age, sex, body mass index (BMI), smoking status, hypertension, diabetes mellitus, dyslipidaemia, family history of coronary artery disease, and previous cardiovascular history were recorded.Clinical presentation at admission, including symptoms such as chest pain, dyspnoea, and history of previous myocardial infarction or revascularization, was documented. Details regarding cardiovascular medications, including antidiabetic drugs, antihypertensive agents, statins, and antiplatelet therapy, were also recorded.

Assessment of Glycaemic Control

Glycaemic control was assessed by measuring glycated haemoglobin (HbA1c) levels. Venous blood samples were collected from all participants, and HbA1c estimation was performed using a standardized laboratory method.Patients were categorized according to glycaemic status based on HbA1c values. HbA1c level was also analyzed as a continuous variable to determine its correlation with the severity of coronary artery disease.

Laboratory Investigations

All patients underwent routine biochemical investigations, including:

- Complete blood count.
- Fasting blood glucose.
- Glycated haemoglobin (HbA1c).
- Serum lipid profile.
- Serum creatinine and renal function tests.
- Other investigations as clinically indicated.

All laboratory investigations were performed according to standard institutional protocols.

Coronary Angiographic Evaluation

Coronary angiography was performed in all enrolled patients using standard imaging techniques. The angiographic findings were evaluated by experienced cardiologists.

The extent and severity of coronary artery disease were assessed based on:

- Presence of significant coronary artery stenosis.
- Number of involved coronary vessels.
- Distribution of coronary lesions.
- Severity and anatomical complexity of lesions.

Significant coronary artery disease was defined as ≥50% luminal diameter stenosis in at least one major epicardial coronary artery.

Assessment of Coronary Artery Disease Severity

The severity of coronary artery disease was quantified using the Gensini scoring system. Each coronary lesion was graded according to percentage diameter stenosis and multiplied by a weighting factor based on anatomical location and importance of the involved coronary segment.The total Gensini score represented the overall coronary atherosclerotic burden. Higher scores indicated more extensive and severe coronary artery disease.

Patients were further categorized into groups based on angiographic severity:

- Mild coronary artery disease.
- Moderate coronary artery disease.
- Severe coronary artery disease.

Study Variables and Outcomes

Primary Outcome

The primary outcome was to determine the association between glycaemic control, assessed by HbA1c levels, and angiographic severity of coronary artery disease.

Secondary Outcomes

Secondary outcomes included:

- Association between HbA1c levels and number of diseased coronary vessels.
- Comparison of HbA1c levels among patients with varying severity of coronary artery disease.
- Correlation between HbA1c levels and Gensini score.
- Identification of independent predictors of severe coronary artery disease.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version [21].Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range) depending on the distribution of data. Categorical variables were expressed as frequencies and percentages.Normality of continuous variables was assessed using the Shapiro–Wilk test. Comparison between two groups was performed using the independent sample t-test or Mann–Whitney U test, while comparison among more than two groups was performed using one-way ANOVA or Kruskal–Wallis test, as appropriate.Categorical variables were compared using the Chi-square test or Fisher's exact test. Correlation between HbA1c

levels and Gensini score was assessed using Pearson's or Spearman's correlation coefficient.Multivariable logistic regression analysis was performed to identify independent predictors of severe coronary artery disease after adjusting for potential confounding factors such as age, sex, diabetes mellitus, hypertension, smoking, and dyslipidaemia.A two-tailed p-value <0.05 was considered statistically significant.

RESULTS

A total of 100 patients undergoing coronary angiography were included in the study. The mean age of the study population was 56.8 ± 10.4 years, with the majority of patients belonging to the age group of 51–60 years (36.0%). Males constituted the predominant proportion of the study population (72.0%), while females accounted for 28.0%. Diabetes mellitus was present in 54.0% of patients, whereas hypertension and dyslipidaemia were observed in 62.0% and 48.0% of patients, respectively. A history of smoking was reported in 42.0% of participants (Table 1).

Table 1. Baseline demographic and clinical characteristics of study population (n=100)

Parameter	n (%) / Mean ± SD
Age (years), mean ± SD	56.8 ± 10.4
Age group (years)	
<40	6 (6.0)
40–50	22 (22.0)
51–60	36 (36.0)
>60	36 (36.0)
Male sex	72 (72.0)
Female sex	28 (28.0)
Diabetes mellitus	54 (54.0)
Hypertension	62 (62.0)
Dyslipidaemia	48 (48.0)
Smoking history	42 (42.0)
Family history of CAD	26 (26.0)
Previous myocardial infarction	18 (18.0)

The mean HbA1c level among the study participants was 7.2 ± 1.5%. Based on glycaemic control, 46.0% of patients had good glycaemic control (HbA1c <7%), while 54.0% had poor glycaemic control (HbA1c ≥7%). Patients with poor glycaemic control had significantly higher fasting blood glucose levels compared with those having good glycaemic control (p<0.001) (Table 2).

Table 2. Distribution of patients according to glycaemic control status

Glycaemic parameter	Good control (HbA1c <7%) n=46	Poor control (HbA1c ≥7%) n=54	p-value
HbA1c (%)	6.2 ± 0.5	8.1 ± 1.2	<0.001
Fasting blood glucose (mg/dL)	118.4 ± 24.6	178.5 ± 52.8	<0.001
Diabetes mellitus, n (%)	18 (39.1)	36 (66.7)	0.006
Serum triglycerides (mg/dL)	142.5 ± 38.2	168.7 ± 54.3	0.009
LDL cholesterol (mg/dL)	108.4 ± 31.6	121.6 ± 36.4	0.061

Coronary angiography revealed significant coronary artery disease in all enrolled patients. Single-vessel disease was observed in 32.0%, double-vessel disease in 38.0%, and triple-vessel disease in 30.0% of patients. Patients with poor glycaemic control demonstrated a significantly higher proportion of multivessel coronary artery disease compared with those having good glycaemic control (p=0.003) (Table 3).

Table 3. Distribution of coronary artery disease severity according to glycaemic control

Angiographic finding	Good control (n=46)	Poor control (n=54)	p-value

Single-vessel disease	21 (45.7)	11 (20.4)	
Double-vessel disease	17 (37.0)	21 (38.9)	
Triple-vessel disease	8 (17.3)	22 (40.7)	0.003
Multivessel disease (≥2 vessels)	25 (54.3)	43 (79.6)	0.009

The mean Gensini score of the study population was 42.6 ± 25.8. Patients with poor glycaemic control had significantly higher mean Gensini scores compared with patients with good glycaemic control (55.8 ± 26.4 vs 27.1 ± 18.7; p<0.001). A progressive increase in coronary atherosclerotic burden was observed with increasing HbA1c levels (Table 4).

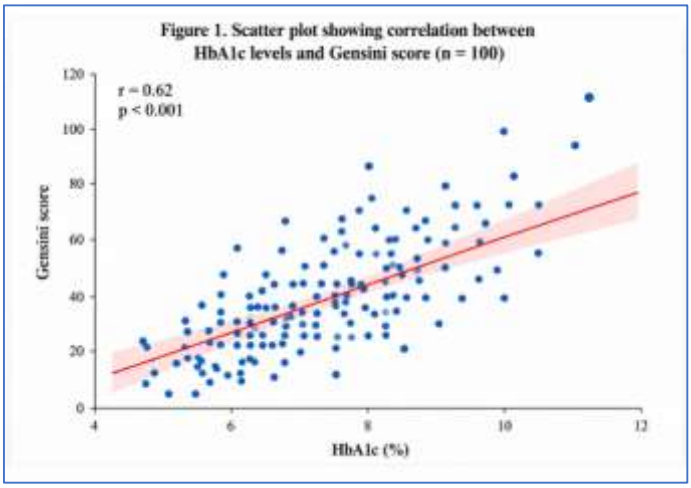
Table 4. Association between HbA1c levels and coronary artery disease severity score

Parameter	Good glycaemic control (n=46)	Poor glycaemic control (n=54)	p-value
Gensini score, mean ± SD	27.1 ± 18.7	55.8 ± 26.4	<0.001
Mild CAD (Gensini <30)	28 (60.9)	12 (22.2)	
Moderate CAD (30–60)	14 (30.4)	22 (40.7)	
Severe CAD (>60)	4 (8.7)	20 (37.1)	<0.001

Correlation analysis demonstrated a significant positive correlation between HbA1c levels and Gensini score (r=0.62, p<0.001). Increasing HbA1c levels were associated with greater angiographic disease burden. HbA1c also showed a significant association with the presence of multivessel coronary artery disease (Table 5).

Table 5. Correlation between glycaemic parameters and severity of coronary artery disease

Variable	Correlation coefficient (r)	p-value
HbA1c vs Gensini score	0.62	<0.001
Fasting glucose vs Gensini score	0.48	<0.001
Duration of diabetes vs Gensini score	0.39	0.004
HbA1c vs number of diseased vessels	0.45	<0.001

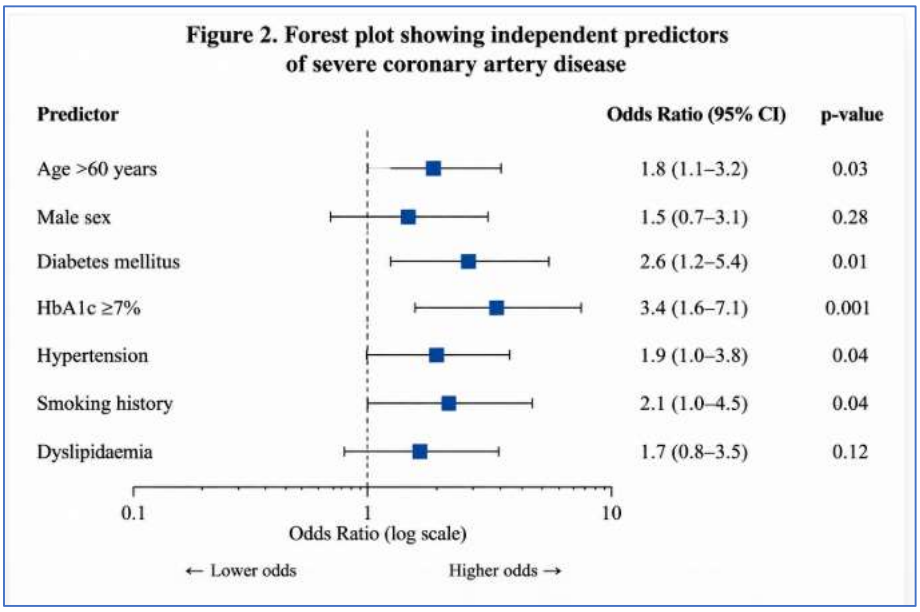


On multivariable logistic regression analysis, poor glycaemic control (HbA1c ≥7%) was found to be an independent predictor of severe coronary artery disease. After adjustment for age, sex, hypertension, smoking, and dyslipidaemia, patients with poor glycaemic control had 3.4-fold higher odds of severe CAD compared with patients having HbA1c <7% (Table 6).

Table 6. Multivariable logistic regression analysis of predictors of severe coronary artery disease

Predictor	Odds Ratio (OR)	95% CI	p-value

Age >60 years	1.8	1.1–3.2	0.03
Male sex	1.5	0.7–3.1	0.28
Diabetes mellitus	2.6	1.2–5.4	0.01
HbA1c ≥7%	3.4	1.6–7.1	0.001
Hypertension	1.9	1.0–3.8	0.04
Smoking history	2.1	1.0–4.5	0.04
Dyslipidaemia	1.7	0.8–3.5	0.12



DISCUSSION

Coronary artery disease (CAD) continues to be a major cause of cardiovascular morbidity and mortality worldwide. Diabetes mellitus and chronic hyperglycaemia are important contributors to accelerated coronary atherosclerosis through mechanisms involving endothelial dysfunction, oxidative stress, inflammation, and vascular remodeling. The present study evaluated the association between glycaemic control, assessed by glycated haemoglobin (HbA1c), and the angiographic severity of CAD among 100 patients undergoing coronary angiography.In the present study, the mean age of participants was 56.8 ± 10.4 years, with a male predominance (72%). Diabetes mellitus was present in 54% of patients, and 54% had poor glycaemic control (HbA1c ≥7%). Coronary angiography revealed a higher proportion of multivessel coronary artery disease among patients with poor glycaemic control. These findings emphasize the significant contribution of prolonged hyperglycaemia towards increased coronary atherosclerotic burden.The major finding of our study was the significant association between poor glycaemic control and increased severity of coronary artery disease. Patients with HbA1c ≥7% had significantly higher mean Gensini scores compared with those with HbA1c <7% (55.8 ± 26.4 vs 27.1 ± 18.7; p<0.001). Additionally, HbA1c demonstrated a significant positive correlation with Gensini score (r=0.62, p<0.001), indicating that worsening glycaemic control was associated with progressive increase in coronary atherosclerotic severity. Similar findings were reported by Dutta et al., who demonstrated a significant correlation between HbA1c levels and severity of CAD assessed by SYNTAX score, along with an increasing number of diseased vessels with higher HbA1c levels. [15] The association between HbA1c and coronary lesion severity observed in our study is consistent with previous literature. Tsuruta et al. reported that higher HbA1c levels were associated with greater coronary atherosclerotic burden and increased severity of coronary lesions, suggesting that HbA1c may act as an important marker of cardiovascular risk. [16] Similarly, Jiao et al. demonstrated that HbA1c was an independent predictor of severe coronary stenosis and adverse cardiovascular outcomes among patients with type 2 diabetes mellitus and coronary heart disease. [17] In our study, poor glycaemic control was associated with increased prevalence of triple-vessel disease (40.7% vs 17.3%) and multivessel

coronary artery disease (79.6% vs 54.3%). This finding suggests that chronic hyperglycaemia may contribute not only to the development of CAD but also to diffuse and complex coronary involvement. Dutta et al. similarly observed that increasing HbA1c levels were associated with a greater number of diseased coronary vessels, supporting the role of HbA1c as a marker of angiographic disease severity. [15] The positive correlation between HbA1c and Gensini score in our study indicates that HbA1c reflects the overall coronary atherosclerotic burden. The Gensini scoring system provides a quantitative assessment of coronary disease by considering both severity and anatomical distribution of stenosis. Studies have demonstrated that Gensini score is a useful tool for evaluating angiographic severity and predicting cardiovascular outcomes. [18] Patients with diabetes and coronary heart disease have been shown to exhibit higher Gensini scores, reflecting increased coronary lesion complexity and burden. [18] Multivariable logistic regression analysis in our study showed that HbA1c ≥7% was an independent predictor of severe coronary artery disease (OR 3.4, 95% CI 1.6–7.1; p=0.001) after adjustment for conventional cardiovascular risk factors. This finding indicates that glycaemic status provides additional information beyond traditional risk factors such as age, hypertension, smoking, and dyslipidaemia. Previous study reported a similar association, demonstrating a significant positive correlation between HbA1c and CAD severity, with HbA1c acting as an important predictor of angiographic disease burden. [19] The relationship between poor glycaemic control and severe CAD can be explained by several pathophysiological mechanisms. Chronic hyperglycaemia promotes formation of advanced glycation end products, which induce endothelial injury, vascular inflammation, and arterial stiffness. Increased oxidative stress and activation of inflammatory pathways accelerate lipid deposition and plaque progression. Furthermore, hyperglycaemia contributes to impaired endothelial nitric oxide production, platelet activation, and a prothrombotic state, resulting in progression of coronary atherosclerosis.The findings of our study are also supported by studies evaluating HbA1c among patients without previously diagnosed diabetes. Wei et al. demonstrated that HbA1c levels were significantly associated with severity of coronary stenosis even among patients without diagnosed diabetes, suggesting that HbA1c may provide cardiovascular risk information beyond conventional diabetic classification. [20]Previous study also reported that HbA1c could serve as an independent marker for predicting the presence and severity of CAD among non-diabetic individuals. [21] However, the association between HbA1c and CAD severity has not been consistently demonstrated in all studies. Habib et al. did not find a significant relationship between HbA1c levels and severe CAD assessed by SYNTAX score among patients presenting with acute coronary syndrome. Differences in patient selection, acute clinical presentation, sample size, and assessment methods may explain these variations. [22]The clinical implications of our findings are important. HbA1c is a simple, routinely available, and inexpensive biomarker that may help identify patients at increased risk of severe coronary artery disease. Assessment of HbA1c before coronary angiography may assist in early risk stratification and implementation of aggressive preventive strategies, including optimized glycaemic control, lipid management, blood pressure control, and lifestyle modification.

CONCLUSION

The present study demonstrated a significant association between poor glycaemic control and increased severity of coronary artery disease among patients undergoing coronary angiography. Higher HbA1c levels were associated with greater coronary atherosclerotic burden, increased multivessel disease, and higher Gensini scores. HbA1c may serve as a simple and useful marker for risk stratification and identification of patients with severe coronary artery disease.

Limitations

The study was limited by its small sample size, single-centre design, and cross-sectional nature, which restricted assessment of causal relationships. Other factors such as duration of diabetes, glycaemic variability, inflammatory markers, and long-term cardiovascular outcomes were not evaluated. Larger multicentric prospective studies with longer follow-up are required to validate these findings.

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