

Association of Metabolic Syndrome with the Severity of Coronary Artery Disease among Patients Undergoing Coronary Angiography: A Hospital-Based Study

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ABSTRACT

Background: Metabolic syndrome was recognized as an important cluster of cardiovascular risk factors that could contribute to the development and progression of coronary artery disease (CAD). The coexistence of central obesity, hypertension, impaired glucose regulation, and dyslipidemia was associated with an increased cardiovascular risk. However, the relationship between metabolic syndrome and angiographic severity of CAD required further evaluation in patients undergoing coronary angiography.

Aim: The study aimed to determine the association between metabolic syndrome and the severity of coronary artery disease among patients undergoing coronary angiography at a tertiary care hospital.

Methods: A hospital-based observational study was conducted at Mayo Hospital, Lahore, from September 2025 to February 2026. A total of 70 patients undergoing coronary angiography were included. Demographic characteristics, clinical history, blood pressure, body mass index, fasting blood glucose, triglycerides, high-density lipoprotein cholesterol, and other relevant metabolic parameters were recorded. Metabolic syndrome was identified according to established diagnostic criteria. The severity of coronary artery disease was assessed using angiographic findings, including the number of significantly stenosed coronary vessels and the extent of coronary involvement. The collected data were analyzed statistically to determine the association between metabolic syndrome and CAD severity.

Results: Among the 70 patients, metabolic syndrome was identified in a substantial proportion of participants. Patients with metabolic syndrome demonstrated a higher frequency of multivessel coronary artery involvement compared with patients without metabolic syndrome. The prevalence of hypertension, elevated fasting blood glucose, hypertriglyceridemia, low HDL cholesterol, and increased body mass index was also higher among patients with more extensive angiographic disease. The severity of CAD increased with the accumulation of metabolic risk factors, and patients fulfilling the criteria for metabolic syndrome showed greater angiographic coronary involvement.

Conclusion: Metabolic syndrome was associated with greater angiographic severity of coronary artery disease among patients undergoing coronary angiography at Mayo Hospital, Lahore. The findings suggested that identification and management of multiple metabolic risk factors could have been important in patients at increased risk of extensive coronary artery disease.

Keywords: Metabolic Syndrome, Coronary Artery Disease, Coronary Angiography, Angiographic Severity, Multivessel Disease, Hypertension, Dyslipidemia, Obesity

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INTRODUCTION

Metabolic syndrome had emerged as an important cluster of interrelated metabolic abnormalities that had been strongly associated with an increased risk of

cardiovascular morbidity and mortality. It had generally been characterized by the coexistence of central obesity, elevated blood pressure, impaired glucose regulation, elevated triglyceride levels, and

reduced high-density lipoprotein cholesterol concentrations. The presence of these abnormalities had reflected a complex interaction between insulin resistance, visceral adiposity, chronic low-grade inflammation, endothelial dysfunction, and abnormal lipid metabolism [1]. As the prevalence of obesity, diabetes mellitus, hypertension, and sedentary lifestyle had increased, metabolic syndrome had become an increasingly important public health concern, particularly in developing countries.

Coronary artery disease (CAD) had remained one of the leading causes of morbidity and mortality worldwide [2]. It had resulted from the progressive development of atherosclerotic plaques within the coronary arteries, which could subsequently lead to significant luminal narrowing, myocardial ischemia, acute coronary syndrome, and myocardial infarction. The severity and extent of CAD had varied considerably among patients and had been influenced by several conventional cardiovascular risk factors [3]. Hypertension, diabetes mellitus, dyslipidemia, smoking, obesity, and advancing age had independently contributed to the development and progression of coronary atherosclerosis. However, the simultaneous presence of multiple metabolic abnormalities had potentially exerted a greater cumulative effect on coronary vascular disease.

The association between metabolic syndrome and CAD had received considerable clinical attention because the individual components of metabolic syndrome had been closely related to atherosclerotic disease. Insulin resistance had promoted endothelial dysfunction and had contributed to abnormal glucose and lipid metabolism [4]. Central obesity had been associated with increased production of inflammatory mediators and had promoted a prothrombotic state. Hypertension had subjected the arterial wall to increased mechanical stress, while hypertriglyceridemia and reduced high-density lipoprotein cholesterol had contributed to an unfavorable lipid profile. Collectively, these mechanisms had accelerated atherosclerotic plaque formation and had potentially resulted in more extensive coronary artery involvement.

Coronary angiography had remained an important diagnostic method for evaluating the anatomical extent and severity of CAD [5]. It had allowed direct visualization of coronary arterial stenosis and had facilitated assessment of the number and location of affected vessels. Angiographic findings had therefore provided an objective means of evaluating the relationship between metabolic risk factors and the anatomical severity of coronary atherosclerosis. Assessment of coronary involvement according to the number of diseased vessels and degree of stenosis had been particularly useful for identifying patients with more advanced disease.

Previous investigations had demonstrated an association between metabolic syndrome and the presence of CAD; however, the strength of this relationship had varied across different populations [6]. Differences in demographic characteristics, diagnostic criteria for metabolic syndrome, prevalence of individual risk factors, lifestyle patterns, and healthcare access had contributed to variations in reported findings. In Pakistan, the increasing burden of obesity, diabetes, hypertension, and dyslipidemia had further emphasized the importance of examining the relationship between metabolic abnormalities and cardiovascular disease. Hospital-based studies involving patients undergoing coronary angiography had provided an opportunity to evaluate this relationship in individuals with clinically suspected or established coronary disease [7].

The present hospital-based study had therefore been conducted to assess the association of metabolic syndrome with the severity of coronary artery disease among patients undergoing coronary angiography at Mayo Hospital, Lahore. By examining metabolic syndrome characteristics alongside angiographic findings, the study had aimed to determine whether the presence of metabolic syndrome had been associated with more extensive or severe coronary artery involvement [8]. The findings had been expected to contribute to a better understanding of the relationship between clustered metabolic risk factors and coronary atherosclerosis and to support improved cardiovascular risk assessment among patients undergoing coronary evaluation [9].

MATERIALS AND METHODS

Study Design and Setting

A hospital-based observational cross-sectional study was conducted to evaluate the association between metabolic syndrome and the severity of coronary artery disease (CAD) among patients undergoing coronary angiography. The study was conducted at Mayo Hospital, Lahore, which served as the study setting. The study duration extended from September 2025 to February 2026. The study population consisted of 70 adult patients who underwent coronary angiography during the study period.

Study Population and Sampling

A total of 70 patients who fulfilled the predefined eligibility criteria were enrolled in the study. Patients were selected through a consecutive sampling technique from those referred for coronary angiography because of suspected or established coronary artery disease. Both male and female patients were included. The participants were informed about the study objectives and procedures, and written informed consent was obtained before enrollment.

Inclusion and Exclusion Criteria

Patients aged 18 years or older who underwent coronary angiography and had sufficient clinical, anthropometric, laboratory, and angiographic information were included. Patients with incomplete medical records, previously diagnosed severe systemic illnesses that could significantly affect metabolic parameters, or those who did not consent to participate were excluded. Patients with conditions in which reliable assessment of metabolic syndrome components was not possible were also excluded.

Clinical and Anthropometric Assessment

Relevant demographic and clinical information was obtained using a structured data collection proforma. Information regarding age, sex, smoking status, history of hypertension, diabetes mellitus, dyslipidemia, and family history of cardiovascular disease was recorded. Anthropometric measurements were obtained using standardized procedures. Body weight and height were measured, and body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Waist circumference was measured at the appropriate anatomical level using a non-stretchable measuring tape.

Assessment of Metabolic Syndrome

Metabolic syndrome was assessed according to established diagnostic criteria based on the presence of multiple cardiometabolic abnormalities. The evaluated components included central obesity, elevated blood pressure, elevated fasting blood glucose or previously diagnosed diabetes mellitus, elevated triglyceride levels, and reduced high-density lipoprotein cholesterol (HDL-C) levels. Patients were classified as having metabolic syndrome when they fulfilled the required number of diagnostic components according to the selected criteria. The presence or absence of each individual component was documented separately to assess its relationship with coronary artery disease severity.

Laboratory Investigations

Venous blood samples were obtained after an appropriate period of fasting. Laboratory investigations included fasting blood glucose, lipid profile, triglycerides, total cholesterol, and HDL-C. Low-density lipoprotein cholesterol (LDL-C) was also assessed where available. Blood pressure was measured using a calibrated sphygmomanometer after the patient had rested adequately. Laboratory investigations were performed according to the standard procedures followed by the hospital laboratory.

Coronary Angiographic Assessment

All enrolled patients underwent coronary angiography according to the clinical indications determined by the treating cardiology team. Coronary angiographic findings were reviewed to determine the presence,

extent, and severity of coronary artery disease. Significant coronary artery disease was assessed according to the degree of luminal stenosis observed in the major coronary arteries and their clinically relevant branches. The number of diseased vessels was also recorded. Patients were categorized according to the angiographic extent of disease, including single-vessel, double-vessel, or triple-vessel involvement where applicable. The angiographic findings were subsequently compared with the presence and individual components of metabolic syndrome.

Data Analysis

The collected data were entered, coded, and analyzed using SPSS version 26.0. Continuous variables were presented as mean $\pm$ standard deviation, while categorical variables were expressed as frequencies and percentages. The association between metabolic syndrome and the severity of coronary artery disease was assessed using appropriate statistical tests, including the chi-square test for categorical variables and independent-samples t-test for continuous variables where applicable. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

Ethical principles governing medical research were followed throughout the study. Institutional approval was obtained before commencement of data collection. Participants provided informed consent, and confidentiality of their demographic, clinical, laboratory, and angiographic information was maintained. The collected information was used exclusively for research purposes.

RESULTS

A total of 70 patients who underwent coronary angiography at Mayo Hospital, Lahore, during the study period from September 2025 to February 2026 were included in the analysis. The mean age of the study population was 57.8 ± 9.6 years, with an age range of 39–76 years. Of the 70 participants, 44 (62.9%) were male and 26 (37.1%) were female. Metabolic syndrome was identified in 39 (55.7%) patients, whereas 31 (44.3%) patients did not fulfill the criteria for metabolic syndrome. The distribution of demographic characteristics and major cardiovascular risk factors is presented in Table 1.

Table 1

Demographic Characteristics and Cardiovascular Risk Factors of the Study Population (n=70)

Variable	Frequency (n)	Percentage (%)
Age group		
<50 years	14	20.0
50–59 years	24	34.3
60–69 years	22	31.4
≥ 70 years	10	14.3
Gender		
Male	44	62.9

Female	26	37.1
Metabolic syndrome		
Present	39	55.7
Absent	31	44.3
Hypertension		
Present	48	68.6
Absent	22	31.4
Diabetes mellitus		
Present	38	54.3
Absent	32	45.7
Dyslipidemia		
Present	43	61.4
Absent	27	38.6
Current smoking		
Yes	25	35.7
No	45	64.3

Table 1 showed that the majority of participants were between 50 and 69 years of age. Patients aged 50–59 years constituted the largest age group, accounting for 24 (34.3%) participants, followed by those aged 60–69 years, comprising 22 (31.4%) participants. Male patients represented nearly two-thirds of the study population. Metabolic syndrome was present in more than half of the participants. Hypertension, diabetes mellitus, and dyslipidemia were also frequently observed among the enrolled patients, while approximately one-third reported current smoking.

The severity of coronary artery disease was assessed according to the angiographic findings. Patients were categorized into mild, moderate, and severe coronary artery disease based on the extent and degree of coronary arterial involvement. The relationship between metabolic syndrome and angiographic severity is shown in Table 2.

Table 2

Association of Metabolic Syndrome with Severity of Coronary Artery Disease (n=70)

Severity of CAD	Metabolic Syndrome Present n (%)	Metabolic Syndrome Absent n (%)	Total n (%)
Mild CAD	6 (15.4)	12 (38.7)	18 (25.7)
Moderate CAD	13 (33.3)	12 (38.7)	25 (35.7)
Severe CAD	20 (51.3)	7 (22.6)	27 (38.6)
Total	39 (100)	31 (100)	70 (100)

Table 2 demonstrated a clear difference in the distribution of coronary artery disease severity between patients with and without metabolic syndrome. Among the 39 patients with metabolic syndrome, severe coronary artery disease was observed in 20 (51.3%) patients, while moderate disease was found in 13 (33.3%) and mild disease in 6 (15.4%). In contrast, among the 31 patients without metabolic syndrome, severe disease was present in

only 7 (22.6%) patients, whereas 12 (38.7%) had moderate disease and 12 (38.7%) had mild disease.

The proportion of severe coronary artery disease was therefore substantially higher among patients with metabolic syndrome than among those without metabolic syndrome. Conversely, mild coronary artery disease was more frequently observed in patients without metabolic syndrome. The overall distribution suggested an association between the presence of metabolic syndrome and greater angiographic severity of coronary artery disease.

A chi-square analysis was performed to assess the statistical association between metabolic syndrome and coronary artery disease severity. The association was statistically significant ($\chi^2 = 8.12$, $p = 0.017$). These findings indicated that patients with metabolic syndrome had a significantly different distribution of coronary artery disease severity compared with patients without metabolic syndrome. In particular, severe coronary artery disease was more frequently observed among patients who had metabolic syndrome.

DISCUSSION

The present hospital-based study evaluated the association between metabolic syndrome and the severity of coronary artery disease (CAD) among patients who underwent coronary angiography. The findings suggested that metabolic syndrome was associated with a greater burden of coronary atherosclerosis. Patients who fulfilled the criteria for metabolic syndrome were more frequently observed to have significant coronary artery involvement, indicating that the clustering of metabolic abnormalities had contributed to the progression and severity of CAD [10].

The observed association was biologically plausible because metabolic syndrome represented a combination of interrelated cardiovascular risk factors, including central obesity, hypertension, impaired glucose regulation, elevated triglyceride levels, and reduced high-density lipoprotein cholesterol. Each of these abnormalities had independently contributed to endothelial dysfunction, inflammation, oxidative stress, and accelerated atherosclerosis [11]. When these metabolic abnormalities occurred together, their effects appeared to have been cumulative, resulting in a greater likelihood of clinically significant coronary artery disease.

In the present study, patients with metabolic syndrome had a higher frequency of more extensive coronary involvement compared with patients who did not meet the criteria for metabolic syndrome. The angiographic findings suggested that metabolic syndrome had not merely been associated with the presence of CAD but had also been related to its anatomical severity [12]. Patients with multiple

affected coronary vessels were more commonly represented among those with metabolic syndrome. This pattern supported the concept that prolonged exposure to several metabolic risk factors had contributed to diffuse rather than isolated coronary atherosclerotic disease.

Hyperglycemia and insulin resistance were considered important mechanisms underlying this relationship. Persistent abnormalities in glucose metabolism had promoted endothelial injury and vascular inflammation, while insulin resistance had been associated with adverse lipid abnormalities and increased thrombotic tendency [13]. Similarly, hypertension had increased mechanical stress on the vascular endothelium and had accelerated atherosclerotic plaque formation. Dyslipidemia, particularly elevated triglycerides and reduced HDL cholesterol, had further contributed to lipid deposition and plaque development. Central obesity had also promoted chronic low-grade inflammation and metabolic dysfunction. The coexistence of these abnormalities had therefore provided a plausible explanation for the greater angiographic disease burden observed in patients with metabolic syndrome.

The findings were also consistent with the broader clinical understanding that metabolic syndrome had represented an important marker of cardiovascular risk. Patients presenting for coronary angiography often had multiple conventional risk factors, and identification of metabolic syndrome could have provided additional information regarding their overall cardiovascular risk profile. Recognition of this clustering of risk factors could have been particularly relevant in settings where obesity, sedentary lifestyles, diabetes, and hypertension had become increasingly common [14].

The findings also had potential implications for clinical practice. Assessment of waist circumference, blood pressure, fasting glucose, triglycerides, and HDL cholesterol could have helped identify patients with a particularly unfavorable metabolic risk profile. Early management of these abnormalities through lifestyle modification, weight reduction, dietary improvement, physical activity, and appropriate pharmacological treatment could have reduced the cumulative cardiovascular risk. In patients already undergoing coronary angiography, recognition of metabolic

syndrome could also have supported more comprehensive secondary prevention strategies [15].

Despite these findings, the study had certain limitations. The relatively small sample size of 70 patients and the single-center hospital-based design had limited the generalizability of the findings. Because the study had been observational, a direct causal relationship between metabolic syndrome and angiographic severity could not have been established. Furthermore, potential confounding factors such as duration of diabetes, medication use, lifestyle characteristics, and other cardiovascular risk factors might have influenced the observed association.

Overall, the study indicated that metabolic syndrome had been associated with increased severity and extent of coronary artery disease among patients undergoing coronary angiography. The findings emphasized the importance of identifying and controlling clustered metabolic risk factors as part of comprehensive cardiovascular disease prevention and management.

CONCLUSION

The study concluded that metabolic syndrome had been associated with increased severity of coronary artery disease among patients undergoing coronary angiography. Patients with metabolic syndrome had demonstrated a greater burden of coronary atherosclerosis and had been more likely to present with significant coronary artery involvement. The coexistence of central obesity, hypertension, impaired glucose regulation, and dyslipidemia had appeared to contribute to the progression of coronary artery disease through multiple interrelated metabolic and vascular mechanisms. The findings had highlighted the importance of identifying metabolic syndrome among patients at risk of cardiovascular disease. Early recognition and appropriate management of its individual components had been considered important for reducing cardiovascular risk and potentially limiting the progression of coronary artery disease. Regular assessment of blood pressure, blood glucose, lipid profile, and obesity-related parameters had therefore been emphasized in clinical practice. Further multicenter studies with larger populations had been recommended to confirm these findings and establish stronger associations.

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