

Angiographic Characteristics of Coronary Artery Disease in Patients with Systolic Heart Failure: A Sub-Saharan Referral Center Experience

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Background: Heart failure (HF) is an increasing burden in Sub-Saharan Africa, with coronary artery disease (CAD) emerging as a major cause. However, angiographic data in HF patients remain scarce in this region.

Methods: This retrospective study included 169 HF patients who underwent coronary angiography between 2023 and 2025 at Mogadishu Somali Türkiye Training and Research Hospital. CAD severity was classified as minor, moderate, or severe ($\geq 70\%$ stenosis in epicardial arteries or $\geq 50\%$ in the left main). Demographic, clinical, and echocardiographic data were analyzed. Logistic regression identified predictors of severe CAD.

Results: The mean age was 54.3 ± 10.9 years, and 33.1% were male. CAD was present in 53.3% of patients, with severe CAD in 23.1%. Single-vessel disease was most frequent, followed by double-vessel, triple-vessel, and left main involvement. Based on SYNTAX scoring, 27.2% had low, 10.1% intermediate, and 6.5% high scores, indicating a subset with complex anatomy. On univariate analysis, diabetes ($P < 0.001$), dyslipidemia ($P < 0.001$), smoking ($P = 0.03$), and khat chewing ($P = 0.03$) were significantly associated with severe CAD. Patients with severe CAD also had lower ejection fraction (26.3% vs 29.8%, $P = 0.01$) and higher SYNTAX scores (34.7 vs 19.6, $P < 0.001$). In multivariate analysis, diabetes (OR = 7.44, 95% CI: 3.04–18.17, $P < 0.001$) and smoking (OR = 2.61, 95% CI: 1.10–6.23, $P = 0.03$) remained independent predictors.

Conclusion: Severe CAD is common among HF patients in Somalia and is strongly associated with diabetes and smoking. Systematic ischemic evaluation and aggressive risk factor control should be prioritized to improve outcomes. This study provides one of the first angiographic datasets from the region, offering evidence to guide screening, optimize scarce diagnostic resources, and inform future multicenter research.

Keywords: coronary artery disease, heart failure, angiography, sub-saharan Africa, smoking

Introduction

Cardiovascular disease (CVD) is responsible for over 1 million deaths in sub-Saharan Africa in 2019 alone.¹ It also contributes significantly to global CVD mortality. Alongside rising rates of coronary heart disease, infectious diseases and nutritional disorders continue to challenge healthcare systems across the region.^{2–6}

Numerous studies, including the prominent multicenter THESUS-HF study on heart failure in Africa, have shown that the primary causes of heart failure in the region remain non-ischemic, with hypertension, rheumatic heart disease, and dilated cardiomyopathy being the leading contributors.⁷ However, there is a growing incidence of ischemic heart diseases in sub-Saharan Africa.⁸

Heart failure is currently categorized into three types based on left ventricular ejection fraction (LVEF): reduced (HFrEF, LVEF $\leq 40\%$), mildly reduced (HFmrEF, LVEF 41–49%), and preserved (HFpEF, LVEF $\geq 50\%$).⁹

Heart failure can result from both ischemic and non-ischemic causes. The severity of coronary artery disease (CAD) typically influences the rate at which ischemic cardiomyopathy develops and progresses.¹⁰

Although CAD has long been identified as a key cause and treatment focus for heart failure, the effectiveness of percutaneous coronary intervention for revascularization in HF patients remains a subject of debate.¹¹

The demographics of HFrEF in sub-Saharan Africa differ from other regions, with an epidemiological shift toward ischemic causes driven by a rising prevalence of CAD risk factors. Data from 12 clinical studies before 2005 across eight SSA countries indicate that up to 75% of heart failure cases were of non-ischemic origin.^{7,12} Yuyun et al reported that ischemic heart disease was the leading cause of CVD mortality in SSA, accounting for 5% of all deaths and 40% of CVD-related deaths.¹³

Most research in SSA relies on electrocardiography and echocardiography to diagnose ischemic heart disease. Understanding the angiographic characteristics of CAD in heart failure is clinically important, as it provides direct anatomical confirmation of ischemia, informs decisions on revascularization, and helps stratify patient risk. In regions with limited resources, such data can guide efficient allocation of diagnostic and therapeutic services. Furthermore, documenting angiographic patterns in Sub-Saharan populations allows comparison with global cohorts, clarifying whether risk factors and disease expression are region-specific or universally consistent. This knowledge is essential for shaping preventive strategies and designing future multicenter studies.

In light of these trends, we aimed to assess the prevalence and angiographic characteristics of coronary artery disease in patients with heart failure (both HFrEF and HFmrEF) undergoing coronary angiography at a tertiary cardiac referral center in the region.

Methodology

This is a retrospective, cross-sectional, record-based study conducted at the largest tertiary care hospital in Somalia, a Turkish-affiliated institution. The study covered a 2-year period from January 2023 to January 2025 and focused on the angiographic profiles of coronary artery disease in patients diagnosed with heart failure.

The study population included patients aged 18 years and older with a confirmed diagnosis of heart failure, including heart failure with reduced ejection fraction (HFrEF) and mildly reduced ejection fraction (HFmrEF), who underwent coronary angiography for suspected coronary artery disease. Patients were retrospectively identified through hospital admission logs and echocardiography records coded for heart failure.

In addition to angiographic data, detailed demographic and clinical variables were extracted from patient medical records. These included age, sex, cardiovascular risk factors (hypertension, diabetes mellitus, dyslipidemia, smoking, family history of CAD, and khat chewing), New York Heart Association (NYHA) functional class, echocardiographic findings (LVEF and regional wall motion abnormalities), and selected laboratory parameters when available. These variables were collected to enable comparison between patients with and without severe CAD.

LVEF was extracted from echocardiographic reports in the hospital digital imaging system, where it had been assessed using the modified biplane Simpson method from standard apical two- and four-chamber views. Patients with LVEF $< 40\%$ were classified as HFrEF, and those with LVEF between 41–49% as HFmrEF.

Patients with previous coronary revascularization, severe valvular heart disease as the primary cause of heart failure, or incomplete angiographic data were excluded. A total of 169 heart failure patients meeting the inclusion criteria were enrolled.

All patients included in the analysis underwent coronary angiography. Coronary angiograms were reviewed using archived angiographic video files stored in the hospital's digital imaging system to confirm lesion severity, location, and anatomical involvement. Diagnostic CAG (coronary angiogram) was performed by interventional cardiologists via radial or femoral access using standard technique in ≥ 2 views. Angiographic findings were visually estimated by experienced operators during the procedure.

CAD was classified angiographically into:

- Minor CAD: <50% stenosis in all vessels.
- Moderate CAD: 50–69% stenosis in non-LM epicardial arteries (LAD, LCx, RCA).
- Severe CAD: $\geq 70\%$ stenosis in any epicardial artery or $\geq 50\%$ stenosis in the left main (LM).

Patients were further categorized into single-vessel disease (SVD), double-vessel disease (DVD), or triple-vessel disease (TVD). Patients were further categorized into single-vessel disease (SVD), double-vessel disease (DVD), or triple-vessel disease (TVD).

The SYNTAX Score, a validated tool for quantifying the anatomical complexity of coronary artery disease, was retrospectively calculated using the official SYNTAX calculator and standard lesion definitions.¹⁴ It was assessed in patients with angiographically detectable CAD. Patients were classified into three categories based on their scores: low (1–22), intermediate (23–32), and high (≥ 33). The SYNTAX Score was used for both descriptive reporting and comparative analysis between patients with and without severe CAD, but it was not included in regression modeling.

The research protocol was approved by the Ethics Committee of Mogadishu Somali Türkiye Training and Research Hospital (MSTH/20380), and the study adhered to the Declaration of Helsinki. All data were anonymized, and no identifiable patient information was used.

Statistical Analysis

Data were analyzed using SPSS version 27.0. Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean $\pm$ standard deviation (SD) or median (interquartile range) based on their distribution.

The Shapiro–Wilk test was used to assess the normality of continuous variables. For normally distributed data, comparisons between groups were performed using the independent-samples *t*-test. For non-normally distributed data, the Mann–Whitney *U*-test was applied. Categorical variables were compared using the Chi-square test or Fisher’s exact test, as appropriate.

Variables with $P < 0.20$ in univariate analysis were included in a multivariate logistic regression model to identify independent predictors of severe CAD. Results were reported as odds ratios (OR) with 95% confidence intervals (CI). Model performance was evaluated using the Hosmer–Lemeshow goodness-of-fit test (Chi-square = 15.380, *df* = 8, $P = 0.052$), indicating an acceptable model fit. A *P*-value > 0.05 on the Hosmer–Lemeshow test was considered indicative of a good model fit.

Results

A total of 169 patients with heart failure were included. The mean age was 54.3 ± 10.9 years, and 56 patients (33.1%) were male.

Coronary angiography revealed normal coronary arteries in 79 patients (46.7%), minor CAD in 35 (20.7%), moderate CAD in 16 (9.5%), and severe CAD in 39 (23.1%). The clinical and demographic characteristics of the study population, stratified by severe CAD status, are presented in [Table 1](#).

Severe CAD was significantly associated with diabetes mellitus (31 patients, 79.5% vs 51 patients, 30.0%; $P < 0.001$), smoking (25 patients, 64.1% vs 54 patients, 36.2%; $P = 0.002$), dyslipidemia (30 patients, 76.9% vs 71 patients, 41.5%; $P < 0.001$), and khat chewing (18 patients, 46.2% vs 47 patients, 27.7%; $P = 0.03$). These patients also had a lower mean ejection fraction ($26.3 \pm 5.3\%$ vs $29.8 \pm 6.0\%$, $P = 0.01$) and higher SYNTAX scores (34.7 ± 5.5 vs 19.6 ± 4.2 , $P < 0.001$) compared with those without severe CAD.

Regarding angiographic patterns, single-vessel disease was the most common (51 patients, 30.2%), followed by double-vessel disease (24 patients, 14.2%), triple-vessel disease (13 patients, 7.7%), and left main involvement (2 patients, 1.2%). By SYNTAX score, 27 patients (16.0%) had low scores (< 22), 17 (10.1%) had intermediate scores (23–32), and 11 (6.5%) had high scores (≥ 33), indicating a subset with complex coronary anatomy ([Table 2](#)).

On univariable logistic regression, diabetes mellitus, smoking, dyslipidemia, and khat chewing were significantly associated with severe CAD. Other variables including age, sex, hypertension, ejection fraction, NYHA class, and family history of CAD were not statistically significant.

Table 1 Baseline Characteristics of the Patients

Characteristics	Total (n = 169)	No Severe CAD (n = 130), n (%)	Severe CAD (n = 39), n (%)	P-value
Male, n (%)	56 (33.1%)	32 (24.6%)	24 (61.5%)	0.04
Age (mean $\pm$ SD)	54.34 $\pm$ 10.89	52.5 $\pm$ 10.9	57.8 $\pm$ 10.1	0.02
NYHA I	87 (51.8%)	66 (50.8%)	21 (53.8%)	0.50
NYHA II	55 (32.7%)	46 (35.4%)	9 (23.1%)	
NYHA III	23 (13.7%)	16 (12.3%)	7 (17.9%)	
NYHA IV	3 (1.8%)	2 (1.5%)	1 (2.6%)	
Diabetes Mellitus	70 (41.4%)	39 (30.0%)	31 (79.5%)	<0.001
Hypertension	83 (49.1%)	59 (45.4%)	24 (61.5%)	0.08
Smoking	72 (42.6%)	47 (36.2%)	25 (64.1%)	0.03
Dyslipidemia	84 (49.7%)	54 (41.5%)	30 (76.9%)	<0.001
Family History of CAD	45 (26.6%)	31 (23.8%)	14 (35.9%)	0.14
Khat Chewing	54 (32.0%)	36 (27.7%)	18 (46.2%)	0.03
EF % (mean $\pm$ SD)	28.6 $\pm$ 6	26.3 $\pm$ 5.3	29.8 $\pm$ 6	0.01
RWMA	42 (24.9%)	34 (26.2%)	8 (20.5%)	0.48
SYNTAX score (mean $\pm$ SD)	26.4 $\pm$ 5.3	24.3 $\pm$ 4.8	34.7 $\pm$ 5.5	<0.001

Abbreviations: CAD, coronary artery disease, EF, ejection fraction, NYHA, New York Heart Association, RWMA, regional wall motion abnormalities, SD, standard deviation.

Table 2 Angiographic Findings of the Study Population

Angiographic Findings	Number of Cases n (%)
Coronary angiography results	
Normal coronary angiography results	79 (46.7)
Minor CAD	35 (20.7)
Moderate CAD	16 (9.5)
Severe CAD	39 (23.1)
Number of diseased vessels	
SVD	51 (30.2)
DVD	24 (14.2)
TVD	13 (7.7)
LM involvement	2 (1.2)
SYNTAX score	
Low (<22)	27 (16)
Intermediate (23–32)	17 (10.1)
High (>33)	11 (6.5)

Abbreviations: CAD, Coronary artery disease, SVD, single vessel disease, DVD, double vessel disease, TVD, triple vessel disease, LM, left main.

Table 3 Univariable and Multivariable Logistic Regression for Predictors of Severe CAD

Variable	Univariable OR	95% CI	P-value	Multivariable OR	95% CI	P-value
Ejection Fraction	1.027	0.979–1.078	0.274	1.012	0.971–1.055	0.36
Diabetes Mellitus	Not estimable [†]	—	—	7.435	3.042–18.170	<0.001
Smoking	0.317	0.150–0.668	0.003	2.612	1.095–6.231	0.03
Age	1.005	0.980–1.031	0.677	1.022	0.985–1.060	0.23
Gender	1.470	0.678–3.187	0.330	1.354	0.578–3.171	0.50
Hypertension	0.515	0.250–1.062	0.072	0.841	0.399–1.774	0.6
Dyslipidemia	0.470	0.227–0.971	0.041	ns	—	ns
Khat Chewing	0.447	0.214–0.934	0.032	1.563	0.626–3.901	0.33
NYHA Class	1.064	0.673–1.683	0.791	ns	—	ns
Family History of CAD	0.559	0.259–1.206	0.138	0.701	0.314–1.565	0.39

Notes: [†]DM could not be estimated in univariable analysis due to quasi-complete separation of data. ns = Not severe, excluded from final multivariable model.

Abbreviations: OR, odds ratio; CI, confidence interval; DM, diabetes mellitus; CAD, coronary artery disease; NYHA, New York Heart Association.

In multivariable logistic regression, diabetes mellitus (OR = 7.44, 95% CI: 3.04–18.17, $P < 0.001$) and smoking (OR = 2.61, 95% CI: 1.10–6.23, $P = 0.03$) remained independent predictors of severe CAD, while dyslipidemia and khat chewing lost significance. Although age and khat chewing showed positive trends, they did not reach statistical significance ($P = 0.23$ and $P = 0.33$, respectively). The full regression analysis is shown in [Table 3](#).

Discussion

Categorizing patients with left ventricular systolic dysfunction (LVSD) as ischemic or non-ischemic is crucial, as the incidence of ischemic cardiomyopathy (ICMP) continues to rise.⁹ ICMP is now recognized as a leading cause of heart failure, and identifying CAD in unexplained HF is essential given its association with higher adverse cardiac events and mortality.⁶

In this study, we evaluated angiographic profiles and predictors of CAD in 169 patients with heart failure and reduced or mildly reduced ejection fraction in Somalia. The high prevalence of CAD observed in our cohort (53.3%) aligns broadly with findings from similar sub-Saharan African settings. For example, Kimeu et al reported a CAD prevalence of 60.3% among heart failure patients in Kenya and 52.3% among Black African populations, which closely parallels our findings.¹⁰ In contrast, the Heart of Soweto study reported a notably lower CAD prevalence of approximately 10%.¹² This discrepancy is likely due to methodological differences: the Heart of Soweto relied primarily on clinical suspicion, ECG findings, and selective use of confirmatory tests (eg, stress testing, nuclear imaging, or cardiac catheterization), whereas our study performed routine coronary angiography for all patients. Variations in diagnostic protocols, population characteristics, and resource availability likely account for the differing prevalence estimates.

Our study identified diabetes mellitus and tobacco smoking as independent predictors of severe CAD among patients with heart failure. These findings are consistent with prior research. For instance, Deney et al identified diabetes mellitus as an independent risk factor for CAD using multivariate logistic regression,¹¹ and Yuyun et al reported smoking as a significant predictor of CAD in HFrEF patients.¹³ Importantly, similar trends have been reported outside Africa. An Indian study of patients with severe LV systolic dysfunction demonstrated that diabetes and dyslipidemia were independent predictors of significant CAD.¹⁴ These consistent associations across both African and non-African populations reinforce the universal role of diabetes and related metabolic risk factors, as well as smoking, in driving the burden of CAD.

Beyond prevalence, the angiographic patterns of CAD provide further insight into disease severity. In our cohort, a substantial proportion of patients demonstrated single-vessel disease (SVD), double-vessel disease (DVD), and triple-vessel disease (TVD), with left main (LM) involvement noted in a smaller subset. Similar findings were reported in Nepal, where obstructive CAD accounted for one-third of HFrEF cases, with 48% TVD, 39% SVD, 13% DVD, and occasional LM involvement.¹⁵ Comparable angiographic distributions have also been observed outside South Asia; for instance, a Turkish study comparing young and elderly STEMI patients found SVD predominated in younger individuals, while multivessel disease was markedly more frequent in older patients.¹⁶ These parallels highlight that multivessel disease and LM involvement are common across diverse regions and carry important prognostic and therapeutic implications.

The implications of these findings are especially relevant for low-resource settings. Identifying clinical predictors such as diabetes and smoking can support early recognition of ischemic etiology in heart failure, particularly where advanced diagnostic tools are not widely available. Moreover, our findings reinforce the clinical value of routine coronary angiographic assessment in selected heart failure populations, even in constrained environments. European cohorts, such as the BIOSAT-CHF analysis, have shown that coronary angiography is underutilized in worsening heart failure, despite evidence that it frequently reveals significant CAD with important prognostic implications.¹⁷ Similarly, systematic angiographic evaluation of HFpEF and HFmrEF patients in France demonstrated that up to 80% harbor significant coronary stenoses, often requiring revascularization.¹⁸ Together, these findings support a more systematic approach to ischemic evaluation in heart failure patients globally.

Within the East African context, the rising burden of heart failure among younger individuals (<40 years) is of particular concern,¹⁹ and our own prior work in Somalia has shown that ischemic cardiomyopathy is already a leading factor contributing to complications such as left ventricular thrombus among HFrEF patients.²⁰ Coronary artery disease is increasingly recognized as a major driver of systolic dysfunction in this age group, where early identification can substantially alter long-term outcomes. Recent evidence has highlighted this trend globally.²¹ These observations reinforce the need for heightened vigilance and timely ischemic evaluation in relatively young patients across East Africa, where limited resources necessitate careful prioritization of high-risk groups.

In summary, the high prevalence of CAD in Somali heart failure patients highlights an urgent need for improved diabetes control and smoking cessation initiatives. Clinicians should integrate cardiovascular risk profiling into routine HF management and prioritize high-risk patients—such as those with diabetes or smoking history—for ischemic evaluation. Prospective, multicenter research in sub-Saharan Africa is warranted to validate these findings and to assess the impact of early ischemic assessment and revascularization strategies on long-term outcomes.

Strengths and Limitations

A key strength of this study was its use of universal coronary angiographic evaluation, providing precise prevalence estimates of coronary artery disease (CAD) among heart failure (HF) patients in a Sub-Saharan African setting where such data remain scarce. This systematic use of angiography reduces diagnostic uncertainty and allows for a more reliable evaluation of CAD burden compared to studies relying solely on clinical criteria or non-invasive testing.

However, the study has several limitations. First, the modest sample size may have limited statistical power to detect all significant associations. Second, being a single-center study, the findings may not be fully generalizable to broader populations across East Africa and other regions. Third, due to the retrospective design, important variables such as socio-economic status and access to healthcare services could not be evaluated, even though these factors likely influence both HF presentation and CAD prevalence. This limits our ability to explore the social determinants of health in this population.

Treatment history—including prior revascularization procedures and use of medications such as statins, antiplatelets, or beta-blockers—was not consistently documented and thus could not be included in the analysis. This omission may have influenced the observed ejection fraction and angiographic findings, potentially confounding the relationships analyzed. Additionally, symptom profiles and electrocardiographic data were not systematically captured across all patients, precluding detailed comparisons of clinical presentations between CAD-positive and CAD-negative groups.

Selection bias is also a possibility, as only patients who underwent coronary angiography were included. This could lead to underrepresentation of HF patients with low clinical suspicion of CAD. While coronary angiography remains the gold standard for anatomical assessment, the absence of functional assessments such as fractional flow reserve (FFR) or non-invasive stress testing may have resulted in over- or underestimation of the true physiological significance of lesions.

Despite these limitations, the study offers meaningful insight into the epidemiology and predictors of CAD among HF patients in Somalia. It highlights the importance of routine ischemic evaluation—especially in high-risk groups such as diabetics and smokers—and sets the stage for future prospective, multicenter studies that incorporate broader clinical, socioeconomic, and outcome data.

Conclusion

In this Somali cohort of patients with heart failure, coronary artery disease (CAD) was frequent, and diabetes mellitus and smoking were strong independent predictors. These findings highlight the heavy burden of ischemic heart disease in heart failure and the importance of targeted prevention. In resource-limited settings, clinicians should prioritize early ischemic evaluation of high-risk patients. Prospective multicenter studies are needed to confirm these associations and assess the impact of early intervention on clinical outcomes.

AI Declarations

In accordance with the Taylor & Francis AI Policy, I confirm that I have used generative AI tools during the preparation of this paper. Specifically, I used ChatGPT (OpenAI, GPT-4.0, June 2025 version) for assistance in the editing of academic language and the review of relevant literature to ensure clarity, coherence, and comprehensiveness of the paper. All AI-generated content has been critically reviewed and edited by the author(s) to ensure accuracy and integrity. The final content is the sole responsibility of the author(s).

Data Sharing Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

The research protocol was approved by the Ethics Committee of Mogadishu Somali Türkiye Training and Research Hospital with the reference (MSTH/20380) and the study complied with the ethical guidelines outlined in the Declaration of Helsinki. consent was waived for the retrospective analysis.

Consent for Publication

The study is retrospective in nature and involves anonymized data.

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Disclosure

The authors declare that they have no competing interests.

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