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Research Article

Clinical Features, Risk Factors, and Outcomes of Acute Coronary Syndrome in Young Sudanese Patients: A Retrospective Single-Tertiary Care Center Study

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Abstract

Background: Coronary artery disease (CAD) is a leading cause of death worldwide, even in young patients. This study aimed to characterize the clinical features, risk factors, and prognosis of acute coronary syndrome (ACS) in young Sudanese patients.
Methods: A total of 100 Sudanese patients aged up to 45 years with ACS were enrolled in a retrospective cross-sectional study at the Sudan Heart Center from 2022 to 2023. Their clinical data, including the findings, management, and outcome of their electrocardiogram (ECG), echocardiography, and coronary angiography within one month, were recorded and analyzed using the SPSS program version 25.
Results: Of the 100 patients, 74% were male and 26% were female, and the median age was 39. Risk factors included hypertension (33%), diabetes mellitus (30%), obesity (26%), and smoking (25%). ST-elevation myocardial infarction (STEMI) occurred in 73% of cases, mild ejection fractions occurred in 45 patients, and mitral regurgitation and left ventricular thrombosis each occurred in six patients. Most patients (73%) had occlusive CAD, primarily in the left anterior descending (LAD) artery (74%). Of the patients, 34% received thrombolysis, 26% had percutaneous coronary intervention (PCI), and 16% had coronary artery bypass grafting (CABG). Adverse events were significantly higher with a *P*-value of 0.000 in patients with diabetes, hypertension, a smoking habit, hyperlipidemia, obesity, occlusive CAD, and multivessel involvement ($P = 0.001$).
Conclusion: Classical risk factors, especially hypertension, continue to significantly contribute to CAD and ACS in young adults in Sudan. It is imperative to prioritize interventions to prevent or mitigate these risk factors, including implementing strategies for blood pressure regulation, blood glucose monitoring, smoking cessation, and lipid management in young adults.

Keywords: coronary artery disease, acute coronary syndrome, myocardial infarction, young adults

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1. Introduction

Coronary artery disease (CAD) is the leading cause of death in men and women worldwide. CAD causes morbidity and mortality in different age groups, leading to more than 4.5 million deaths in the developing world [1]. Myocardial infarction (MI) typically occurs many years after the development of coronary atherosclerosis, often in individuals aged between their fifth and seventh decades. However, around 2–10% of patients may experience acute coronary syndrome (ACS) before the age of 45 [2], constituting 10% of cases of ST-segment elevation acute myocardial infarction (AMI). There is some variation in the definition of CAD among younger patients, with most studies classifying young as 45 years old and younger [3].

Recent studies attributed the increasing incidence of MI in young adults to the increased prevalence of risk factors like obesity, smoking, and lack of physical activity [4]. The most common category of MI in the young age group is plaque rupture of coronary atherosclerosis, which should be suspected in patients with traditional risk factors such as smoking, DM, hypertension, and hyperlipidemia [5, 6]. Other less common categories of MI in young patients include recreational drug use, coronary vasospasm, myocarditis, vasculitis, spontaneous coronary artery dissection, hypercoagulable states, embolism, and MI with intact fibrous cap, among others [5, 6].

AMI in young populations can lead to death, resulting in a significant public health crisis that is not intensively investigated. The Framingham Heart Study has shown that men under 45 years old experience adverse outcomes after presenting with AMI during a follow-up period of over a decade [7]. In addition, MI at a younger age carries significant psychological morbidity and financial constraints for patients and their families [8]. Data on the characteristics of MI in Sudanese patients aged 45 years or younger is lacking. This study aims to assess the clinical characteristics, angiographic profile, treatment modalities, and adverse events during a one-month follow-up evaluation of AMI in young Sudanese patients.

2. Methods

2.1. Data collection

A total of 100 young Sudanese patients aged 45 and younger were enrolled in a prospective cross-sectional study at the Sudan Heart Center, conducted between August 2022 and January 2023. This study included all young Sudanese patients presenting with ACS who underwent coronary angiography (CAG) during this time, including those currently under follow-up. Patients older than 45 or those who declined to participate were excluded from the study.

Clinical data and initial electrocardiogram (ECG) and CAG findings for each patient were gathered by the principal investigator using a structured questionnaire. This questionnaire consisted of seven domains: demographic data, clinical characteristics, MI patterns, echocardiography results, angiographic findings, medical interventions in the form of reception of thrombolysis or undergoing revascularization, and adverse effect outcomes within 30 days of MI.

2.2. Statistical analysis

Data were analyzed using SPSS version 25 and are presented in tables. The chi-square test served as the significance test, with a *P*-value threshold of 0.05.

3. Results

The study included 100 patients, 74 (74%) male and 26 (26%) female. Their ages ranged from 20 to 45, with a mean age of 39 ± 6 years. Most patients (47%) fell within the age group of 41 to 45 years (Table **1**). The study identified a total of six cardiovascular risk factors, the most prevalent of which was hypertension, found in 33% of the patients. This was followed by diabetes mellitus in 30%, obesity in 26%, smoking in 25%, and hyperlipidemia in 11% of the sample. Notably, only 2% of the patients reported a family history of ischemic heart disease (IHD) at a young age. Additionally, 44% of the patients had no risk factors, 24% had three concurrent risk factors, and 26% had only one (Table **1**).

Table 1: Demographic data and previous risk factors of 100 patients with ACD.

Data		**Number (%)**
Sex	Male	74 (74%)
	Female	26 (26%)
Age (yrs)	Mean 39 ± 6	
	41–45	47 (47%)
	36–40	24 (24%)
	31–35	12 (12%)
	26–30	13 (13%)
	20–25	4 (4%)
Previously known risk factors	Hypertension	33 (33%)
	DM	30 (30%)
	Obesity	26 (26%)
	Smoking	25 (25%)
	Hyperlipidemia	11 (11%)
	FH of IHD at a young age	2 (2%)
Number of risk factors per patient	Patients with one risk factor	26 (26%)
	Patients with two risk factors	6 (6%)
	Patients with three risk factors	24 (24%)
	Patients with no risk factors	44 (44%)

DM, diabetes mellitus; IHD, ischemic heart disease; ACD, acute coronary artery disease; FH, family history

Upon arrival at the hospital, ECG indicated ST-elevation myocardial infarction (STEMI) in 73% of the patients, while the remaining 27% were diagnosed with non-ST-elevation myocardial infarction (NSTEMI). CAG revealed that 73% of the patients had occlusive CAD and 27% had non-occlusive CAD. The left anterior descending (LAD) artery was the most commonly affected, involved in 74% of cases, followed by the right coronary artery (RCA) in 30%, the left circumflex artery (LCX) in 21%, and the left main coronary artery (LMCA) in 3% of cases with occlusive CAD. Additionally, most patients (69%) presented with single vessel disease (SVD), 11% with double vessel disease (DVD), and 12% with triple vessel disease (TVD) as observed in the CAG results (Table **2**).

Table 2: Findings of ECG and CAG in 100 patients.

		Number (%)
MI patterns	ST-elevation myocardial infarction (STEMI)	73 (73%)
	Non-ST-elevation myocardial infarction (NSTEMI)	27 (27%)
CAD type	Occlusive coronary artery disease (CAD)	73 (73%)
	Single vessel disease (SVD)	69 (69%)
Number of arteries involved	Non-occlusive coronary artery disease (CAD)	27 (27%)
	Triple vessel disease (TVD)	12 (12%)
	Double vessel disease (DVD)	11 (11%)
	Normal coronary angiography (CAG)	8 (8%)
Major vessel involved	Left Anterior Descending Artery (LAD)	74 (74%)
	Right Coronary Artery (RCA)	30 (30%)
	Left Circumflex Artery (LCX)	21 (21%)
	Left Main Coronary Artery (LMCA)	3 (3%)

Thirty-four patients (34%) who presented early with STEMI received thrombolysis medications, while the remaining 39 patients (39%) did not receive treatment due to their late presentation. Revascularization was performed in 42 (42%) patients, of whom 26 (26%) underwent percutaneous coronary intervention (PCI) and 16 (16%) had coronary artery bypass graft (CABG). The remaining 31 (31%) patients received only medications (Table **3**).

Table 3: Medical interventions, adverse events, and outcomes within one month.

		Number (%)
Medical intervention	Thrombolysis	34 (34%)
	No thrombolysis (due to late presentation)	39 (39%)
	Percutaneous coronary intervention (PCI)	26 (26%)
	Coronary artery bypass graft (CABG)	15 (15%)
	PCI + CABG	1 (1%)
	Only medication therapy	31 (31%)
Ejection fraction (%)	50–70% (normal)	21 (21%)
	40–49% (mildly reduced)	45 (45%)
	30–39% (moderately reduced)	22 (22%)
	<30% (severely reduced)	12 (12%)
Echo findings	Mitral regurgitation (MR)	6 (6%)
	Left ventricle thrombus (LFT)	6 (6%)
Adverse events and outcomes in one month	Heart failure (HF)	19 (19%)
	Arrhythmia	2 (2%)
	Reinfarction	2 (2%)
	Stent thrombosis	1 (1%)
	Cardiac arrest	1 (1%)
	Death	0 (0%)
	No adverse events	75 (75%)

The one-month follow-up indicated a mildly reduced ejection fraction (EF) of 40% to 49% in 45 (45%) patients, 30% to 39% in 22 (33%) patients, and less than 30% in 12 (12%) patients. Other ECG findings indicated mitral regurgitation (MR) in six patients (6%) and left ventricular (LV) thrombosis in the same number of patients (6%). Adverse events were reported in 25 patients (25%), which included heart failure (HF) in 19 patients (19%), ranging from infarction in 2 patients (2%), arrhythmia in 2 patients (2%), stent thrombosis in 1 patient (1%), and cardiac arrest in 1 patient (1%). No patients died in one month (Table **3**).

The study demonstrated that patients who had experienced adverse events were more likely to have DM (72% vs 16%; P = 0.000), hypertension (76% vs 18.7%; P = 0.000), a smoking habit (48% vs 17.3%; P = 0.003), hyperlipidemia (40% vs 1.3%; P = 0.000), obesity (72% vs 10.7%; P = 0.000), and a family history of IHD at a young age (8% vs 0%; P = 0.048) compared to those without adverse events. Additionally, adverse events were more common among patients with SETMI than those with NSTEMI (31.5% vs 7.4%; P = 0.010). Patients with occlusive CAD had a higher prevalence of adverse events than those with non-occlusive CAD (32.9% vs 3.7%; P = 0.000). Patients with multi-vessel disease had higher rates of adverse events than those with SVD (83.3% vs 36.4%, 14.5%, 12.5%; P = 0.001). The most involved vessel in patients with adverse events was LAD (88% vs 69.3%; P = 0.025), followed by RCA (48% vs 24%; P = 0.014) and LCX (52% vs 10.7%; P = 0.000). The study also demonstrated that reduced EF can increase the risk of adverse events, with more adverse events occurring in patients with severely and moderately reduced EF than in others (100% vs 31.8%, 8.9%, 9.5%; P = 0.000). Additionally, adverse events were more prevalent among patients with MR (16% vs 2.7%; P = 0.033) and LV thrombosis (20% vs 1.3%; P = 0.003) compared to those without. All this is shown in Table **4**.

4. Discussion

The present study aimed to assess the clinical characteristics, angiographic findings, and 30-day outcomes associated with CAD in young Sudanese patients. Our findings reveal that AMI in young Sudanese patients occurs more frequently in males (74%) than in females (26%). This observation may be attributed to higher prevalence rates of diabetes mellitus, hypertension, and smoking among males compared to females. This finding is consistent with several prior studies, including those conducted by Mark *et al.*, Liqaa *et al.*, Srikanth *et al.*, and Pankaj *et al.*, all of whom identified a predominance of males among young adults suffering from AMI [9–12].

The mean age of the participants was 39 ± 6 years, with the majority (47%) falling within the 41–45 age group. This age is significantly younger compared to the average age of individuals experiencing acute AMI in the general population, which typically ranges from 55.9 to 62.9 years. Our findings align with those of Srikanth *et al.*, who reported a mean age of 39 ± 5 years among young MI patients [13]. Additionally, our results are consistent with a Polish study that examined the angiographic characteristics of CAD patients younger than 40, where the mean age was 35.1 ± 4.4 years. Similarly, research by Wang *et al*. on 86 young MI patients aged 45 and under found a mean age of 40 years [14].

Table 4: Relationship between risk factors and adverse events using a chi-square test.

		AE: Yes (*n* = 25)	AE: No (*n* = 75)	*P*-value
Risk factors	HTN	19 (76%)	14 (18.7%)	0.000
	DM	18 (72%)	12 (16%)	0.000
	Smoking	12 (48%)	13 (17.3%)	0.003
	Hyperlipidemia	10 (40%)	1 (1.3%)	0.000
	Obesity	18 (72%)	8 (10.7%)	0.000
	Family history of IHD at a young age	2 (8%)	0 (0%)	0.048
MI type	STEMI (*n* = 73)	23 (31.5%)	50 (68.5%)	0.010
	NSTEMI (*n* = 27)	2 (7.4%)	25 (92.6%)	
CAD type	Occlusive (*n* = 73)	24 (32.9%)	49 (67.1%)	0.000
	Non-occlusive (*n* = 27)	1 (3.7%)	26 (69.3%)	
Number of vessels involved	Normal CAG (*n* = 8)	1 (12.5%)	7 (87.5%)	0.001
	SVD (*n* = 69)	10 (14.5%)	59 (85.5%)	
	DVD (*n* = 11)	4 (36.4%)	7 (36.6%)	
	TVD (*n* = 12)	10 (83.3%)	2 (16.7%)	
Main vessel involved	LAD	22 (88%)	52 (69.3%)	0.025
	LCX	12 (48%)	18 (24%)	0.014
	RCA	13 (52%)	8 (10.7%)	0.000
	LMCA	2 (8%)	1 (1.3%)	0.153
Ejection fraction (%)	<30% (*n* = 12)	12 (100%)	0 (0%)	0.000
	30–39% (*n* = 22)	7 (31.8%)	15 (68.2%)	
	40–49% (*n* = 45)	4 (8.9%)	41 (91.1%)	
	50–70% (*n* = 21)	2 (9.5%)	19 (90.5%)	
ECG findings	MR (*n* = 6)	4 (8.9%)	2 (2.7%)	0.033
	LV thrombus (n = 6)	2 (9.5%)	1 (1.3%)	0.003

AE, adverse events; DM, diabetes mellitus; IHD, ischemic heart disease; STEMI, ST-elevation myocardial infraction; NSTEMI, non-ST-elevation myocardial infraction; CAD, coronary artery disease; SVD, single vessel disease; DVD, double vessel disease; TVD, triple vessel disease; LAD, left anterior descending artery; LCX, left circumflex artery; RCA, right coronary artery; LMCA, left main coronary artery; MR, mitral regurgitation; LV, left ventricle

Differences in lifestyles and dietary patterns among young and older adults require specific consideration regarding early diagnosis and risk factor modification for CAD in young people [15]. The classic risk factors of CAD in the older population include DM, HTN, obesity, and smoking [15]. However, these factors also increase the risk of CAD in the young population, indicating their vital role in CAD regardless of age, consistent with the suggestion of other studies. Our study shows that hypertension is the leading risk factor for CAD in young patients. Rajeev *et al.*, Srikanth *et al.*, Mark *et al.*, and Tamrakar *et al.* have shown that smoking was the most prevalent risk factor linked to CAD [13, 16–18]. The results of a study from the Gulf Coast showed that the significant risk factors for MI were smoking (49.9%), obesity (38.3%), and a family history of MI at a young age (21.4%) [18]. Although dyslipidemia comprised 11% of the risk factors in our study, and other studies of AMI in the young population reported dyslipidemia as a risk factor ranging between 2%

and 80% [19–21]. In addition, these risk factors were positively associated with adverse events, which aligns closely with Nordenskjöld *et al.*, who identified independent predictors of adverse events, including diabetes, hypertension, current smoking, and family history of MI [22, 23].

Most subjects (73%) had STEMI concerning MI patterns based on ECG. Consistently, like in studies of Hui et al., Tamrakar et al., Mark et al., and Rajeev et al., STEMI was recorded at rates of 59%, 87%, 87.6%, and 95%, respectively [16, 18–24]. STEMI increases the risk of adverse events, as reported by the systematic review and the study by Ren *et al.*, in which STEMI was associated with higher mortality and adverse events than NSTEMI [20, 25].

The present study showed that 73% of the cases had obstructive CAD. This is in agreement with studies reporting rates ranging from 60–75% and others with a higher prevalence rate (>80%) [23, 26, 27].

In this study, most of the patients (69%) with critical CAD had SVD, with the LAD being the most common vessel involved (74%). These findings were consistent with numerous studies, such as those by Rabindra *et al.*, Binayendu *et al.*, Vinod *et al.*, and Sinha *et al.*, which all reported the LAD as the most involved artery in cases with SVD [19, 28–30]. Extensive coronary involvement is usually infrequent in the young population with MI, which explains the low rates of DVD (11%) and TVD (12%) in our study [17, 19–21]. Most studies reported a reduced left ventricular ejection fraction (LVEF), which complicated MI in young patients but was mild (37–55%). However, other studies reported reduced EF to <50% in several patients [20, 31].

In the current study, adverse events, mainly HF (19%), were reported in 25% of the patients. Similar findings were noted in studies by Rabindra *et al.*, McCaughey *et al.*, and Vinod *et al.*, where the rates of HF were 5.8%, 8%, and 5.3%, respectively [38, 30, 32].

Concerning the one-month outcomes, the study demonstrated no deaths among our group. Studies by McCaughey *et al.*, Vinod *et al.*, and Ajaz *et al.* closely followed our findings, mentioning no mortality during hospitalization for over 30 days post-MI [30–32]. In contrast, other studies have shown in-hospital mortality rates of approximately 0–10% among young MI patients [28]. The study from the Gulf Coast showed an in-hospital mortality rate of 7% [33]. The difference in follow-up duration might explain these variations.

Our study had several limitations that should be addressed. First, it involved a single center with a relatively small sample size, possibly due to selective recruitment and several exclusion criteria. The results cannot be generalized to all patients with diabetes, and a bigger sample size is needed for more accurate results. The study sample over-represented male respondents, so the results can only be generalized to a population with the same characteristics. Information about marital status, psychosocial stress, and physical activity should have been obtained. Finally, the follow-up duration was relatively short. It may have reduced the accuracy of the data regarding the adverse events, so a more extended follow-up period would have been more informative.

5. Conclusion

CAD in young individuals has emerged as a significant clinical concern, representing approximately 10% of STEMI cases globally. This trend

underscores the critical need for comprehensive risk stratification and early intervention in this demographic. In Sudan, the rising prevalence of traditional cardiovascular risk factors like hypertension, diabetes mellitus, and obesity has exacerbated the burden of premature CAD, posing a significant public health challenge. Aggressive management of these modifiable risk factors is essential to mitigate adverse outcomes.

Moreover, young patients with CAD often exhibit high-risk anatomical features, such as occlusive CAD, multivessel involvement (e.g., triple-vessel disease), and reduced EF (<40%), which are strongly associated with poor prognosis and heighten the rates of major adverse cardiovascular events (MACE). Early identification of these predictors through advanced imaging (e.g., CAG and ECG) and timely revascularization can significantly improve clinical outcomes.

Recommendations

The present study included a small sample of patients with a short follow-up period and focused on the bivariate associations (one predictor vs one outcome at a time). We recommend further multicenter studies with long-term follow-up periods and larger sample sizes to ensure logistic regression and multivariate analysis to identify independent predictors of adverse outcomes.

Public health campaigns focusing on the importance of regular screening and managing hypertension, diabetes, obesity, and smoking cessation are crucial in reducing the morbidity and mortality of ACS in young adults.

Declarations

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None.

Ethical Considerations

Ethical approval was granted by the Ethical Committee at the Sudan Medical Specialization Board (SMSB) and the scientific research division of the Sudan Heart Center. Informed consent was obtained from the patients before their inclusion in the study. All patient data were anonymized, securely stored, and used exclusively for this research.

Competing Interests

The authors disclose no potential conflicts of interest related to this article's research, authorship, or publication.

Availability of Data and Materials

All data are available upon request.

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Abbreviations and Symbols

CAD: Coronary artery disease

ACS: Acute coronary syndrome

STEMI: ST-elevation myocardial infarction

LAD: Left anterior descending artery

PCI: Percutaneous coronary intervention

CABG: Coronary artery bypass grafting

AMI: Acute myocardial infarction

CAG: Coronary angiography

EF: Ejection fraction

SMSB: Sudan Medical Specialization Board

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