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ANGIOGRAPHICALLY PROVEN CORONARY ARTERY DISEASE IN EASTERN INDIA: CLINICAL AND ECHOCARDIOGRAPHIC ASSOCIATIONS

Abstract

Background: Coronary artery disease (CAD) remains a leading cause of mortality in India, with early presentation and high prevalence of traditional cardiovascular risk factors.

Methods: This hospital-based observational study included adult patients undergoing coronary angiography for suspected CAD at a tertiary care center in Bihar. Clinical characteristics, laboratory parameters, electrocardiographic findings, and transthoracic echocardiographic variables were analyzed and compared between patients with and without angiographically proven CAD.

Results: Among 303 patients, 216 (71.3%) had significant CAD. Patients with CAD were older and had a higher prevalence of diabetes mellitus, hypertension, chronic kidney disease, and typical chest pain. Echocardiographic assessment revealed lower left ventricular ejection fraction and a higher frequency of regional wall motion abnormalities in CAD patients. Age, diabetes, hypertension, and typical angina were independently associated with CAD.

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Conclusion: Traditional risk factors and echocardiographic evidence of systolic dysfunction remain strongly associated with CAD in this population, emphasizing the importance of comprehensive non-invasive evaluation in resource-limited settings.

Keywords:-Coronary artery disease; Echocardiography; Left ventricular dysfunction; Coronary angiography; Cardiovascular risk factors.

Introduction

Coronary artery disease (CAD) is the leading cause of death worldwide, accounting for approximately 17.9 million deaths each year, with more than 75% of these deaths occurring in low- and middle-income countries [1]. The growing global burden of CAD poses a significant public health challenge, particularly in regions where early diagnosis and timely intervention remain limited due to socioeconomic and healthcare resource constraints.

In India, CAD affects nearly 10–12% of the adult population and often presents 5–10 years earlier than in Western populations, contributing to increased morbidity and premature mortality [2,3]. Similarly, in the United Arab Emirates (UAE), CAD is responsible for 35–40% of all deaths, with disease onset occurring 10–15 years earlier compared to Western countries [4]. This alarming trend is largely attributed to the high prevalence of cardiovascular risk factors such as diabetes mellitus, hypertension, dyslipidemia, obesity, smoking, and chronic kidney disease among younger individuals [5].

Coronary angiography is considered the gold standard for diagnosing CAD; however, it is an invasive, expensive procedure and is not readily accessible in many healthcare settings [6]. As a result, reliance on non-invasive clinical evaluation and readily available investigations plays a crucial role in the initial assessment of patients with suspected CAD, especially in resource-limited environments.

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Clinical risk factors including advancing age, diabetes mellitus, hypertension, chronic kidney disease, and typical anginal chest pain have been consistently shown to be strongly associated with the presence and severity of CAD [7,8]. In addition, laboratory parameters such as fasting blood glucose, lipid profile, renal function indices, and inflammatory markers provide valuable insight into the systemic processes contributing to atherosclerosis and disease progression.

Transthoracic echocardiography (TTE) is a widely available, non-invasive imaging modality that offers important information regarding cardiac structure and function. Echocardiographic parameters such as left ventricular ejection fraction (EF) and the presence of regional wall motion abnormalities (RWMA) are well-recognized indicators of myocardial ischemia and infarction and have demonstrated significant associations with angiographically confirmed CAD [9,10].

Evaluating the relationship between clinical characteristics, laboratory findings, and echocardiographic parameters in patients undergoing coronary angiography can enhance understanding of CAD presentation and severity. Such an approach may aid clinicians in identifying high-risk patients earlier and optimizing diagnostic decision-making prior to invasive evaluation.

Therefore, the present study aims to assess the association of clinical, laboratory, and echocardiographic variables with angiographically proven coronary artery disease in patients evaluated for suspected CAD, with particular emphasis on their relevance in populations with a high burden of cardiovascular risk factors.

Methodology

Study Design and Setting

This hospital-based observational analytical study was conducted at a tertiary care teaching hospital in Bihar, India. The institution functions as a major referral center for cardiovascular diseases and caters to patients from both urban and rural backgrounds. The study was carried out over a predefined study period, during

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which eligible patients presenting with suspected coronary artery disease (CAD) were consecutively enrolled.

Study Population

Adult patients aged 18 years and above who were clinically evaluated for suspected CAD and subsequently underwent diagnostic coronary angiography were included in the study. Patients with a prior history of coronary artery bypass grafting or percutaneous coronary intervention, congenital heart disease, non-ischemic cardiomyopathy, or incomplete clinical or echocardiographic data were excluded. All included patients had complete clinical, laboratory, electrocardiographic, echocardiographic, and angiographic records available for analysis.

Ethical Approval

The study protocol was reviewed and approved by the Institutional Ethics Committee of the participating hospital. The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Although the authors are undergraduate medical students enrolled at Tashkent State Medical University, the study population and data were entirely collected in India. The data were obtained from a tertiary care teaching hospital in Bihar, India, where all clinical evaluations, echocardiographic assessments, and coronary angiographies were performed.

The participating students are of Indian nationality, and data collection was carried out in accordance with local institutional from the Indian study site.

Clinical and Laboratory Assessment

Detailed demographic and clinical data were recorded using a structured proforma. Information regarding age, sex, and cardiovascular risk factors such as

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diabetes mellitus, hypertension, smoking status, obesity, and chronic kidney disease was collected. Symptom characteristics, including typical chest pain and dyspnea, were documented. Laboratory investigations included fasting blood glucose, lipid profile, renal function parameters, hemoglobin levels, inflammatory markers, and complete blood counts, as per standard hospital protocols.

Electrocardiographic Evaluation

A standard 12-lead electrocardiogram (ECG) was performed for all patients at presentation. ECGs were analyzed for the presence of ischemic changes, including ST-segment elevation, ST-segment depression, T-wave inversion, and pathological Q-waves.

Echocardiographic Assessment

All patients underwent transthoracic echocardiography (TTE) using standard imaging protocols. Left ventricular ejection fraction (EF) was assessed using the modified Simpson's biplane method. The presence of regional wall motion abnormalities (RWMA) and valvular heart disease was documented. Echocardiographic findings were interpreted by experienced cardiologists blinded to angiographic results.

Coronary Angiography

Coronary angiography was performed using the standard Judkins technique. Angiographic images were analyzed to assess the presence and severity of coronary artery stenosis. Significant CAD was defined as ≥50% luminal diameter stenosis in at least one major epicardial coronary artery. Based on angiographic findings, patients were classified into CAD and non-CAD groups for comparative analysis.

Statistical Analysis

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Statistical analysis was performed using JASP (Jeffreys's Amazing Statistics Program), version 2.7.6. Continuous variables were expressed as mean ± standard deviation (SD) and compared between groups using the independent samples *t*-test or the Mann–Whitney U test, as appropriate based on data distribution. Categorical variables were presented as frequencies and percentages and compared using the Chi-square test or Fisher's exact test. Multivariate logistic regression analysis was conducted to identify variables independently associated with angiographically proven coronary artery disease. Results were reported as odds ratios (ORs) with 95% confidence intervals (CI). All statistical tests were two-tailed, and a *p*-value of less than 0.05 was considered statistically significant.

Results

Study Population and Baseline Characteristics

A total of 303 consecutive patients who underwent coronary angiography for suspected coronary artery disease (CAD) were included in the analysis. Of these, 216 patients (71.3%) had angiographically proven CAD, while 87 patients (28.7%) had no significant coronary artery disease.

Patients with CAD were significantly older than those without CAD, with a mean age of 61.25 ± 9.88 years compared to 53.06 ± 9.32 years ($p < 0.001$). Male patients constituted a higher proportion of the CAD group (60.2%) compared to the non-CAD group (52.9%), though this difference was not statistically significant. The baseline demographic profile of the study population is presented in Table 1.

Table 1. Baseline Demographic Characteristics

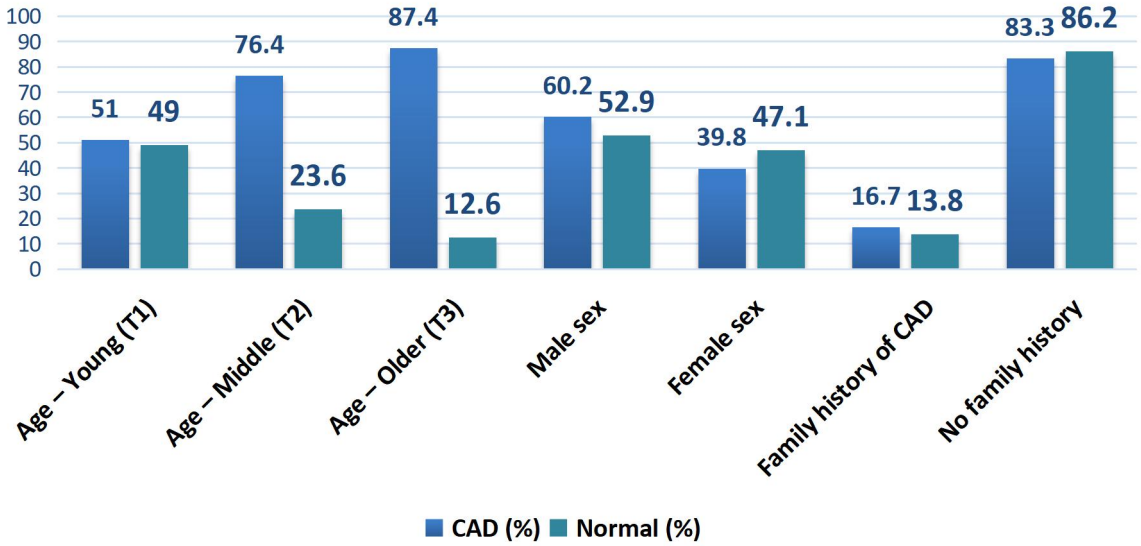
Variable	CAD (n = 216)	Non-CAD (n = 87)	*p*-value
Age (years), mean ± SD	61.25 ± 9.88	53.06 ± 9.32	<0.001
Male sex, n (%)	130 (60.2)	46 (52.9)	0.243
Female sex, n (%)	86 (39.8)	41 (47.1)	—

Distribution of Cardiovascular Risk Factors

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The distribution of unmodifiable and modifiable cardiovascular risk factors among patients with and without coronary artery disease (CAD) is shown in Figure 1 and Figure 2. Increasing age demonstrated a clear association with CAD, with the highest prevalence observed in the older age group compared to middle-aged and younger patients. Male sex was more frequent among CAD patients, whereas female sex predominated in the non-CAD group. A positive family history of CAD was infrequent in both groups (Figure 1).

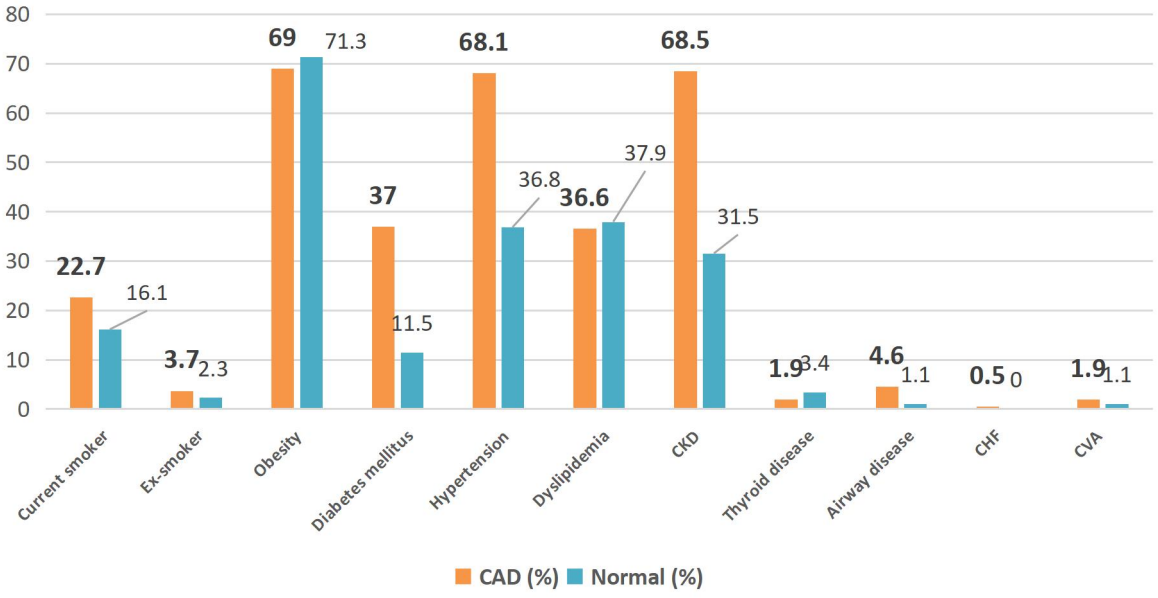
Figure 1. Distribution of Unmodifiable Cardiovascular Risk Factors in Patients With and Without Coronary Artery Disease.



Among modifiable risk factors, obesity, hypertension, diabetes mellitus, dyslipidemia, and chronic kidney disease were substantially more prevalent in patients with CAD. Hypertension and obesity were the most commonly observed modifiable risk factors in the CAD group. Current smoking was more frequent among CAD patients, while ex-smoking status showed minimal difference between groups. Other comorbid conditions, including thyroid disease, chronic airway disease, congestive heart failure, and cerebrovascular accident, were infrequent in both CAD and non-CAD patients (Figure 2).

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Figure 2. Distribution of Modifiable Cardiovascular Risk Factors in Patients with and Without Coronary Artery Disease



Clinical Risk Factors and Symptom Characteristics

Traditional cardiovascular risk factors were more frequently observed in patients with CAD. Diabetes mellitus was present in 37.0% of CAD patients compared to 11.5% of non-CAD patients ($p < 0.001$). Hypertension was observed in 68.1% of CAD patients versus 36.8% in the non-CAD group ($p < 0.001$). Chronic kidney disease was also significantly more prevalent in the CAD group (23.6% vs. 4.6%, $p < 0.001$).

Typical chest pain showed a strong association with angiographically proven CAD and was reported by 71.3% of CAD patients, compared to only 11.5% of non-CAD patients ($p < 0.001$). Dyspnea was more frequently reported among non-CAD patients ($p = 0.029$). The distribution of clinical and electrocardiographic characteristics is detailed in Table **2**.

Table 2. Clinical and Electrocardiographic Characteristics

Variable	CAD (%)	Non-CAD (%)	*p*-value

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Diabetes mellitus	37.0	11.5	<0.001
Hypertension	68.1	36.8	<0.001
Smoking	22.7	16.1	0.201
Chronic kidney disease	23.6	4.6	<0.001
Typical chest pain	71.3	11.5	<0.001
Dyspnea	40.3	54.0	0.029
RWMA present	38.0	4.6	<0.001
ST-segment depression	27.3	13.8	0.012
T-wave inversion	36.6	12.6	<0.001

Laboratory Parameters

Patients with CAD demonstrated significantly higher metabolic and inflammatory markers. Mean fasting blood sugar levels were higher in the CAD group (125.97 ± 56.25 mg/dL) compared to the non-CAD group (102.34 ± 34.79 mg/dL, $p < 0.001$). Triglyceride levels were also significantly elevated among CAD patients. Renal function, assessed by estimated glomerular filtration rate (eGFR), was significantly lower in the CAD group ($p = 0.003$). A detailed comparison of laboratory parameters is provided in Table 3.

Echocardiographic Findings

Transthoracic echocardiography revealed significant functional differences between the two groups. The mean left ventricular ejection fraction (EF) was significantly lower in patients with CAD (45.91 ± 8.94%) compared to non-CAD patients (50.52 ± 8.04%, $p < 0.001$). Regional wall motion abnormalities were present in 38.0% of CAD patients, whereas only 4.6% of non-CAD patients demonstrated RWMA ($p < 0.001$). Echocardiographic and laboratory findings are summarized together in Table 3.

Table 3. Laboratory and Echocardiographic Parameters

Variable	CAD (Mean ± SD)	Non-CAD (Mean ± SD)	*p*-value

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Fasting blood sugar (mg/dL)	125.97 ± 56.25	102.34 ± 34.79	<0.001
Triglycerides (mg/dL)	159.07 ± 104.55	128.68 ± 75.54	0.001
eGFR (mL/min)	77.55 ± 20.44	84.88 ± 16.38	0.003
ESR (mm/hr)	21.26 ± 16.43	14.99 ± 13.73	<0.001
EF-TTE (%)	45.91 ± 8.94	50.52 ± 8.04	<0.001

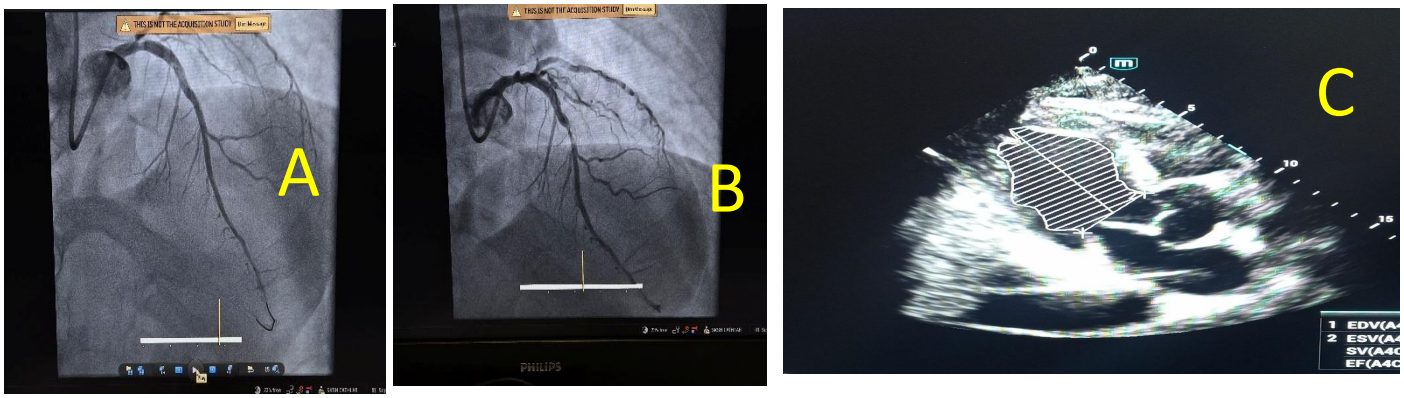
Multivariate Analysis

On multivariate logistic regression analysis, increasing age remained independently associated with CAD, with an approximately 8% increase in odds per year. Diabetes mellitus and hypertension were independently associated with a more than three-fold increase in the likelihood of CAD. Typical chest pain emerged as the strongest independent clinical correlate, demonstrating a markedly elevated odds ratio. The results of multivariate analysis are shown in Table 4.

Table 4. Multivariate Logistic Regression Analysis

Variable	Adjusted OR	95% CI	*p*-value
Age (per year)	1.08	1.03–1.13	<0.001
Diabetes mellitus	3.38	1.32–8.67	0.015
Hypertension	3.58	1.61–7.95	0.002
Typical chest pain	26.27	9.94–69.42	<0.001

Figure 3. Illustrates representative angiographic and echocardiographic findings from a patient included in the study.



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Figure 3. Coronary angiography and echocardiographic findings in a representative patient. **(A)** Coronary angiography performed after intervention demonstrates improved luminal patency of the left anterior descending (LAD) artery with restoration of distal flow. **(B)** Coronary angiography before intervention shows significant stenosis of the LAD with reduced distal contrast opacification. **(C)** Transthoracic echocardiographic apical four-chamber view illustrates left ventricular endocardial border tracing for ejection fraction assessment, with evidence of regional wall motion abnormality in the corresponding myocardial segments.

The left panels (A and B) show coronary angiography images obtained in standard projections. The images demonstrate the left coronary arterial system, including the left main coronary artery with its bifurcation into the left anterior descending (LAD) and left circumflex (LCx) arteries. There is evidence of significant luminal narrowing involving the LAD, consistent with obstructive coronary artery disease, as visualized by reduced contrast opacification distal to the stenotic segment.

The right panel (C) depicts a transthoracic echocardiographic apical four-chamber view, with endocardial border tracing performed for assessment of left ventricular systolic function. The outlined region represents the left ventricular cavity used for calculation of left ventricular ejection fraction (EF) using the modified Simpson’s method. The image demonstrates reduced systolic excursion of the ventricular walls, suggestive of regional wall motion abnormality, corresponding to the angiographically involved coronary territory.

Discussion

In this cross-sectional study of 303 patients undergoing coronary angiography for suspected coronary artery disease (CAD), we observed that increasing age, hypertension, diabetes mellitus, and typical anginal symptoms were the strongest

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independent correlates of angiographically proven CAD. These findings are consistent with large-scale analyses that have identified similar patterns across both South Asian and international cohorts, reinforcing the dominance of traditional cardiovascular risk factors in CAD pathogenesis and structural remodelling [11–13].

The mean age of CAD patients was significantly higher than that of non-CAD participants, consistent with the progressive vascular and endothelial deterioration associated with aging described by Yafasov et al. [11]. Although a male predominance was observed, the difference was not statistically significant, reflecting a narrowing sex gap similar to that noted in South Indian tertiary-care registries by Mandal et al. [12]. Hypertension and diabetes each demonstrated more than a threefold increase in CAD risk in our multivariate analysis, mirroring earlier findings from Hoxha et al. [13] and Dons et al. [14], where the coexistence of these comorbidities substantially magnified atherosclerotic burden. Chronic kidney disease was also significantly more common among CAD patients, aligning with Akhtaruzzaman et al. [15] and Hoxha et al. [13], who demonstrated that microvascular inflammation and reduced renal clearance exacerbate vascular injury.

Typical anginal pain was the most potent clinical predictor of CAD in our study, consistent with observations from Kumar et al. [16] and Bhatti et al. [17], who reported that classical chest pain remains a reliable correlate of significant coronary obstruction in South Asian patients. Dyspnea, conversely, was more frequent among non-CAD subjects, reflecting non-ischemic etiologies such as hypertensive heart disease or diastolic dysfunction, as noted by Jakubiak et al. [18]. Electrocardiographic abnormalities, including T-wave inversion and ST-segment depression, were significantly higher among CAD patients, reaffirming findings by Leow et al. [19] and Tsaban et al. [20], who linked repolarization disturbances with subclinical ischemic remodeling.

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Echocardiographic evaluation revealed a marked reduction in left ventricular ejection fraction and a higher prevalence of regional wall motion abnormalities (RWMA) in CAD patients—findings consistent with Ma et al. [21] and Gill et al. [22], who documented similar patterns in hypertensive and diabetic populations. The coexistence of metabolic dysregulation and systolic dysfunction further supports the inflammatory-metabolic hypothesis of atherosclerosis, as described by Hannen et al. [23] and Pojani et al. [24]. The lower eGFR values among CAD patients in our cohort reinforce the bidirectional cardio-renal interaction previously highlighted in South Asian populations by Akhtaruzzaman et al. [15] and Ahmed et al. [25].

Multivariate regression analysis confirmed that age, hypertension, diabetes, and typical angina independently predicted angiographically proven CAD. This pattern parallels the INTERHEART South Asia data by Patel et al. [26] and the global findings by Yusuf et al. [27], indicating that these risk factors maintain universal predictive significance regardless of ethnicity. However, unlike the European cohorts analyzed by Tsaban et al. [20], where sex and smoking were stronger contributors, our study showed a predominance of metabolic and hemodynamic risk clustering—consistent with regional data from Gupta et al. [28] and Prabhakaran et al. [29]. Echocardiographic indices of structural dysfunction also correlated strongly with metabolic derangement, underscoring the early onset of subclinical myocardial remodeling even before symptomatic heart failure, similar to the trends reported by Chahal et al. [30] and Srikanth et al. [31].

Clinically, these results emphasize the continued relevance of traditional metabolic-hypertensive factors in CAD risk assessment among Indian and South Asian populations. Routine echocardiographic evaluation, particularly among hypertensive and diabetic individuals, may aid early identification of subclinical left ventricular dysfunction, as suggested by Bhatti et al. [17] and Jakubiak et al. [18]. Furthermore, the integration of metabolic screening and cardiac imaging

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aligns with preventive frameworks proposed by Mohan et al. [32] and Sharma et al. [33], highlighting the benefit of a multimodal approach to cardiovascular risk stratification.

Nevertheless, this study's limitations must be acknowledged. The cross-sectional design restricts causal inference, and the lack of longitudinal follow-up precludes prognostic assessment. Certain lipid subfractions and diastolic indices were unavailable for all subjects, and the single-center nature of the cohort may limit external generalizability. However, the strengths include angiographically confirmed CAD, comprehensive echocardiographic assessment, and robust multivariate adjustment, providing a realistic picture of CAD correlates in contemporary Indian tertiary practice

Conclusion

In this tertiary-care cohort from eastern India, coronary artery disease was strongly associated with advancing age, diabetes mellitus, hypertension, and classical anginal symptoms. Echocardiographic evidence of left ventricular systolic dysfunction and regional wall motion abnormalities provided robust functional correlates of angiographically significant disease. These findings reaffirm the central role of traditional cardiometabolic risk factors in the pathophysiology of CAD within South Asian populations.

A systematic approach integrating clinical assessment, routine laboratory evaluation, electrocardiography, and transthoracic echocardiography offers valuable insight into disease burden and myocardial involvement, particularly in resource-limited settings. Emphasis on early risk identification and aggressive modification of metabolic and hypertensive factors remains essential to mitigating the growing burden of coronary artery disease in high-risk populations.

Author Contributions

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Kalash Dwivedi: Contributed to study conception and design, data collection, data analysis, interpretation of results, and manuscript drafting.

Jainil Sejpal: Contributed to data collection, literature review, and critical revision of the manuscript.

Sirojiddinov Sardor: Provided academic supervision, methodological guidance, and final review of the manuscript.

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