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ORIGINAL RESEARCH

# The Association Between Markers of Lipid Homeostasis, Inflammation, and Atherosclerosis Index in Patients with Type 2 Diabetes and Coronary Heart Disease Stratified by Glycemic Control: A Cross-Sectional Study

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**Objective:** This cross-sectional study investigates the relationship between systemic markers of lipid homeostasis, inflammation, and atherosclerosis index (AI) in patients with both type 2 diabetes and coronary heart disease (CHD), stratified by their glycemic control status.

**Methods:** A total of 120 patients with type 2 diabetes and CHD were included and stratified into a Good Glycemic Control group (GGC, HbA1c<7%, n=72) and a Poor Glycemic Control group (PGC, HbA1c≥7%, n=48). AI was assessed using brachial-ankle pulse wave velocity (baPWV), and coronary stenosis was evaluated angiographically. Blood lipids, glucose metabolism indicators (Fasting Plasma Glucose [FPG], Fasting Insulin [FINS], HOMA-IR), and serum inflammatory markers (TNF-α, IL-1β, hs-CRP) were quantified. Pearson correlation and logistic regression analyses were used to assess associations and identify risk factors for AI.

**Results:** The PGC group exhibited significantly higher AI and coronary stenosis scores, a more atherogenic lipid profile (higher TC, TG, LDL-C; lower HDL-C), and elevated HOMA-IR and inflammatory markers compared to the GGC group (all P<0.05). Baseline characteristics and medication use were similar, except for higher insulin use in the PGC group. Pearson analysis revealed that AI was positively correlated with hs-CRP, TG, coronary stenosis scores, and HOMA-IR (all P<0.05). Logistic regression identified hs-CRP, TG, coronary stenosis score, and HOMA-IR as independent risk factors for increased AI.

**Conclusion:** In patients with type 2 diabetes and CHD, poor glycemic control is strongly associated with increased arterial stiffness, dyslipidemia, systemic inflammation, and insulin resistance. These findings highlight the critical, intertwined roles of these pathways in atherosclerosis and underscore the necessity of a multifactorial approach to cardiovascular risk management in this high-risk population.

**Keywords:** diabetes, coronary heart disease, lipid homeostasis, atherosclerosis, glycemic control, inflammation

## Introduction

Diabetes and coronary heart disease (CHD) are major global health concerns, with their coexistence significantly exacerbating the risk of cardiovascular complications.[1–3] The persistent hyperglycemia characteristic of diabetes adversely affects multiple organ systems and accelerates atherosclerosis, ultimately compromising myocardial blood supply and leading to CHD. The prevention and management of diabetes-related cardiovascular risk is therefore a critical public health priority, particularly given the increased mortality from diabetic heart disease, which is directly correlated with advancing age.

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Diabetes-related microvascular and macrovascular pathologies extend beyond the immediate damage caused by hyperglycemia, involving chronic inflammation, dyslipidemia, and oxidative stress.[4,5] Atherosclerosis, the primary pathological foundation for macrovascular complications in diabetes combined with CHD, is characterized by lipid and fibrous deposition in the vascular wall, leading to reduced vessel elasticity, stenosis, and even occlusion. While macrophage activity is central to atherogenesis,[6,7] systemic markers reflecting these processes are crucial for clinical assessment. Elevated free fatty acids, triglycerides, and oxidized LDL in diabetic patients further intensify vascular inflammation and atherosclerosis.[8,9] While the individual links between hyperglycemia, dyslipidemia, inflammation, and CHD are well-documented, a comprehensive analysis of their interplay within a specific high-risk cohort of patients already diagnosed with both conditions is less explored. In particular, the incremental impact of glycemic control status on the relationship between these systemic markers and a functional measure of arterial stiffness like the AI warrants further elucidation to refine risk stratification and therapeutic strategies in this vulnerable population.

AI, a clinical metric commonly used to assess the overall stiffness and functional impairment of blood vessels, offers a comprehensive evaluation of atherosclerosis. Investigating the association between systemic lipid and inflammatory markers and AI in this patient population is essential for elucidating the underlying pathophysiology and informing targeted therapeutic strategies. This study explores this relationship, aiming to provide a scientific basis for integrated management of diabetes and coronary heart disease.

# Materials and Methods

## Study Population and Grouping

The patient enrollment and study flow are detailed in Figure 1. A total of 165 patients with established diagnoses of both type 2 diabetes and coronary heart disease, admitted to our hospital between June 2021 and December 2022, were initially screened for eligibility. Of these, 45 patients were excluded: 15 did not meet the specific inclusion criteria (eg, age outside the 40–70 year range, lack of definitive CHD diagnosis as per study protocol, or type 1 diabetes), 20 met one or more exclusion criteria (such as acute infection or severe organ dysfunction), and 10 declined to participate or did not provide informed consent. Consequently, 120 eligible patients who provided informed consent were enrolled in the study. These participants were then stratified based on their mean HbA1c levels over the preceding three months into the Good Glycemic Control (GGC) group (HbA1c <7%, n=72) and the Poor Glycemic Control (PGC) group (HbA1c ≥7%, n=48). Written informed consent was obtained from all participants. The sample size was determined based on detecting a clinically significant difference in the primary outcome of AI between the groups, with an estimated power of 80% and a significance level of 0.05, considering data from previous similar studies.

## Inclusion and Exclusion Criteria

Inclusion criteria comprised patients aged over 18 years, regardless of gender, with clinically diagnosed type 2 diabetes and a confirmed history of coronary heart disease. Type 2 diabetes was diagnosed according to the American Diabetes Association criteria. Coronary heart disease was diagnosed based on established clinical criteria, including a history of myocardial infarction, angiographically confirmed coronary stenosis (≥50% in at least one major coronary artery), or previous coronary revascularization procedures. Exclusion criteria included acute infections, recent major surgery, pregnancy or lactation, known allergies to study-related drugs or contrast agents, and severe hepatic or renal dysfunction.

## Atherosclerosis Index and Coronary Artery Stenosis Assessment

AI was assessed using brachial-ankle pulse wave velocity (baPWV), a non-invasive and commonly accepted surrogate measure of arterial stiffness, with values ≥1400 cm/s indicating increased arterial stiffness.[10] For the purpose of this study, AI is used as a general term referring to this assessment. Higher baPWV values are associated with advanced atherosclerosis and serve as a predictor for atherosclerotic cardiovascular disease, highlighting its role as a key component in cardiovascular risk evaluation.[10] Coronary stenosis was evaluated via angiography, and the degree of stenosis was graded based on lumen narrowing: 1 (1–25% stenosis), 2 (26–50% stenosis), 4 (51–75% stenosis), 8 (76–90% stenosis), 16 (91–99% stenosis), and 32 (100% occlusion).

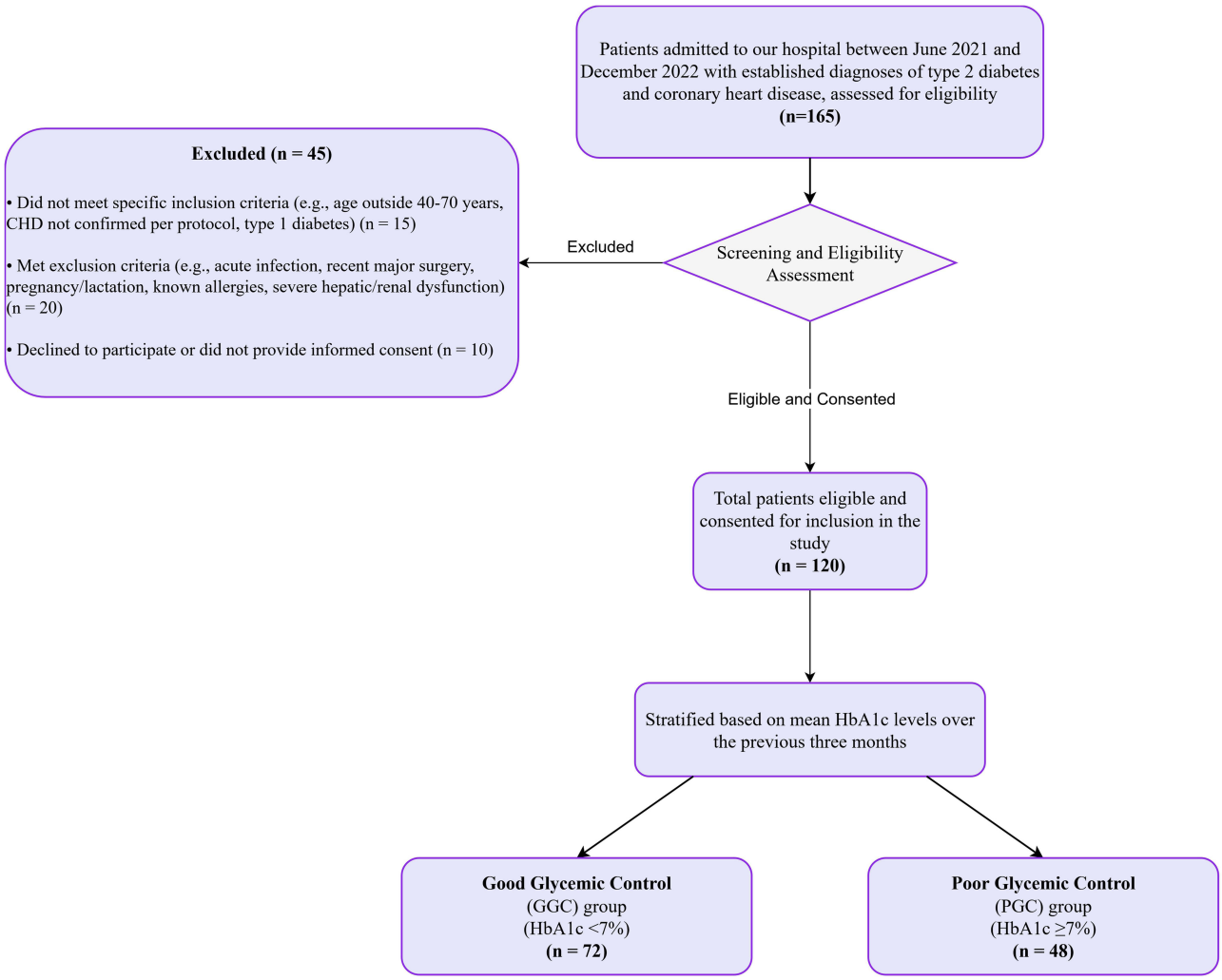


**Figure 1** The study flow diagram.

## Biochemical and Lipid Analysis

Fasting blood samples were collected, and serum was isolated by centrifugation. TC, TG, LDL-C, and HDL-C levels were measured using a Roche Cobas automated biochemical analyzer. FPG and FINS were also analyzed, with HOMA-IR calculated as HOMA-IR = FINS (μU/mL) × FPG (mmol/L) / 22.5.

## ELISA for Inflammatory Markers

Serum concentrations of TNF-α, IL-1β, and hs-CRP were determined using enzyme-linked immunosorbent assay (ELISA) following standard protocols. Absorbance was measured at 450 nm, and concentrations were extrapolated using a standard curve. Commercially available ELISA kits were used for all measurements (R&D Systems, Minneapolis, MN, USA for TNF-α and IL-1β; specific high-sensitivity kits for hs-CRP from DRG Instruments GmbH, Germany), and assays were performed according to the manufacturers' instructions. All other reagents were of analytical grade and obtained from standard commercial suppliers.

## Statistical Analysis

Data normality was assessed using the Shapiro–Wilk test. Normally distributed continuous variables were compared using Student's *t*-test for two independent groups, with results expressed as mean ± standard deviation (SD). For non-normally distributed data, the Mann–Whitney *U*-test was used, and data were expressed as median (interquartile range). Categorical

variables were compared using the Chi-square test or Fisher's exact test, as appropriate. Pearson correlation analysis assessed relationships among normally distributed variables, while Spearman correlation was used for non-normally distributed variables. Logistic regression was employed to identify risk factors for AI (defined as AI values above the median for the cohort). Prior to performing logistic regression, multicollinearity among the independent variables was assessed using variance inflation factors (VIFs), with a VIF value > 5.0 considered indicative of significant collinearity; no significant multicollinearity was detected among the variables included in the final model. Statistical analysis was performed using SigmaStat Version 3.1 (Systat Software, Inc)., with $P<0.05$ considered statistically significant.

# Results

## Comparison of General Data of Patients

The baseline characteristics of the GGC and PGC groups are summarized in Table 1. The GGC group comprised 40 males and 32 females, with a mean age of 62.79 ± 3.27 years and an average BMI of 22.35 ± 1.87 kg/m². In this group, 15.27% had hypertension, 26.38% had a smoking history, and 22.22% had a history of alcohol consumption in the past five years. The PGC group included 22 males and 24 females, with a mean age of 63.37 ± 4.66 years and an average BMI of 22.47 ± 2.06 kg/m². In this group, 12.50% had hypertension, 25.00% had a smoking history, and 14.58% had a history of alcohol consumption in the past five years. No statistically significant differences were found between the two groups regarding these variables ($P > 0.05$; Table 1). Baseline medication use is presented in Table 2. There were no significant differences in the use of statins, metformin, ACE inhibitors/ARBs, antiplatelet agents, GLP-1 RAs, or SGLT2 inhibitors between the two groups. However, insulin use was significantly higher in the PGC group ($P < 0.01$).

## Atherosclerosis Index and Coronary Artery Stenosis Score

Analysis revealed that both the atherosclerosis index (AI) and coronary artery stenosis scores were significantly higher in the PGC group compared to the GGC group ($P < 0.05$; Figure 2, Table 3). This suggests a more advanced state of atherosclerosis and coronary artery disease in patients with poor glycemic control.

**Table 1** Statistics of General Data of Patients

| Project | Good Glycemic Control group (GGC) (n=72) | Poor Glycemic Control group (PGC) (n=48) | T value /χ2 value | P value |
|---|---|---|---|---|
| Gender (male: female) | 40:32 | 22:24 | 0.771 | 0.380 |
| Age (years, mean ± SD) | 62.79±3.27 | 63.37±4.66 | 0.725 | 0.470 |
| BMI (kg/m$^2$, mean ± SD) | 22.35±1.87 | 22.47±2.06 | 0.323 | 0.747 |
| Hypertension (%) | 11 (15.27%) | 6 (12.50%) | 0.187 | 0.665 |
| Smoking history (%) | 19 (26.38%) | 12 (25.00%) | 0.029 | 0.865 |
| History of alcohol consumption (%) | 16 (22.22%) | 7 (14.58%) | 1.109 | 0.292 |

**Note**: T-values are for continuous variables (Age, BMI), $\chi^2$ values for categorical variables.

**Table 2** Baseline Medication Use in Study Groups

| Medication Class | Good Glycemic Control group (n=72) No. (%) | Poor Glycemic Control group (n=48) No. (%) | $\chi^2$ value | P value |
|---|---|---|---|---|
| Statins | 60 (83.3%) | 40 (83.3%) | 0.000 | 1.000 |
| Metformin | 65 (90.3%) | 43 (89.6%) | 0.021 | 0.887 |
| ACE Inhibitors/ARBs | 55 (76.4%) | 38 (79.2%) | 0.148 | 0.701 |
| Antiplatelet Agents | 70 (97.2%) | 47 (97.9%) | 0.075 | 0.785[a] |
| GLP-1 RAs | 5 (6.9%) | 6 (12.5%) | 1.258 | 0.262 |
| SGLT2 inhibitors | 3 (4.2%) | 4 (8.3%) | 0.817 | 0.366 |
| Insulin | 20 (27.8%) | 25 (52.1%) | 6.890 | 0.009 |

**Notes**: Data are n (%). P-values calculated using Chi-square test. [a]Fisher's exact test used.
**Abbreviations**: GLP-1 RAs, Glucagon-like peptide-1 receptor agonists; SGLT2, Sodium-glucose cotransporter-2.

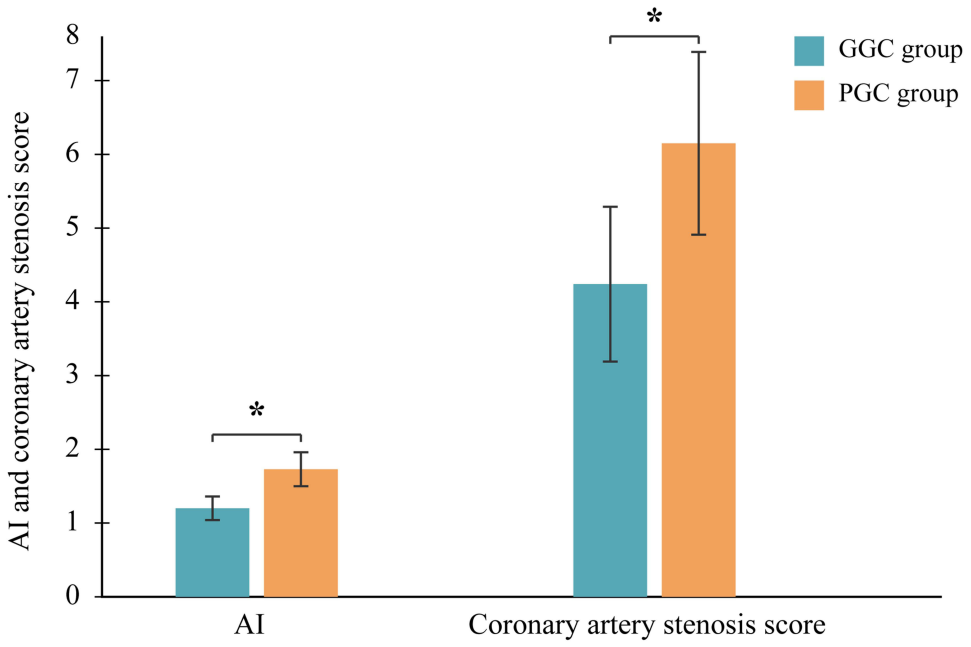


**Figure 2** Comparison of Atherosclerosis Index (AI) and Coronary Artery Stenosis Score Between Good Glycemic Control (GGC) and Poor Glycemic Control (PGC) Groups. The PGC group, characterized by poor glycemic control, shows notably higher AI and coronary artery stenosis scores compared to the GGC group, indicating a more advanced state of atherosclerosis and coronary artery disease. Data are presented as mean ± SD. *P < 0.05 vs GGC group, determined by Student's *t*-test.

## Lipid Level Analysis

Lipid profiles differed significantly between the two groups. The PGC group exhibited higher levels of total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDL-C), alongside lower levels of high-density lipoprotein cholesterol (HDL-C) compared to the GGC group (P < 0.05; Table 4). These findings underscore the dyslipidemia associated with poor glycemic control, contributing to the heightened risk of atherosclerosis.

## Detection of Blood Glucose Metabolism Indicators

The levels of fasting plasma glucose (FPG), fasting insulin (FINS), and the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) were significantly elevated in the PGC group compared to the GGC group (P < 0.05; Table 5).

**Table 3** Atherosclerosis Index (AI) and Coronary Artery Stenosis Score

| Group | AI (mean ± SD) | Coronary Artery Stenosis Score (mean ± SD) |
|---|---|---|
| GGC group (n=72) | 1.24±0.16 | 4.24±1.05 |
| PGC group (n=48) | 1.73±0.23 | 6.15±1.24 |
| T value | 13.089 | 9.751 |
| P value | <0.001 | <0.001 |

**Table 4** Analysis of Lipid Levels

| Group | TC (mg/dl, mean ± SD) | TG (mg/dl, mean ± SD) | LDL-C (mg/dl, mean ± SD) | HDL-C (mg/dl, mean ± SD) |
|---|---|---|---|---|
| GGC group (n=72) | 186.43±15.25 | 143.15±10.29 | 105.66±12.24 | 69.45±8.51 |
| PGC group (n=48) | 225.48±17.34 | 195.36±15.22 | 131.49±15.38 | 46.31±5.44 |
| T value | 13.229 | 20.384 | 10.627 | 18.518 |
| P value | <0.001 | <0.001 | <0.001 | <0.001 |


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**Table 5** Detection of Blood Glucose Metabolic Indices

| Group | FPG (mmol/l, mean ± SD) | FINS (μIU/mL, mean ± SD) | HOMA-IR (mean ± SD) |
|---|---|---|---|
| GGC group (n=72) | 6.58±0.57 | 9.63±1.94 | 1.95±0.15 |
| PGC group (n=48) | 7.69±0.75 | 13.25±2.03 | 3.11±0.24 |
| T value | 9.322 | 10.715 | 29.661 |
| P value | <0.001 | <0.001 | <0.001 |

These results indicate a more pronounced insulin resistance and impaired glucose metabolism in patients with higher HbA1c levels.

## ELISA Detection of Inflammatory Factors

Serum levels of TNF-α, IL-1β, and hs-CRP were significantly higher in the PGC group than in the GGC group, indicating heightened systemic inflammation in patients with poor glycemic control ($P < 0.05$; Figure 3, Table 6). Elevated inflammatory markers are known to exacerbate atherosclerosis progression, aligning with the observed increase in AI and coronary artery stenosis scores.

## Pearson Correlation Analysis of Atherosclerosis Index (AI)

Pearson correlation analysis revealed significant positive correlations between AI and several variables, including hs-CRP ($r = 0.537$, $P < 0.001$), TG ($r = 0.612$, $P < 0.001$), coronary artery stenosis score ($r = 0.492$, $P < 0.001$), and HOMA-IR ($r = 0.217$, $P = 0.017$; Table 7). These results suggest that inflammatory markers, lipid levels, coronary artery stenosis, and insulin resistance contribute to the worsening of atherosclerosis.

## Logistic Regression Analysis of Influencing Factors for AI

Logistic regression analysis identified hs-CRP, TG, coronary artery stenosis score, and HOMA-IR as significant risk factors for AI. Specifically, elevated hs-CRP ($\beta = 0.308$, $P = 0.002$, $OR = 1.288$), TG ($\beta = 0.671$, $P = 0.014$, $OR = 1.214$), coronary artery stenosis score ($\beta = 0.893$, $P = 0.026$, $OR = 1.018$), and HOMA-IR ($\beta = 0.416$, $P = 0.002$, $OR = 1.209$)

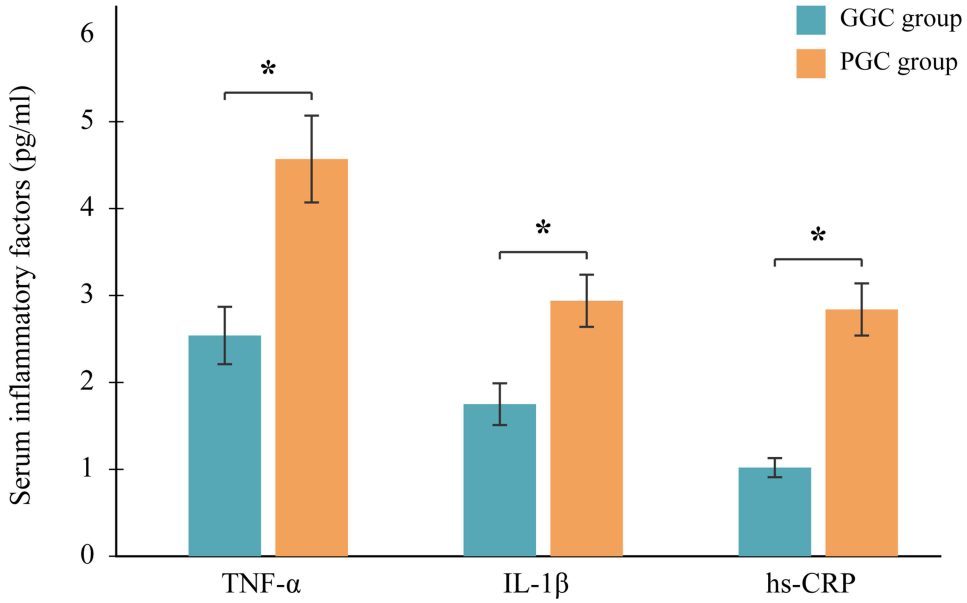


**Figure 3** Serum Inflammatory Factor Levels in Good Glycemic Control (GGC) and Poor Glycemic Control (PGC) Groups Detected by ELISA. The ELISA results reveal significantly elevated levels of these inflammatory factors in the PGC group, which corresponds to patients with poor glycemic control. The increased levels of TNF-α, IL-1β, and hs-CRP ($P < 0.05$ for all comparisons) suggest heightened systemic inflammation, which is a known contributor to the progression of atherosclerosis. Data are presented as mean ± SD. *$P < 0.05$ vs GGC group, determined by Student's *t*-test.

**Table 6** ELISA Detection of Inflammatory Factors

| Group | TNF-α (pg/mL, mean ± SD) | IL-1β (pg/mL, mean ± SD) | hs-CRP (pg/mL, mean ± SD) |
|---|---|---|---|
| GGC group (n=72) | 2.54±0.33 | 1.75±0.24 | 1.02±0.11 |
| PGC group (n=48) | 4.57±0.50 | 2.94±0.30 | 2.84±0.30 |
| T value | 25.015 | 24.283 | 40.665 |
| P value | <0.001 | <0.001 | <0.001 |

**Table 7** Pearson Correlation Analysis of Factors with Atherosclerosis Index (AI)

| Index | R value | P value |
|---|---|---|
| hs-CRP | 0.537 | <0.001 |
| TG | 0.612 | <0.001 |
| Coronary artery stenosis score | 0.492 | <0.001 |
| HOMA-IR | 0.217 | 0.017 |

**Table 8** Logistic Regression Analysis of Influencing Factors for Atherosclerosis Index (AI)

| Factor | β | Wald | P value | OR | 95% CI |
|---|---|---|---|---|---|
| hs-CRP | 0.308 | 9.528 | 0.002 | 1.288 | 1.107–1.358 |
| TG | 0.671 | 6.024 | 0.014 | 1.214 | 1.136–1.449 |
| Coronary artery stenosis score | 0.893 | 4.995 | 0.026 | 1.018 | 1.002–1.034 |
| HOMA-IR | 0.416 | 9.736 | 0.002 | 1.209 | 1.034–1.375 |

were all independently associated with increased AI (Table 8). These findings highlight the critical role of systemic inflammation, lipid dysregulation, and insulin resistance in the progression of atherosclerosis.

## Discussion

This study investigated the association between markers of lipid homeostasis, inflammation, and atherosclerosis index (AI) in patients with both diabetes and coronary heart disease, comparing those with good versus poor glycemic control. Our findings confirm that poor glycemic control (HbA1c ≥7%) is associated with a significantly more adverse cardiometabolic profile, characterized by higher AI and coronary artery stenosis scores compared to those with good glycemic control. These results underscore the detrimental impact of uncontrolled hyperglycemia on the progression of cardiovascular disease.

The mechanisms underlying the accelerated atherosclerosis in the setting of poor glycemic control are multifaceted. Diabetes-induced metabolic abnormalities, such as insulin resistance, dyslipidemia, and chronic inflammation, directly contribute to the pathogenesis of coronary artery disease.[11–13] Hyperglycemia promotes the generation of reactive oxygen species, leading to endothelial dysfunction and the oxidation of low-density lipoprotein cholesterol (LDL-C).[14–17] Oxidized LDL is a key driver of atherosclerosis, as it triggers the recruitment of macrophages, the formation of foam cells, and the proliferation of smooth muscle cells within the arterial wall.[18,19] The PGC group exhibited a more atherogenic lipid profile, with elevated levels of total cholesterol, triglycerides, and LDL-C, alongside reduced levels of high-density lipoprotein cholesterol (HDL-C). This dysregulation of lipid homeostasis directly contributes to the heightened risk of atherosclerosis and plaque development.[20] Indeed, various indices have been proposed to evaluate atherosclerotic risk, and the atherogenic index of plasma (AIP), which reflects the balance between triglycerides and HDL-C, has also been identified as a marker for cardiovascular disease.[21] Although AIP was not directly calculated as a primary endpoint in our study, the individual components (TG and HDL-C) were significantly altered in our PGC group, aligning with the concept that dyslipidemia in this pattern is highly atherogenic.

Inflammation plays a crucial role in the initiation and progression of atherosclerosis.[22] The present study found significantly increased levels of pro-inflammatory cytokines, such as TNF-α and IL-1β, as well as the acute-phase reactant high-sensitivity C-reactive protein (hs-CRP) in the PGC group. These inflammatory mediators can impair endothelial function, promote the migration of inflammatory cells into the vascular wall, and enhance the formation and instability of atherosclerotic plaques.[22] This chronic inflammatory state is not merely a consequence of atherosclerosis but is also a key driver of the process; pro-inflammatory cytokines contribute directly to endothelial dysfunction and arterial stiffening, which in turn can perpetuate inflammation, creating a vicious cycle.[23] While our study cannot delineate cause from effect, emerging evidence suggests that therapies targeting inflammatory pathways, such as canakinumab (an IL-1β inhibitor), can reduce cardiovascular events, underscoring the therapeutic potential of modulating these biomarkers to improve vascular outcomes.[24] Furthermore, the observed increase in insulin resistance, as evidenced by elevated fasting insulin and HOMA-IR, exacerbates the metabolic disturbances and directly contributes to the worsening of atherosclerosis.[18,25]

It is noteworthy that patients in the Good Glycemic Control group, despite having HbA1c levels <7%, still presented with established CHD. This underscores the multifactorial nature of CHD in diabetes, where factors such as duration of diabetes, prior glycemic variability, and persistent subclinical inflammation can contribute to cardiovascular risk even when current glycemic targets are met. This phenomenon, often referred to as a "glycemic legacy" or "metabolic memory", suggests that the detrimental effects of past periods of hyperglycemia on the vasculature can persist for years, a concept supported by long-term follow-up from landmark trials like the UKPDS.[26,27] Therefore, achieving HbA1c targets is crucial but may not fully abrogate cardiovascular risk in this particularly vulnerable population.

The Pearson correlation and logistic regression analyses further elucidated the key factors influencing the progression of atherosclerosis in this patient population. The positive correlations between AI and hs-CRP, triglycerides, coronary artery stenosis score, and HOMA-IR underscored the critical roles of systemic inflammation, lipid dysregulation, severity of coronary artery disease, and insulin resistance in the development of atherosclerosis.[28,29] While individual links between hyperglycemia, dyslipidemia, inflammation, and CHD are well-documented,[11–13] this study provides a focused analysis within a specific high-risk cohort of patients already diagnosed with both conditions, highlighting the incremental impact of glycemic control status on a comprehensive panel of biomarkers and the AI. These findings highlight the need for comprehensive management strategies targeting these pathways to mitigate the cardiovascular risk in diabetic patients with poor glycemic control.

It is also pertinent to consider the role of newer anti-diabetic medications with proven cardiovascular benefits. Agents such as glucagon-like peptide-1 receptor agonists (GLP-1 RAs) and sodium-glucose cotransporter-2 (SGLT2) inhibitors not only improve glycemic control but also possess anti-inflammatory and direct vasculoprotective effects, as demonstrated by their ability to reduce cardiovascular mortality and heart failure hospitalization through mechanisms involving improved endothelial function and reduced systemic inflammation.[30] Specifically, GLP-1 RAs enhance insulin secretion while suppressing postprandial glucagon and inflammation, contributing to their cardioprotective properties in type 2 diabetes patients with established cardiovascular disease.[30,31] Although the use of these agents was limited in our cohort, their growing role in clinical practice may modify the relationships observed in this study. Future research should investigate whether these therapies can attenuate the adverse associations between poor glycemic control, inflammation, and arterial stiffness highlighted here.

This study has several limitations. Firstly, its cross-sectional design is a significant limitation, precluding the establishment of causal relationships between the observed associations. While we identified strong correlations, we cannot determine whether poor glycemic control directly causes the observed increases in AI, inflammation, and dyslipidemia, or if these are concurrent phenomena. Longitudinal studies are needed to confirm these findings and establish causality. Secondly, the absence of a non-diabetic control group or a group with diabetes but without CHD limits the ability to fully contextualize the findings specifically attributable to the combination of diabetes and CHD versus diabetes alone or general population atherosclerosis. Thirdly, the sample size, while determined by power calculation for the primary outcome, was relatively modest and from a single center, which may limit the generalizability of our findings to other populations. Furthermore, the single-center design may introduce referral bias, and our results might be influenced by local treatment protocols, which could affect medication patterns such as the higher insulin use

observed in the PGC group. Fourthly, the sample sizes of the two groups were unequal, which is a reflection of the clinical distribution of glycemic control in our patient population, although our study was adequately powered for the main comparisons. Fifthly, we did not systematically collect data on other microvascular or macrovascular complications, such as chronic kidney disease (CKD) or retinopathy, which could also influence the measured outcomes. Additionally, our use of baPWV as the AI is a measure of arterial stiffness and serves as an indirect surrogate for atherosclerotic burden, rather than a direct quantification of atherosclerotic plaque volume or composition. Finally, while we focused on systemic markers of inflammation and lipid metabolism, direct assessment of macrophage function or lipid accumulation within macrophages was not performed, which was an initial conceptual interest but beyond the scope of the current study design.

In conclusion, the present study provides valuable insights into the mechanisms by which poor glycemic control accelerates the progression of atherosclerosis in diabetic patients with coronary heart disease. The findings emphasize the importance of effective blood glucose management, along with the control of lipid abnormalities, inflammation, and insulin resistance, in order to reduce the cardiovascular morbidity and mortality associated with this high-risk population. Future research should investigate the potential therapeutic interventions that can address these multifaceted metabolic and vascular disturbances and improve clinical outcomes in this vulnerable patient group.

## Abbreviations

ABI, Ankle-Brachial Index; AI, Atherosclerosis Index; CHD, Coronary Heart Disease; ELISA, Enzyme-Linked Immunosorbent Assay; FINS, Fasting Insulin; FPG, Fasting Plasma Glucose; GGC, Good Glycemic Control; HDL-C, High-Density Lipoprotein Cholesterol; HOMA-IR, Homeostatic Model Assessment for Insulin Resistance; hs-CRP, High-Sensitivity C-Reactive Protein; LDL-C, Low-Density Lipoprotein Cholesterol; PGC, Poor Glycemic Control; PWV, Pulse Wave Velocity; TC, Total Cholesterol; TG, Triglycerides; SD, Standard Deviation.

## Data Sharing Statement

The data and materials used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Ethics Approval and Consent to Participate

This study protocol was in accordance with the Declaration of Helsinki of the World Medical Association. This study was approved by the Ethical Research Committee of The Sixth Hospital of Wuhan. Written informed consent was obtained from all participants.

## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors declare no competing interests in this work.

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