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CORRELATION OF ANGIOGRAPHIC SEVERITY OF CORONARY ARTERY DISEASE WITH GLYCOCYLATED HEMOGLOBIN IN ST-SEGMENT ELEVATION MYOCARDIAL INFARCTION

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ABSTRACT

Background: Coronary artery disease (CAD) and type 2 diabetes mellitus (T2DM) frequently coexist and significantly impact cardiovascular morbidity and mortality, particularly in low- and middle-income countries. Glycated hemoglobin (HbA1c) is a well-established biomarker for long-term glycemic control and can serve as a predictor of coronary atherosclerotic disease burden. The study aimed to evaluate the correlation between HbA1c levels in blood and the angiographic severity of CAD, as quantified by the SYNTAX score, in T2DM patients presenting with ST-segment elevation myocardial infarction (STEMI).

Methods: Total 74 patients aged 30–70 years with confirmed STEMI and T2DM (HbA1c ≥6.5%) recruited at Lady Reading Hospital Peshawar. Patients underwent coronary angiography, and SYNTAX score was calculated to assess CAD severities. Patients were stratified into good (≤8%) and poor (>8%) glycemic control groups based on HbA1c levels. The relationship between HbA1c and the SYNTAX score was analyzed using Spearman's correlation and chi-square tests.

Results: The mean HbA1c was 8.4 ± 0.9%, and the mean SYNTAX score was 25.2 ± 7.9. Statistically significant moderate positive correlation was observed between HbA1c and the SYNTAX score ($r = 0.57$, $p < 0.001$). Patients who had poor glycemic control had significantly higher SYNTAX scores ($p < 0.001$), with a greater proportion presenting with intermediate to high CAD severity.

Conclusion: Elevated HbA1c level is significantly associated with more angiographic severity of CAD in diabetic patients with STEMI. HbA1c may serve as a valuable marker for early risk stratification and intervention planning in acute coronary syndromes, especially in populations with high diabetes prevalence.

INTRODUCTION

Coronary artery disease (CAD) is the leading cause of mortality worldwide, causing approximately 7.5 million deaths annually(1). Among the most significant contributors to the causation and progression of CAD is diabetes mellitus (DM), a global epidemic that disproportionately affects low- and middle-income population countries(2). In Pakistan, the prevalence of type 2 diabetes mellitus (T2DM) among adults aged 25 years and above is estimated at 13.7%, reflecting a growing public health crisis(3). Notably, nearly one-third of all CAD-related deaths are attributable to diabetes(4). The interplay between diabetes and CAD is complex and multifactorial(5). Chronic hyperglycemia, insulin resistance, oxidative stress, and systemic inflammation collectively accelerate the atherosclerotic process and impair endothelial function, leading to diffuse and multivessel coronary artery involvement(6). Consequently, individuals with diabetes who present with acute coronary syndromes, especially in T-segment elevation myocardial infarction (STEMI), are at significantly increased risk for unfavorable cardiovascular outcomes(7). Studies have shown that these patients have a two- to four times increased incidence of major adverse cardiovascular events often attributed to hyperglycemia-induced vascular injury(8). Glycated hemoglobin (HbA1c) serves as a robust and standardized biomarker of long-term glycemic control(9). Unlike random or fasting blood glucose levels, the HbA1c levels shows average plasma glucose concentrations over time period of the preceding 8–12 weeks and has been endorsed by leading cardiovascular and diabetes associations for both diagnosis and risk stratification(10). Importantly, several clinical investigations have shown positive association between elevated HbA1c level and the severity of coronary artery disease(11). The SYNTAX (Synergy between Percutaneous Coronary Intervention with Taxus and Cardiac Surgery) score provides comprehensive assessment of anatomy and anatomical complexity of CAD(12). Higher SYNTAX scores have been consistently observed in diabetic patients and have been shown to correlate positively with HbA1c levels, suggesting a direct link between poor glycemic control and advanced coronary pathology ($r = 0.320$; $p = 0.002$)(12). Despite a wealth of international data, the association between HbA1c and angiographic severity of CAD has not been properly explored in the Pakistani population, where both diabetes and CAD are highly prevalent. Local evidence is essential to inform context-specific clinical strategies and public health interventions. To address this gap, the present study investigates the correlation between HbA1c levels at time of admission in hospital and the angiographic severity of CAD, as quantified by the SYNTAX scores, in diabetic patients presented with STEMI. By elucidating this relationship in a local context, this study aims to reinforce the importance of stringent glycemic control and regular HbA1c monitoring as key components in the prevention and management of complex coronary artery disease among high-risk diabetic individuals.

Methods

Study Design and Setting: The cross-sectional analytical research study implemented at department of cardiology, Lady Reading Hospital, Peshawar—a tertiary care referral center in northern Pakistan. Approved by **Ethical Review Board at Lady Reading Hospital, Peshawar (Ref: 103/LRH/MTI/ 04/04/2024)**.

Study Duration: Data were collected over a six-month period from **May 2024 to November 2024**.

Sample Size and Sampling Technique: A total of 74 patients were enrolled, calculated using a correlation coefficient of $r = 0.320$, with a 5% level of significance and 80% statistical power. A non-probability consecutive sampling technique was mellitus enroll patients presenting with STEMI and T2DM.

Eligibility Criteria

Inclusion Criteria

- Age between 30 - 70 years
- Diagnosed T2DM for at least six months
- HbA1c ≥6.5%
- Diagnosis of STEMI, confirmed by:
  - History of chest pain
  - Persistent ST-segment elevation greater than 1 mm in two contiguous limb leads. OR greater than 2 mm in two contiguous precordial leads
  - Elevated cardiac troponin levels (>10 pg/ml)
- **Exclusion**
- Previous history of coronary artery bypass grafting
- Past coronary angiography
- Cardiomyopathies
- Chronic kidney disease
- Familial hypercholesterolemia
- Severe cardiopulmonary compromise

Data Collection: Patients with the eligibility criteria were enrolled from the cardiology inpatient unit. Written informed consent obtained after explaining the research study objectives, procedures, and potential risks. A structured proforma was used to recording demographic and clinical data. Data of each participant included age, gender, body mass index (BMI), duration of diabetes, treatment modality, education level, residence, and socioeconomic status.

Fasting blood samples were collected from T2DM to assess the HbA1c levels. Based on these values, patients were stratified in two groups:

- **Good control**: HbA1c ≤8%
- **Poor control**: HbA1c >8%

All participants underwent coronary angiography. Two interventional cardiologists who were blinded to the HbA1c status performed angiography. The SYNTAX score was calculated using the standardized algorithm to evaluate the anatomy and complexity of coronary artery disease. CAD severity grouped based on SYNTAX score as:

- Low ≤22
- Intermediate 23–32
- High ≥33)

Statistical Analysis: SPSS version 25.0 was used for data analysis. The continuous variables such as age, BMI, duration of diabetes, HbA1c, and SYNTAX score were tested for normality using the Shapiro-Wilk test. Study data shown as mean ± standard deviation or median (interquartile range).

The relationship between HbA1c groups and CAD severity was analyzed with the Chi-square or Fisher's exact test.Correlation in between HbA1c and SYNTAX score was assessed with **Spearman's rank correlation coefficient (r)**. Strength of correlation was interpreted as:

- $r \leq \pm 0.40$: weak correlation
- $r = \pm 0.41–0.59$: moderate correlation
- $r \geq \pm 0.60$: strong correlation Positive and negative values indicated the direction of the relationship. Statistically insignificant if p-value of less than 0.05.

Subgroup analytics were performed to know the impact of age, gender, BMI, duration of diabetes, and treatment modality on the primary outcome.

RESULTS

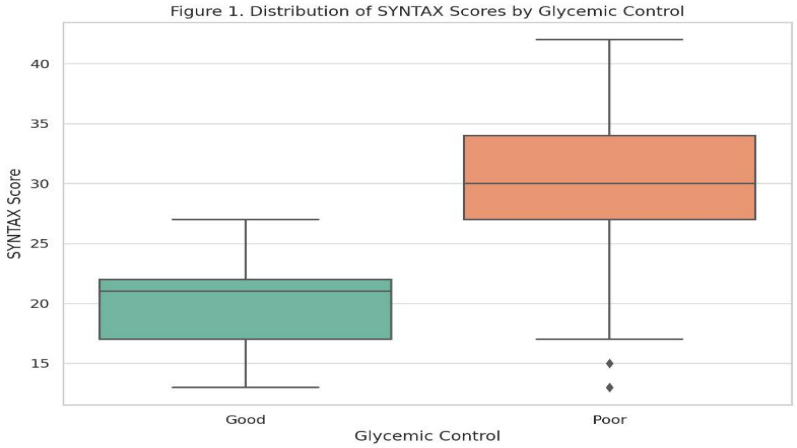
A total of 74 patient with STEMI and T2DM were recruited. The mean age was 50.7 ± 10.1 years, with 70.3% male. The average body mass index of participants was 27.1 ± 3.20 kg/m², and the median time period of diabetes was 6.9 years (IQR: 4.5–10.2 years).

Based on glycemic control, 33 patients (44.6%) had HbA1c ≤8% (good control), and 41 patients (55.4%) had HbA1c >8% (poor control). The mean HbA1c level was 8.4 ± 0.9%. The SYNTAX score ranged 8 to 48, a mean of 25.2 ± 7.9, and was categorized as follows:

- **Low severity (≤22)**: 30 patients (40.5%)
- **Intermediate severity (23–32)**: 31 patients (41.9%)
- **High severity (≥33)**: 13 patients (17.6%)

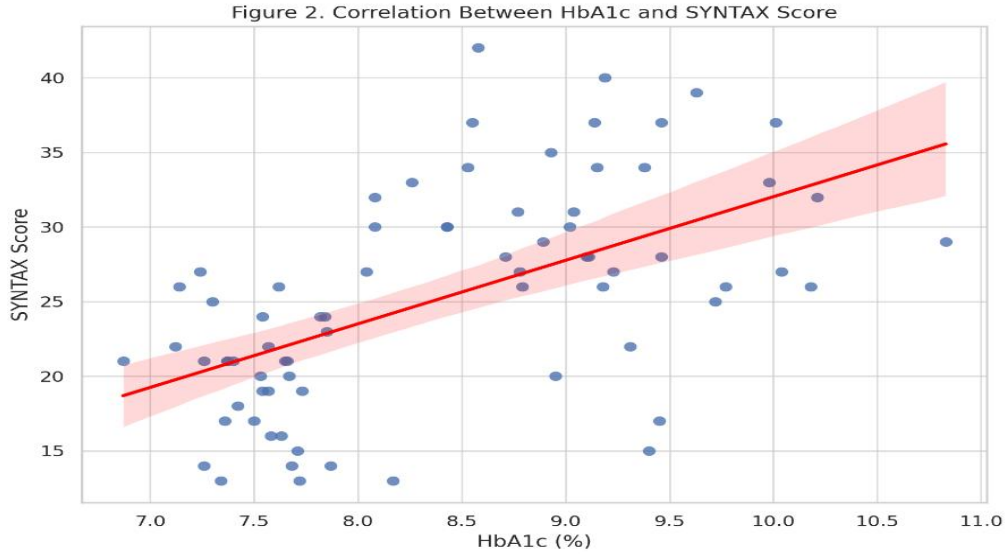
A **moderate positive correlation** was comprehend in between HbA1c and SYNTAX score (**Spearmanr = 0.57, p < 0.001**), indicating a significant correlation between poor glycemic control and angiographic severity of CAD.

Figure 1:The distribution of SYNTAX Scores by Glycemic Control



This boxplot visually compares the SYNTAX score distribution between patients with good (HbA1c ≤8%) and poor (HbA1c >8%) glycemic control. It clearly shows a higher median SYNTAX score and broader range among poor controlgroup.

Figure 2: Correlation Between SYNTAX Score and levels of HbA1c



This scatter plot illustrates a moderate positive correlation (r = 0.57) between HbA1c level with SYNTAX score, with a fitted regression line indicating the upward trend of CAD severity with increasing HbA1c.

The **Chi-square test** demonstrated significant relationship between **glycemic control and CAD severity** ($\chi^2 = 33.11$, $p < 0.001$). Notably:

- In the **good control** group, 75.8% had low SYNTAX scores, and **none** had high scores.
- In the **poor control** group, 56.1% had intermediate and 31.7% had high SYNTAX scores.

Table 1: Glycemic Control Status vs CAD Severity

Glycemic_Control	High	Intermediate	Low
Good	0	8	25
Poor	13	23	5

These results underscore the significant relationship between elevated HbA1c levels and greater angiographic burden of CAD among diabetic STEMI patients.

DISCUSSION

This study investigated the association between long-term glycemic control, as assessed and predicted by HbA1c and the angiographic severity of CAD in patients presenting with STEMI and T2DM. The results demonstrated statistically significant moderate positive correlation between HbA1c and SYNTAX score ($r = 0.57$, $p < 0.001$), reinforcing the role of chronic hyperglycemia in promoting diffuse and complex coronary pathology. Our study results were consistent with prior international studies that had shown same associations. Arbel et al. found that HbA1c related to SYNTAX score more than 22 in non-diabetic patients hospitalized with myocardial infarction or stable angina, suggesting that HbA1c correlated with severity as demonstrated by the SYNTAX score(13). Similarly, a study by Kilic and Baydar demonstrated a stronger correlation between HbA1c levels and SYNTAX score II compared to fasting glucose levels in non-STEMI highlighting the significance of HbA1c as a predictor of CAD complexity(14). Further supporting this association, a study conducted in North-Eastern India observed that an increase in HbA1c levels has strong correlations with severity of disease and higher SYNTAX scores among non-diabetic patients with proven CAD on angiography(15). Additionally, a study by Yan et al demonstrated a positive correlation between HbA1c and the SYNTAX score in patients of CAD, suggesting that HbA1c measurement could be used for evaluating the angiographic severity and complexity of coronary artery lesions(16). These findings underscore the pathophysiological mechanisms through which poor glycemic control exacerbates atherosclerotic progression. Chronic hyperglycemia contributes to endothelial dysfunction, oxidative stress, low-grade systemic inflammation, and enhanced platelet aggregation, all of which accelerate coronary artery plaque formation and instability(17). These processes are particularly relevant in the setting of STEMI, where plaque rupture and thrombosis are central events. In present study, patients with poor uncontrolled glycemic control (HbA1c >8%) were significantly more likely to present with intermediate or high SYNTAX scores compared to those with good control (HbA1c ≤8%). These findings suggest that inadequate glycemic management is associated not only with increased cardiovascular risk but also with more anatomically complex CAD requiring potentially more aggressive interventional strategies. Importantly, our study provides much-needed local data from Pakistan, where the burden of diabetes and cardiovascular disease continues to rise. The integration of HbA1c as a routine marker for risk stratification in diabetic STEMI patients could facilitate early identification of high-risk individuals and promote timely intervention.

Study limitations included cross-sectional design that limits causal inference. Additionally, the sample size, though adequately powered for correlation analysis, may not allow for detailed subgroup stratifications. Other confounding variables, such as lipid profile, inflammatory markers, and medication adherence, were not assessed and may influence the observed relationship.

CONCLUSION

This study demonstrates a statistically significant and clinically relevant association between elevated glycated hemoglobin (HbA1c) levels and angiographic severity of CADas measured by the SYNTAX score in patients presenting with STEMI and T2DM. Patients with poor uncontrolled glycemic control (HbA1c >8%) showed significantly more complex and extensive coronary lesions compared to those with good glycemic control.

The study findings reinforce the importance of HbA1c not only as a diagnostic marker for diabetes but also as a potential predictor of anatomical disease burden in acute coronary syndromes. Our results align with international literature and add valuable data from a local South Asian population, where both diabetes and cardiovascular disease are highly prevalent.

RECOMMENDATIONS

Future research studies should focus on longitudinal and multicenter studies to validate the observed correlation between HbA1c and angiographic severity of CADin diverse populations. Researchers are encouraged to explore potential mechanistic pathways linking chronic hyperglycemia to coronary plaque complexity using advanced imaging and molecular techniques. Additionally, integrating HbA1c into composite risk prediction models alongside inflammatory and lipid markers may enhance the accuracy of CAD severity forecasting. Studies evaluating the impact of intensified glycemic control on anatomical and clinical outcomes in STEMI patients would provide valuable insights for personalized therapeutic strategies.

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