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Research Article

Acute Coronary Syndrome in Young Adults at a University Hospital in Cotonou, Benin: Epidemiological, Diagnostic, Therapeutic and Outcome Aspects

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Abstract

Acute coronary syndrome (ACS) in young adults is uncommon, but it is increasingly reported, including in sub-Saharan Africa. The aim of this study was to describe the epidemiological, diagnostic, therapeutic and in-hospital outcome features of ACS in young adults at the University Clinic of Cardiology (CUC) of the Hubert Koutoukou Maga National University Hospital Center (CNHU-HKM) in Cotonou, Benin. We conducted a single-center, cross-sectional, descriptive study with prospective data collection from 1 January 2020 to 31 August 2022. ACS was diagnosed according to the Fourth Universal Definition of Myocardial Infarction and the European Society of Cardiology guidelines. All patients aged 50 years or younger who were admitted to the CUC with ACS and gave informed consent were included and followed until discharge or death. Among 98 ACS admissions of all ages, 31 (31.6%) concerned patients aged 50 years or younger, who represented 2.6% of the 1,197 admissions. Among the 31 patients included, the mean age was 40.9 ± 7.7 years, with a marked male predominance (87.1%). Pre-event cardiovascular risk, estimated descriptively with the SCORE2 charts, was low in 48.4% of patients. The mean time from symptom onset to admission was 37.8 ± 41.3 hours, and 58.1% of patients were admitted more than 12 hours after onset. ST-elevation ACS accounted for 71.0% of cases. A high probability of atherosclerotic origin according to an exploratory, non-validated score was found in 96.8% of patients; it could not be confirmed angiographically in most of them. All patients except the one who died received the BASIC regimen (beta-blockers, antiplatelet agents, statins, renin–angiotensin system inhibitors and control of cardiovascular risk factors). Thrombolysis was indicated in nine patients, performed in seven (22.6%) and successful in six. Five patients (16.1%) underwent coronary angiography, which showed significant stenoses in three of them; these three patients received drug-eluting stents. At least one in-hospital complication occurred in 41.9% of patients, and in-hospital mortality was 3.2%. In this single-center series, ACS in patients aged 50 years or younger accounted for about one third of ACS admissions. Most of the risk factors observed were modifiable. These descriptive findings, limited by the small sample and the lack of systematic coronary angiography, support the strengthening of preventive measures and of access to reperfusion.

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Keywords

Acute Coronary Syndrome, Young Adults, Cardiovascular Risk Factors, Thrombolysis, Benin

1. Introduction

Cardiovascular diseases are a major public health problem worldwide, particularly in sub-Saharan Africa [1]. Myocardial infarction (MI) is one of the leading causes of morbidity and mortality worldwide [1, 2]. Ischemic heart disease is considered less frequent in sub-Saharan Africa than in Western countries: its prevalence is estimated at 2.1 to 5 per 100,000 inhabitants, compared with 25 to 640 per 100,000 in Europe. The incidence of MI increases with population aging, and the disease mainly affects people older than 50 years [3]. MI in young adults is rare, accounting for 4% to 10% of all MIs regardless of age [4], but an increase in its frequency has been reported and it represents a considerable economic burden. At this age, MI is the most frequent first manifestation of atherosclerotic disease [4-7]. In this respect, descriptive studies based on large samples of young patients are relatively scarce [4].

In Benin, a five-year retrospective study conducted in 2017 by Dakpo [8] reported a 25.2% prevalence of MI among patients younger than 50 years. That preliminary work was retrospective, and no usable information was available in 12% of the records reviewed. To obtain more recent and up-to-date data, we conducted the present study to describe the epidemiological, diagnostic, therapeutic and outcome characteristics of acute coronary syndrome (ACS) in young adults at the University Clinic of Cardiology (CUC) of the Hubert Koutoukou Maga National University Hospital Center (CNHU-HKM) in Cotonou.

In this series, patients aged 50 years or younger accounted for 31.6% of ACS admissions, dyslipidemia was the most frequent cardiovascular risk factor (96.8%), 58.1% of patients were admitted more than 12 hours after symptom onset, thrombolysis was performed in 22.6% of patients, and in-hospital mortality was 3.2%.

2. Materials and Methods

2.1. Study Design and Period

This was a single-center, cross-sectional, descriptive study with prospective data collection. It was conducted over 32 months, from 1 January 2020 to 31 August 2022. Patients were followed from admission until hospital discharge or in-hospital death; no post-discharge follow-up was planned.

2.2. Study Setting

The study took place at the University Clinic of Cardiology (CUC) of the Hubert Koutoukou Maga National University Hospital Center (CNHU-HKM) in Cotonou, Benin.

2.3. Sampling and Selection Criteria

The study population consisted of patients admitted to the CUC of the CNHU-HKM in whom a diagnosis of ACS had been made (see definitions below). We performed systematic (exhaustive) recruitment of all consecutive patients aged 50 years or younger who gave their consent; no sample size was calculated. The only exclusion criterion was refusal to participate. The numbers of admissions and of ACS cases of all ages, used as denominators, were extracted from the department's admission register.

ACS was diagnosed in patients with acute chest pain or equivalent symptoms, on the basis of the electrocardiogram and of high-sensitivity cardiac troponin I (hs-cTnI), according to the Fourth Universal Definition of Myocardial Infarction and the ESC guidelines [9-12]. The upper reference limit (URL) of hs-cTnI in our laboratory is 14 ng/L. ST-elevation ACS (STE-ACS) was defined by persistent ST-segment elevation of at least 1 mm in two contiguous frontal leads, at least 2 mm in two contiguous precordial leads or at least 0.5 mm in the right or posterior leads, or by a new pathological Q wave or a new left bundle branch block. Non–ST-elevation ACS (NSTE-ACS) was defined by horizontal or downsloping ST-segment depression of at least 0.5 mm and/or T-wave inversion in two contiguous leads, without persistent ST-segment elevation. It was classified as non–ST-elevation myocardial infarction (NSTEMI) when hs-cTnI exceeded twice the URL (28 ng/L), and as unstable angina when hs-cTnI was not elevated or was elevated by less than twice the URL. Troponin was measured on admission in patients with ST-segment elevation, and on admission and at 3 hours in patients without ST-segment elevation. Other causes of chest pain or of troponin elevation (myocarditis, pulmonary embolism, aortic dissection, takotsubo syndrome, etc.) were excluded on the basis of the clinical history, transthoracic echocardiography and cardiac magnetic resonance imaging.

2.4. Study Variables

The primary variable was the characteristics of ACS in young adults. The secondary variables were sociodemographic data (age, sex, occupation, geographic origin, marital status, educational level, monthly income) and cardiovascular

risk factors (hypertension, diabetes, dyslipidemia, overweight/general obesity, abdominal obesity).

Dyslipidemia was defined as a triglyceride level ≥ 1.50 g/L and/or a high-density lipoprotein (HDL) cholesterol level < 0.40 g/L in men or < 0.50 g/L in women and/or an elevated low-density lipoprotein (LDL) cholesterol level. The LDL cholesterol threshold was determined according to the cardiovascular risk level calculated with the Systematic COronary Risk Evaluation 2 (SCORE2). LDL hypercholesterolemia was thus defined as an LDL cholesterol level ≥ 1.16 g/L in patients at low cardiovascular risk, ≥ 1.00 g/L in patients at moderate risk, ≥ 0.70 g/L in patients at high risk and ≥ 0.55 g/L in patients at very high risk. These thresholds correspond to the LDL cholesterol targets of the 2019 ESC/EAS guidelines [13] for each risk category. Because SCORE2 was developed for primary prevention in apparently healthy people aged 40–69 years, the risk category was used here only to describe the pre-event risk profile of the patients; strictly, all patients with ACS belong to the very-high-risk category (LDL cholesterol target < 0.55 g/L) [13]. The number of patients above this single threshold of 0.55 g/L was not available for this analysis. Abdominal obesity was defined as a waist circumference ≥ 102 cm in men and ≥ 88 cm in women. Overweight and general obesity were defined according to the World Health Organization (WHO) classification of body mass index (BMI), which is weight in kilograms divided by the square of height in meters (overweight, BMI 25.0–29.9 kg/m^2; obesity, BMI ≥ 30.0 kg/m^2).

The characteristics of ACS included the features of chest pain (typical or atypical, circumstances of onset, associated symptoms); the admission delay; electrocardiographic findings (ST-elevation ACS [STE-ACS], non–ST-elevation ACS [NSTE-ACS] and topography of the lesions); echocardiographic findings (regional wall motion abnormalities, left ventricular geometry and systolic function); biological data (hs-cTnI above or below the laboratory URL); treatment; and in-hospital complications. These comprised arrhythmias (premature ventricular contractions [PVCs], premature atrial contractions [PACs], ventricular tachycardia [VT] and atrial fibrillation [AF]); conduction disorders (sinoatrial block, atrioventricular [AV] block and bundle branch block); hemodynamic complications (left or right heart failure, cardiogenic shock and cardiac arrest); mechanical complications (rupture of the left ventricular free wall, papillary muscle rupture and ventricular septal rupture); left ventricular thrombus; pericarditic reaction; thromboembolic complications (pulmonary embolism and thrombophlebitis); and death.

The admission delay was defined as the time, in hours, elapsed between the onset of chest pain (or of the last episode of chest pain) and admission to the cardiology department of the CNHU-HKM. An admission was considered late when it occurred more than 12 hours after symptom onset. Treatment data included the BASIC regimen (beta-blockers, antiplatelet agents, statins, angiotensin-converting enzyme inhibitors or angiotensin receptor blockers, and control of cardiovascular risk factors), thrombolysis (indication, success and drug used) and coronary angiography (affected artery, type of lesion [significant or not], extent of disease and procedure performed).

A high probability of an atherosclerotic origin of ACS was retained when the patient presented at least one of the following: peripheral artery disease of the lower limbs, assessed by the ankle-brachial index (ABI); a carotid atheromatous plaque, assessed by measurement of carotid intima-media thickness (CIMT); or a probability score for an atherosclerotic origin of ACS in young adults, developed by our team from the Framingham, SCORE2 and Prospective Cardiovascular Münster (PROCAM) global cardiovascular risk assessment models (Table 1) [14]. This exploratory score has not been externally validated; it estimates a pre-test probability and does not confirm coronary atherosclerosis, which requires coronary imaging. Three points were given to the major risk factors (hypertension, diabetes, active smoking and atherogenic dyslipidemia), up to 4 points to an increased CIMT or a reduced ABI, which are signs of established atherosclerosis, and 2 points to a family history of MI in a first-degree relative; 2 points were subtracted in case of a history of venous thromboembolism, which suggests a hemostasis disorder. The score was built so that a single major risk factor or one subclinical atherosclerotic marker made an atherosclerotic origin probable (threshold of 3 points). The pre-event cardiovascular risk level was estimated with the SCORE2 charts for very-high-risk regions [15]; SCORE2 was designed for individuals aged 40–69 years without established cardiovascular disease, was not recalibrated for Benin, and was used here for description only. We also assessed lifestyle, oral contraceptive use, use of drugs or stimulants, excessive alcohol consumption, and long-term treatment with other drugs (anticancer drugs, estrogen–progestin hormones). Congenital coronary anomalies were sought by transthoracic echocardiography in the parasternal short-axis view, and a thrombophilia work-up was proposed to the patients.

Table 1. *Exploratory (non-validated) probability score for an atherosclerotic origin of acute coronary syndrome in young adults (inspired by the Framingham, SCORE2 and PROCAM global cardiovascular risk models).*

Item	Points
History of hypertension	3
History of diabetes	3
Current smoking	3
Atherogenic dyslipidemia	3
Family history of sudden death in a first-degree relative	1
Family history of MI in a first-degree relative	2
CIMT between 0.7 and 1 mm	2

Item	Points
CIMT > 1 mm	4
Reduced ABI	4
History of VTE	−2
Total score	Sum of points

Probability of an atherosclerotic origin: low, score < 3; high, score ≥ 3. ABI, ankle-brachial index; CIMT, carotid intima-media thickness; MI, myocardial infarction; VTE, venous thromboembolism. The score estimates a pre-test probability and does not confirm atherosclerosis.

2.5. Data Collection

Data were collected through clinical and paraclinical examination using a pre-tested data collection form. The data collection tools were a questionnaire, an OMRON automatic digital blood pressure monitor with an appropriately sized cuff, a Littmann stethoscope, a weighing scale, a stadiometer, and a flexible, non-elastic measuring tape graduated in centimeters. High-sensitivity troponin I was measured by chemiluminescence on venous blood samples collected in dry tubes (serum); citrate and EDTA tubes were used for the other biological tests. An 18-lead electrocardiogram (ECG) was recorded with an EDAN SE-1201 device. Doppler echocardiography was performed at the bedside with a MINDRAY Consona N9 and a GE Healthcare VIVID T8 v203 machine.

2.6. Statistical Analysis

Data were entered and analyzed with EpiData version 4.6 and Epi Info version 7.2.2.6 (Centers for Disease Control and Prevention, CDC). Qualitative variables were expressed as percentages with exact (Clopper–Pearson) 95% confidence intervals. The analysis was purely descriptive, and no hypothesis testing was performed. Quantitative variables were described with measures of central tendency and dispersion: the mean with standard deviation (SD), the extreme values (range) and the modal class.

2.7. Ethical Considerations

This study complied with the ethical standards in force. Administrative authorization was obtained from the authorities of the CNHU-HKM and from the head of the cardiology department. The research protocol was submitted to the ethics committee of the Faculty of Medicine of Parakou and received a favorable opinion (reference 0493/CLERB-UP/P/SP/R/SA). Informed consent was obtained from each patient before inclusion in the study. Medical confidentiality, the rights of the participants, and the anonymity and confidentiality of the data were respected throughout the research.

3. Results

3.1. Epidemiological Aspects

During the study period, 1,197 patients were admitted to the CUC of the CNHU-HKM, among whom 98 had ACS, regardless of age (Figure 1). Thirty-one cases of ACS (all included, participation rate 100%) were recorded in patients aged 50 years or younger; the 67 other ACS cases concerned patients older than 50 years. Patients aged 50 years or younger therefore accounted for 31.63% (95% confidence interval [CI], 22.6–41.8) of all ACS admissions and for 2.59% (95% CI, 1.8–3.7) of all admissions to the CUC of the CNHU-HKM. These figures describe the case mix of a single hospital; they are not population-based prevalence or incidence estimates.

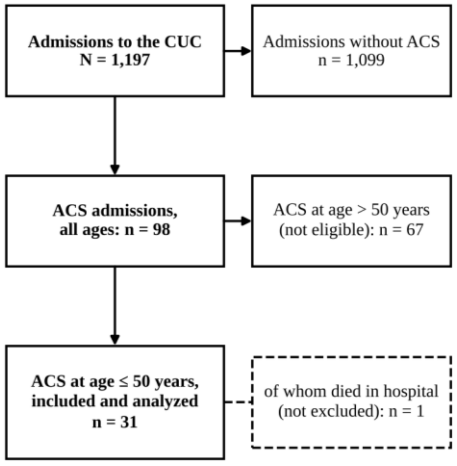


Figure 1. *Flow chart of the distribution of ACS cases at the CUC during the study period. ACS, acute coronary syndrome; CUC, University Clinic of Cardiology. The in-hospital death is a subgroup of the 31 analyzed patients and not an exclusion.*

The mean age of the patients was 40.87 ±7.72 years (range, 21–50 years). The 45–50-year age group was the most represented. Of the 31 patients in our study, 27 (87.1%; 95% CI, 70.2–96.4) were male and 4 (12.9%) were female, giving a male-to-female sex ratio of 6.75. Most patients were of African origin (29/31, 93.5%); the other two were of French and Indian origin. Private-sector employees were the most represented occupational group (45.16%), 80.65% of the patients were married or cohabiting, 67.74% had a secondary education level, and 64.52% had an average monthly income.

All patients had at least one cardiovascular risk factor. The most frequent was dyslipidemia (96.77%; 95% CI, 83.3–99.9), followed by excess weight: overweight in 51.61% of patients, abdominal obesity in 41.94% and general obesity in 22.58%. Hypertension was found in 32.26% of patients, and diabetes and smoking in 16.13% each. Table 2 summarizes these data. The mean lipid levels were 1.92 ±0.47 g/L for total cholesterol, 0.46 ±0.14 g/L for HDL cholesterol, 1.21 ±0.41 g/L for

LDL cholesterol and 1.34 ± 0.79 g/L for triglycerides. LDL hypercholesterolemia was present in 25 patients (80.65%), low HDL cholesterol in 10 (32.26%) and hypertriglyceridemia in 10 (32.26%). Other risk markers were excessive alcohol consumption (two patients, 6.45%), cannabis use (one patient), stimulant use (one patient) and oral contraceptive use (one patient). Three patients (9.68%) had a personal history of MI, and a family history of hypertension and of diabetes was found in 45.16% and 29.03% of patients, respectively. Most of our patients (48.39%) had a low estimated pre-event cardiovascular risk according to SCORE2, whereas 38.7% had a high to very high risk (ten patients, 32.26%, were younger than 40 years, for whom SCORE2 is not validated). The number of patients above the single threshold of 0.55 g/L was not available; the mean LDL cholesterol (1.21 ± 0.41 g/L; range, 0.54–2.18) was well above this target.

Table 2. *Frequency of cardiovascular risk factors in the study population (Cotonou, 2020–2022; N = 31).*

Risk factor	n	%
Hypertension	10	32.26
Diabetes	5	16.13
Smoking	5	16.13
Dyslipidemia	30	96.77
LDL hypercholesterolemia	25	80.65
Low HDL cholesterol	10	32.26
Hypertriglyceridemia	10	32.26
Overweight	16	51.61
General obesity	7	22.58
Abdominal obesity	13	41.94
Personal history of MI	3	9.68
Excessive alcohol consumption	2	6.45
Family history of premature stroke	0	0.00
Family history of MI	1	3.23
Family history of sudden death	1	3.23
Family history of hypertension	14	45.16
Family history of diabetes	9	29.03

MI, myocardial infarction; HDL, high-density lipoprotein; LDL, low-density lipoprotein. Dyslipidemia was present in 30 patients; its components are listed below it and can overlap.

3.2. Diagnostic Aspects

The mean admission delay was 37.77 ± 41.32 hours (range, 2–168 hours). Thirteen patients (41.94%) were admitted within 12 hours of symptom onset: 4 (12.90%) within 6 hours and 9 (29.03%) between 6 and 12 hours. Eighteen patients (58.06%; 95% CI, 39.1–75.5) were admitted more than 12 hours after onset. Chest pain was an inaugural episode in 48.39% of cases, a recurrent pain in 38.71% and crescendo angina in 12.90%. It was typical in most cases (74.19%); it occurred at rest in 67.74% of patients and during exertion in 25.81%. The main symptoms associated with chest pain were dyspnea and palpitations, each in 32.26% of cases. Physical examination at admission was normal in 83.87% of patients.

Regarding the type of ACS, most of our patients had ACS with persistent ST-segment elevation (STE-ACS, 70.97%; 95% CI, 52.0–85.8). NSTE-ACS with hs-cTnI above twice the URL (NSTEMI) accounted for 22.58% of cases and NSTE-ACS with hs-cTnI not above twice the URL (unstable angina) for 6.45%. The anterior territory (anteroseptal, apical, lateral and extensive anterior) and the inferior territory were the most frequently involved, each in 74.19% of cases. Circumferential ACS (extensive anterior and inferior) was found in four patients (12.90%). Pathological Q waves were present in 21 of the 22 patients with STE-ACS (95.45%). These data are summarized in Table 3.

Table 3. *Distribution of patients according to the electrocardiographic characteristics of ACS (Cotonou, 2020–2022; N = 31).*

Characteristic	n	%
Type of ACS		
STE-ACS	22	70.97
NSTE-ACS, troponin-positive	7	22.58
NSTE-ACS, troponin-negative	2	6.45
Electrocardiographic territory		
Anteroseptal	7	22.58
Apical	5	16.13
High lateral	4	12.90
Low lateral	7	22.58
Extensive anterior	10	32.26
Inferior	23	74.19
Basal	9	29.03
Right ventricle	10	32.26

ACS, acute coronary syndrome; NSTE-ACS, non–ST-elevation ACS; STE-ACS, ST-elevation ACS. A patient could have more than one territory involved.

Doppler echocardiography showed regional wall motion abnormalities in 24 patients (77.42%). The walls most often involved were the inferoseptal wall (54.17%), followed by the

inferior wall (50%). Left ventricular (LV) geometry was normal in 17 patients (54.84%). Left ventricular hypertrophy (LVH) was found in 32.26% of cases and LV dilatation in two patients (6.45%). The LV ejection fraction (LVEF) was preserved in most cases (70.97%), with a mean of 53.45% ±12.68% (range, 20%–75%). The mean high-sensitivity troponin I level was 13,226.09 ± 15,614.89 ng/L (range, 3.60 to > 40,000 ng/L). The mean troponin level was 928.86 ± 1,184.13 times the upper limit of normal (range, 0.25 to 3,190.50 times).

Regarding the etiological work-up, Doppler ultrasound of the supra-aortic trunks showed increased CIMT in 20 patients (64.52%), of whom 25% had atheromatous plaques. The ABI was reduced in three patients (9.68%). The exploratory probability score was ≥ 3, indicating a high pre-test probability of atherosclerotic origin, in almost all patients (30/31; 96.77%; 95% CI, 83.3–99.9) (Table 1); this does not constitute confirmation of coronary atherosclerosis. No congenital coronary anomaly was found. A thrombophilia work-up could be performed in nine patients (29.03%) and revealed an isolated protein C deficiency in one patient, who was hypertensive and diabetic and developed pericarditis as a complication of MI; it was normal in the other patients tested.

3.3. Treatment

All patients except the one who died received the BASIC regimen. The other adjunctive treatments mainly comprised proton pump inhibitors (31 patients, 100%), vasodilators (11 patients, 35.48%), anxiolytics (6 patients, 19.35%), diuretics (4 patients, 12.90%), calcium channel blockers (4 patients, 12.90%), oral antidiabetic drugs or insulin (4 patients, 12.90%) and analgesics (3 patients, 9.68%).

Thrombolysis was indicated in nine patients (29.03%) and performed in seven (22.58%; 95% CI, 9.6–41.1). It was indicated in patients with STE-ACS presenting within 12 hours of symptom onset (or later in case of persistent pain), since primary percutaneous coronary intervention (PCI) is not available in Benin [10] (contraindications checked, according to these guidelines: absolute, previous intracranial hemorrhage or stroke of unknown origin, ischemic stroke in the preceding 6 months, central nervous system damage, neoplasm or arteriovenous malformation, major trauma, surgery or head injury in the preceding 3 weeks, gastrointestinal bleeding in the past month, known bleeding disorder, aortic dissection, non-compressible punctures in the past 24 hours; relative, transient ischemic attack in the preceding 6 months, oral anticoagulant therapy, pregnancy or the first week postpartum, refractory hypertension [systolic blood pressure > 180 mmHg and/or diastolic > 110 mmHg], advanced liver disease, infective endocarditis, active peptic ulcer, prolonged or traumatic resuscitation). Two patients could not receive it because of a lack of financial resources. Among the 22 patients with STE-ACS, the 13 others had no indication for thrombolysis because they were admitted beyond the time window (18 of the 31 patients, 58.06%, were admitted more than 12 hours after symptom onset). The exact delay between symptom onset and thrombolysis was not recorded; the mean delay between symptom onset and admission was 37.77 ± 41.32 hours (range, 2–168), and 13 patients (41.94%) were admitted within 12 hours. Thrombolysis was considered successful on the main criterion of a regression of the ST-segment elevation by more than 50%, together with relief of chest pain and, when present, an accelerated idioventricular rhythm (reperfusion arrhythmia) in six of the seven patients (85.71%); in the seventh patient it failed, and the course was unfavorable. Rescue PCI was not an option, since coronary angiography and PCI are not available in Benin. Alteplase was used in six patients and streptokinase in one.

Coronary angiography results were available for five patients (16.13%; 95% CI, 5.5–33.7). They showed lesions on three vessels in four patients (patients 1, 2, 4 and 5) and on two vessels in one (patient 3), counting every vessel with a lesion, significant or not. Significant stenoses were found in patients 1, 2 and 4, who received drug-eluting stents; one of them also received an implantable cardioverter-defibrillator for primary prevention of arrhythmias. The angiographic findings and the treatment of each patient are summarized in Table 4. All five patients had a low overall cardiovascular risk before ACS.

Table 4. *Coronary angiography findings and treatment according to the patient profile (Cotonou, 2020–2022; n = 5).*

Patient (age, years)	Angiographic findings	Treatment
1 (40)	Three-vessel disease. Significant stenoses: second diagonal, Cx, RCA. Non-significant lesion: LAD.	Two DES (RCA, Cx)
2 (49)	Three-vessel disease. Significant stenoses: LAD, first and second diagonals, RCA, RVP. Chronic occlusion of the Cx. Non-significant lesion: left main.	Two DES (RCA); primary-prevention ICD
3 (34)	Two-vessel disease. Non-significant lesions: LAD, RCA.	Medical treatment
4 (49)	Three-vessel disease. Significant stenoses: distal LAD, second diagonal, distal RCA. Non-significant lesion: first marginal.	Two DES (distal RCA, second diagonal)
5 (49)	Three-vessel disease. Non-significant lesions: LAD, Cx, RCA.	Medical treatment

Cx, circumflex artery; DES, drug-eluting stent; ICD, implantable cardioverter-defibrillator; LAD, left anterior descending artery; RCA, right coronary artery; RVP, retroventricular posterior artery; D1, D2, first and second diagonal branches of the LAD. The number of vessels counts every vessel with a lesion, significant or not. Significant stenosis: ≥ 70% visual diameter stenosis (≥ 50% for the left main) [16].

3.4. In-hospital Outcomes

The course was favorable, without complications, in most patients (58.06%). Thirteen patients (41.94%; 95% CI, 24.5–60.9) developed an in-hospital complication of their ACS, mainly arrhythmias, followed by conduction disorders and LV failure. One death was recorded (3.23%; 95% CI, 0.1–16.7). It concerned a patient at high cardiovascular risk (overweight, type 2 diabetes, dyslipidemia) who developed complications of STE-ACS, namely complete AV block and poorly tolerated ventricular tachycardia. Table 5 presents the in-hospital complications of ACS. The mean length of hospital stay was 8.38 ± 3.97 days (range, 2–19 days).

Table 5. *Distribution of patients according to the in-hospital complications of ACS (Cotonou, 2020–2022; N = 13).*

Complication	n	%
Arrhythmias	8	61.54
Conduction disorders	4	30.77
Left ventricular failure	4	30.77
Pericarditis	2	15.38
Cardiogenic shock	1	7.69
Left ventricular thrombus	1	7.69
Death	1	7.69

ACS, acute coronary syndrome. Percentages are calculated among the 13 patients with at least one complication; a patient could have more than one complication.

Twenty-nine patients (93.55%) were discharged alive from the hospital; one patient died, and one patient (patient 3 in Table 4) was transferred to a COVID-19 treatment site during the pandemic, so that the outcome after transfer is unknown. Among the patients with arrhythmias, there were five cases of VT, two cases of isolated PVCs and one case of atrial flutter. Among the patients with conduction disorders, there was one first-degree AV block, one second-degree AV block, one complete AV block and one right bundle branch block.

4. Discussion

4.1. Epidemiological Aspects

Patients aged 50 years or younger accounted for 31.6% of ACS admissions at the CUC (2.6% of all hospital admissions); these are hospital-based proportions, not population prevalence or incidence. In 2017 in Cotonou, in a retrospective study covering 5 years and 6 months, Dakpo [8] reported a lower proportion of 25.2% of MI among patients younger than 50 years, out of all patients admitted for MI at the CUC of the CNHU-HKM. In South Asia, Peerwani et al. [17] reported in 2024 a proportion of 12.2% among ACS patients aged 45 years or younger. Lower proportions have been reported in the literature: 6.8% by Coulibaly et al. [18] in Bamako, Mali (2014), and 16.6% by Yam égo et al. [19] in Dakar, Senegal (2010), both in patients younger than 40 years. Sylla et al. [20] reported a proportion of 23% in Guinea in 2017 among patients younger than 50 years. Comparisons between studies are limited by differences in design, age cut-offs (40 versus 50 years), case definitions (MI versus ACS) and settings, and these data do not allow conclusions about temporal trends in incidence. A rise in cardiovascular risk factors among young people is a plausible contributor but was not assessed in our study.

The most frequent risk factor was dyslipidemia (96.8%), followed by excess weight (overweight and general obesity combined, 74.2%), abdominal obesity (41.9%) and hypertension (32.3%). Matsis et al. [21] also found dyslipidemia to be the predominant risk factor (57.1%), followed by obesity (50%), and Yam égo et al. [19] reported dyslipidemia in 50% of patients. Dakpo [8] found hypertension in 51.2% and dyslipidemia in 48.7% of patients younger than 50 years. The high proportion of dyslipidemia in our study may be explained by the use of the new, lower LDL cholesterol thresholds set by the 2019 European Society of Cardiology (ESC) guidelines [13]; the number of patients above the single threshold of 0.55 g/L was not available, but the mean LDL cholesterol was well above this target. Regarding the cardiovascular risk level, 48.4% of our patients had a low estimated pre-event cardiovascular risk according to SCORE2 (used descriptively; see Methods and limitations), whereas a substantial 38.7% had a high to very high risk. All patients had at least one cardiovascular risk factor. Shah and Jain [22] found in their series that most patients had at least two cardiovascular risk factors. These results show that young people are not as spared as one might think with regard to the risk of cardiovascular events.

4.2. Diagnostic Aspects

The mean admission delay was 37.77 ± 41.32 hours, and 58.06% of patients were admitted more than 12 hours after symptom onset. These results are not entirely satisfactory, but they are better than those of Dakpo [8] in 2017 (mean delay, 66 hours; 78% of late admissions) and those of other African studies: 66 ± 11 hours in Côte d'Ivoire (Adoubi et al. [23],

2010), 53.2 ± 21.3 hours in Senegal (Mboup et al. [24], 2014) and 80% of late admissions in Mali (Coulibaly et al. [18], 2014). Shorter mean delays were reported in Senegal by Yaméogo et al. [19] in 2010 (15 ± 4 hours) and in Tunisia by Mahdhaoui et al. [25] (14 ± 19 hours). However, these delays remain long compared with those of European series: a median of 4 hours in Greece (Pitsavos et al. [26], 2005), 5.4 ± 6.1 hours in Switzerland (De Lopagno [27], 2004), and 62.9% of patients managed within 6 hours in France (Joussein-Remacle et al. [28], 2006). This late admission is explained mainly by delayed consultation, because patients neglect their symptoms or are unaware of the urgency of seeking care for chest pain, and by delays in diagnosis and referral. These delays limit the indications for thrombolysis and worsen the prognosis of our patients, since in this condition "time is muscle".

Chest pain was typical in most of our patients (74.2%), a proportion similar to that reported by Dakpo [8] (80.5%). The FAST-MI 2015 registry in France [29] indeed reported that atypical symptoms were uncommon (15%) in young subjects compared with older ones. Nevertheless, whether the pain is typical or atypical should not cast doubt on the diagnosis of ACS in a young patient. Myocardial infarction was found in 93.5% of our patients (ST-elevation myocardial infarction [STEMI], 71.0%; NSTEMI, 22.6%), and two patients (6.5%) had unstable angina. Similar rates were reported by Dakpo [8] (STEMI, 80.5%; NSTEMI, 19.5%), Lamzarraf [30] (STEMI, 63%) and Kassam et al. [31] (STEMI, 57.5%).

The anterior and inferior territories were the most frequently involved, each in 74.2% of cases, followed by the right ventricular territory (32.3%). Most African studies found a predominance of anterior territory involvement: Lamzarraf [30] in Morocco (70%), Coulibaly et al. [18] in Mali (50%) and Yaméogo et al. [19] in Senegal (50%). These data are consistent with the literature, which most often reports involvement of the left anterior descending artery on coronary angiography in young subjects [3].

Regional wall motion abnormalities were found in 77.4% of the patients in our series. Dakpo [8] reported a similar rate (86.5%), as did Coulibaly et al. [18] (80%) and Lamzarraf [30] (73%). This demonstrates the considerable severity of MI in young subjects. Indeed, regional wall motion abnormalities on transthoracic echocardiography are often proportional to the extent of myocardial necrosis. This is consistent with the almost constant presence of pathological Q waves on the ECG in our patients (95.45% of those with STE-ACS).

CIMT was increased in 20 patients (64.5%), of whom five (25%) had atheromatous plaques. These results suggest early vascular changes in our young patients, although CIMT is only a surrogate marker. CIMT is a simple, noninvasive marker of subclinical atherosclerosis, and a meta-analysis showed that it predicts myocardial infarction and stroke [32]. Increased CIMT is associated with cardiovascular risk factors [33] and with a higher incidence of coronary events [34], and in patients treated by PCI with restenosis [35]; however, its added value for cardiovascular risk assessment remains debated [36].

Most of our patients (30/31) had a high probability of an atherosclerotic origin of their ACS according to our score. This hypothesis could not be confirmed by coronary angiography, which is the gold standard for this purpose, because only five patients (16.1%) were able to undergo it (see section 4.3). Moreover, our score is exploratory and unvalidated, and it assigns 3 points to atherogenic dyslipidemia alone, which is the threshold for a high probability; given the very high frequency of dyslipidemia in our series, this result mainly reflects the prevalence of this risk factor and should be interpreted as hypothesis-generating rather than as evidence of an atherosclerotic etiology. In the literature, several studies on ACS in young subjects report a higher frequency (up to 20%) of patients with angiographically normal coronary arteries [37, 38]. The pathogenesis of ACS in young adults indeed differs from that in older people, particularly when classic risk factors are absent. Non-atherosclerotic causes should be sought, such as spontaneous coronary artery dissection, intramural hematoma, and prothrombotic or vasospastic conditions that favor ACS [38]. In our series, no congenital coronary anomaly was found, and the thrombophilia work-up, possible in only nine patients, revealed an isolated protein C deficiency in one.

4.3. Therapeutic Aspects

Thrombolysis was indicated in nine patients (29.03%) and performed in seven (22.58%), with a success rate of 85.71% (six of seven patients). Dakpo [8] found similar figures in young patients (17.1% of thrombolyses performed; 85.7% of success). Other African studies reported similar or even lower rates of thrombolysis: Lamzarraf [30] in Morocco in 2010 (13%), Mboup et al. [24] in Senegal in 2014 (10.2%) and Coulibaly et al. [18] in Mali in 2014 (no thrombolysis performed in the 20% of patients admitted within the time window, because the drug was unavailable). These rates are markedly lower than those of older Western registries [5], in which the trend has since reversed in favor of primary angioplasty [29], and even than those of some countries of the subregion, such as Côte d'Ivoire [39]. This is explained by the high cost or unavailability of thrombolytic agents, the population's lack of awareness of coronary disease, which lengthens admission delays, the sometimes insufficient qualification of health care staff, and the absence of mobile emergency and home intervention teams. All these factors reduce the indications for thrombolysis, which could play a crucial role in improving the prognosis of our patients. According to current ESC guidelines, patients with STE-ACS presenting within 12 hours of symptom onset should receive reperfusion, with fibrinolysis when primary PCI cannot be performed within 120 minutes of diagnosis [12]; the long admission delays in our series (58.1% beyond 12 hours) and the financial barriers therefore directly limited reperfusion.

Coronary angiography is not available in Benin. Patients

who need it are evacuated to France or to other countries of the subregion (Togo, Senegal); the cost is covered by the State for civil servants and borne by the patients themselves for the others. Results were available for five patients (16.13%), and three of them had significant stenoses and received drug-eluting stents. In these three patients (patients 1, 2 and 4 in Table 4), the extent of coronary involvement contrasted with the low cardiovascular risk level before ACS, but it was consistent with the presence of subclinical atherosclerotic disease (carotid plaque in two of them), which is compatible with an atherosclerotic origin of ACS, although it does not prove it. Dakpo [8] reported a similar proportion (14.6%) of young patients who underwent coronary angiography. This low rate probably reflects the fact that most of our patients were private-sector employees whose average monthly income did not allow them to finance the examination. Coronary angioplasty is nevertheless the preferred revascularization mode in these young patients, given the often limited extent of coronary disease [3, 5]. The short-term prognosis of young patients is generally better than that of older patients [40].

4.4. In-hospital Outcomes

The course was favorable in more than half of the cases (58.1%). In-hospital complications of ACS occurred in 41.9% of patients: arrhythmias (61.5%), mostly ventricular, followed by conduction disorders (30.8%) and LV failure (30.8%). Dakpo [8] found a similar proportion of complications (46.3% vs 76.2% in older patients), with a predominance of conduction disorders (24.4%), followed by arrhythmias (19.5%) and heart failure (12.2%), but in lower proportions than ours. Overall, the literature reports a low rate of complications: 27% in Morocco in 2010 [30], 30% in Mali in 2014 [18] and 14% in India in 2016 [22]. The mean length of hospital stay was 8.38 ± 3.97 days (range, 2–19 days), comparable to that reported by Dakpo [8] (10.9 ± 4.5 days; range, 1–23 days). This is consistent with the relatively low rate of in-hospital complications, which sometimes prolong hospitalization.

We recorded one death (3.2%; 95% CI, 0.1–16.7, i.e., an imprecise estimate based on a single event). Dakpo [8] found a similar mortality rate (2.4%), compared with 12.3% in older patients. Mortality was 7.14% (1/14) in the series of Yam égo et al. [19] in Senegal in 2010, and Coulibaly et al. [18] in Mali in 2014 reported no deaths. These data are consistent with the literature, which indicates that the short-term prognosis is most often very favorable in young patients and that in-hospital complications are rare. In contrast, the long-term prognosis is much less favorable [3, 37, 40]. In a long-term follow-up of patients aged 40 years or younger with MI, a reduced LVEF (≤ 45%) and peripheral arterial disease were the strongest independent predictors of mortality [41].

4.5. Strengths and Limitations of the Study

The prospective design avoided the problems related to the conservation of medical records and the availability of all the information sought. Systematic recruitment of cases over 32 months, with a participation rate of 100%, made it possible to identify all patients aged 50 years or younger with ACS admitted to the CUC during the study period.

Our study also has several limitations. First, it was conducted in a single center and included only 31 patients, which limits the precision of the estimates and the generalizability of the findings. As a university referral hospital, the CUC probably receives a selected population (including more severe cases and patients able to reach a tertiary center), which further limits generalizability to other settings in Benin and sub-Saharan Africa. The percentages reported are hospital-based proportions without population denominators, so no inference on incidence or temporal trends can be drawn. Second, coronary angiography, the gold standard for confirming an atherosclerotic origin, is not available in Benin and depends on the personal financial means of the patients; only five patients underwent it, so the atherosclerotic origin of ACS rests mainly on a probability score developed by our team and not externally validated; moreover, this score assigns 3 points to atherogenic dyslipidemia alone, which equals its positivity threshold, so that its high yield largely reflects the frequency of dyslipidemia. The patients who underwent angiography were those able to pay for it, which introduces a selection bias. Third, the search for non-atherosclerotic causes was limited, as the thrombophilia work-up, also paid for by the patients, could be performed in only nine patients. Fourth, SCORE2 was developed for primary prevention in people aged 40–69 years without established cardiovascular disease and has not been recalibrated for Benin; the LDL cholesterol thresholds derived from it therefore describe the pre-event risk profile and not the post-ACS risk category, which may have over- or underestimated the frequency of dyslipidemia (the number of patients above the single threshold of 0.55 g/L was not available). Fifth, the indication and the success of thrombolysis were judged on clinical and electrocardiographic criteria in a very small number of patients, and the delay between symptom onset and thrombolysis was not recorded. Sixth, troponin positivity was defined with the URL of our laboratory (14 ng/L) and, for NSTEMI, a threshold of twice the URL, rather than with the 99th percentile of the Fourth Universal Definition, which may have led to some misclassification between NSTEMI and unstable angina. Finally, the outcomes were limited to the hospital stay, so long-term prognosis could not be assessed. Larger, multicenter studies with systematic coronary angiography and longer follow-up are needed to confirm these results.

5. Conclusions

Acute coronary syndromes are increasingly reported in sub-Saharan Africa. In this single-center descriptive series, patients aged 50 years or younger accounted for 31.6% of ACS admissions at the CUC, with a marked male predominance, a

very high frequency of dyslipidemia (96.8%) and an in-hospital mortality of 3.2% (one death). These findings, which do not allow conclusions on incidence or trends, call for earlier management of modifiable cardiovascular risk factors, notably dyslipidemia and obesity.

Moreover, the late admission of most patients (58.1% more than 12 hours after symptom onset), the limited use of thrombolysis (22.6%) and the lack of access to coronary angiography in Benin suggest that better identification of ACS by all health care structures, faster transfer and early myocardial revascularization are needed. Raising public awareness, controlling cardiovascular risk factors, training health care staff, and improving the interventional cardiology facilities and access to care should reduce the incidence of this condition and improve its prognosis. Larger multicenter studies with systematic coronary angiography and long-term follow-up are needed to better understand this disease in young patients.

Abbreviations

ABI	Ankle-brachial Index
ACS	Acute Coronary Syndrome
AF	Atrial Fibrillation
AV	Atrioventricular
BMI	Body Mass Index
CI	Confidence Interval
CIMT	Carotid Intima-media Thickness
CNHU-HKM	Hubert Koutoukou Maga National University Hospital Center
CUC	University Clinic of Cardiology
DES	Drug-eluting Stent
ECG	Electrocardiogram
ESC	European Society of Cardiology
HDL	High-density Lipoprotein
hs-cTnI	High-sensitivity Cardiac Troponin I
ICD	Implantable Cardioverter-defibrillator
LDL	Low-density Lipoprotein
LV	Left Ventricular
LVEF	Left Ventricular Ejection Fraction
LVH	Left Ventricular Hypertrophy
MI	Myocardial Infarction
NSTE-ACS	Non–ST-elevation Acute Coronary Syndrome
NSTEMI	Non–ST-elevation Myocardial Infarction
PAC	Premature Atrial Contraction
PCI	Percutaneous Coronary Intervention
PROCAM	Prospective Cardiovascular Münster
PVC	Premature Ventricular Contraction
SCORE2	Systematic COronary Risk Evaluation 2
SD	Standard Deviation
STE-ACS	ST-elevation Acute Coronary Syndrome
STEMI	ST-elevation Myocardial Infarction
URL	Upper Reference Limit
VT	Ventricular Tachycardia
VTE	Venous Thromboembolism
WHO	World Health Organization

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Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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