

Epidemiology and outcomes of myocardial infarction in young adults in Morocco

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Abstract. Ischemic heart disease remains a major global health burden, with ST-segment elevation myocardial infarction (STEMI) representing its most severe form. While incidence has declined in developed countries, concerning trends persist among young adults, particularly in low- and middle-income nations such as Morocco. This retrospective single-center study was conducted at Ibn Sina University Hospital, Morocco's largest cardiology referral facility, to characterize the epidemiological profile, clinical features, management, and in-hospital outcomes of young STEMI patients. We included 62 consecutive patients aged ≤ 45 years admitted between January 2023 and December 2024, diagnosed according to ESC criteria. Data on demographics, cardiovascular risk factors, angiographic findings, treatment strategies, and complications were collected and analyzed. We found that young adults represented 10.2% of all STEMI admissions, with a mean age of 41.2 ± 4.6 years and a strong male predominance (77.4%). Smoking was the most common risk factor. Typical chest pain was the main presenting symptom (90.3%). Coronary angiography revealed predominantly single-vessel disease (85.7%), most often involving the LAD (67.7%). These findings highlight the critical need for enhanced prevention strategies targeting modifiable risks in young populations and optimized care pathways to improve outcomes in the Moroccan healthcare context.

1. Introduction

Cardiovascular diseases (CVDs) are the leading cause of global mortality and morbidity among non-communicable diseases (NCDs). According to World Health Organization (WHO) data, CVDs were responsible for an estimated 17.9 million deaths in 2019, accounting for approximately 32% of all-cause mortality globally. A striking disparity is evident in the geographic distribution, with low- and middle-income countries (LMICs) bearing a disproportionate burden of over 75% of these deaths.

Myocardial infarction (MI) occurring in adults under 45 years of age presents a unique set of clinical and public health challenges. This patient group exhibits distinct pathophysiological mechanisms, prognostic outcomes, and socio-economic impacts compared to older populations [1]. While the overall incidence of MI has declined in older populations thanks to advances in prevention and management, a concerning upward trend is being observed among younger adults, especially in developing countries [2].

International studies estimate that 5 to 10% of all MIs occur before the age of 45, with a marked male predominance and a strong association with modifiable risk factors such as smoking, dyslipidemia, and metabolic syndrome [3]. Unlike older patients, who typically present with multivessel atherosclerotic disease, young adults more frequently have localized coronary lesions, sometimes in otherwise healthy arteries. This suggests the involvement of alternative

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mechanisms like spontaneous coronary artery dissection, coronary spasms, or thrombosis on vulnerable plaques

In Morocco, data on MI in the young remains limited, despite a rapid epidemiological transition that has established CVDs as the primary cause of mortality. The 2018 STEPS survey on NCD risk factors revealed that 94.3% of Moroccans aged 18 to 69 have at least one NCD risk factor, and the prevalence of high cardiovascular risk is 4.9%. A recent Moroccan study highlighted an alarming prevalence of smoking and dyslipidemia among young MI patients, underscoring the urgent need for targeted prevention strategies [4]. This situation is exacerbated by low public awareness of these risks and frequent delays by patients in recognizing the clinical signs of an MI, leading to critical treatment delays. Furthermore, diagnosis in young adults is often complex due to the potential for atypical clinical presentations, which can hinder the timely identification and management of acute coronary syndrome [5].

Although previous Moroccan studies, such as the FES-AMI [4] and MR-MI registries [5], have described the overall burden of acute coronary syndromes, none have specifically focused on young adults (≤ 45 years) with STEMI. International studies have highlighted unique risk profiles in this population, but local data remain scarce. This study is the first to provide a comprehensive characterization of young STEMI patients at a tertiary referral center in Morocco, offering new insights into their epidemiological profile, risk factors, angiographic patterns, management strategies, and short-term outcomes. These findings allow both comparison with international cohorts and identification of context-specific prevention needs.

This study aims to characterize the epidemiological, clinical, and prognostic profile of young adults (≤ 45 years) admitted with STEMI at Ibn Sina University Hospital, in order to fill the gap in local data and to allow comparison with international registries.

2. Materials and Methods

2.1 Study design and population

We performed a retrospective, descriptive analysis at the Cardiology Department of Ibn Sina University Hospital, Rabat. The study cohort comprised all consecutive patients aged ≤ 45 years admitted with a diagnosis of ST-segment elevation myocardial infarction (STEMI) from January 2023 to December 2024. STEMI diagnosis was confirmed based on established European Society of Cardiology guidelines, which mandate persistent ST-segment elevation of ≥ 1 mm in two or more adjacent electrocardiogram leads, alongside elevated cardiac troponin levels.

Exclusion criteria comprised non-ST-segment elevation acute coronary syndromes (NSTEMI-ACS), non-coronary causes of troponin elevation, and medical records with insufficient data for reliable analysis. This rigorous selection process aimed to ensure a homogeneous study population focused on the well-defined clinical entity of STEMI in young adults.

2.2 Data collection

Data were extracted from patient medical records using a standardized, pre-established data collection form. This form was designed to systematically gather information across several categories:

- **Sociodemographic characteristics:** age, gender
- **Medical history:** personal and family history.
- **Cardiovascular risk factors:** traditional and emerging.
- **Paraclinical data:** biological parameters, echocardiography results, angiographic findings.
- **Management and outcomes:** therapeutic strategies employed and in-hospital clinical course.

2.3 Ethical consideration

The study protocol received prior approval from the administration of Ibn Sina University Hospital. Patient confidentiality was strictly maintained through the systematic anonymization of all records. Our methodology adhered to international ethical principles, notably those set forth in the Declaration of Helsinki.

2.4 Statistical analysis

Statistical analysis was performed using JAMOVI (version 2. 6. 45). Categorical variables were expressed as counts and percentages (n, %). Continuous variables were described using means and standard deviations. The results are presented in tables and graphs for optimal clarity and interpretation.

2.5 Limitations

The retrospective and single-center nature of this study may limit the generalizability of our findings. As a tertiary referral hospital, our patient population may not fully represent all young STEMI cases in Morocco, particularly those managed in peripheral hospitals. Furthermore, the retrospective design introduces the possibility of incomplete data and selection bias. These limitations should be considered when interpreting our results.

3. Results

3.1 Sociodemographic Characteristics and Cardiovascular Risk Factors

The study included a total of 62 young patients (≤ 45 years) were admitted for ST-segment elevation myocardial infarction. Among the 609 patients hospitalized for MI during the study period, the frequency of young patients in our cohort was 10.18%.

The mean age of the study population was 41.2 ± 4.6 years, with no significant difference between sexes. Regarding the timing of admissions, 37.1% of cases (n=23) were recorded in 2023, compared to 62.9% (n=39) in 2024. Tobacco use was the most frequently observed risk factor, identified in 64.5% of patients, followed by diabetes and cannabis use (Table 1). Other factors such as dyslipidemia and hypertension were less frequent.

The proportion of young STEMI cases in our cohort is comparable to international data, with similar frequencies reported in France (11.2%) and Saudi Arabia (11.6%). The high prevalence of smoking aligns with global findings, while the relatively frequent cannabis use is a notable feature in the Moroccan context

Table1: Sociodemographic characteristics and cardiovascular risk factors

Smoking was the most frequent risk factor (62.9%), followed by diabetes and cannabis use.

Characteristics	% (n)
Sex	
Male	77% (48)
Female	23% (14)
Alcohol	
No	90.3% (56)
Yes	9.7% (6)
Tobacco	
No	35.5% (23)
Yes	64.5% (40)
Cannabis	
No	72.6% (45)
Yes	27.4% (17)
Obesity	
No	90.3 % (56)
Yes	9.7% (6)
Diabetes	
No	44 (71%)
Yes	18 (29%)
HBP	
No	51 (51)
Yes	9 (9)
Coronary heredity	

No	91.9% (57)
Yes	8.1% (5)
Systemic disease	
No	93.5% (58)
Yes	6.5% (4)
Thromboembolic disease	
No	93.5%
Yes	6.5 %

3.2 Clinical Characteristics at Admission

On admission, the majority of patients presented with typical chest pain (90.3%, n=56), most often occurring at rest and of moderate intensity (Table 2). For nearly two-thirds, this was the first episode of ischemic symptoms. Clinical examination generally showed stable vital signs, although tachycardia was relatively common, and a minority of patients presented with oxygen desaturation.

These findings are consistent with international cohorts, where chest pain remains the predominant symptom in young STEMI patients, though atypical presentations still occur and may contribute to diagnostic delays.

Table 2: Clinical characteristics at the time of admission

Most patients presented with typical chest pain, predominantly of moderate intensity and occurring at rest.

Characteristics	% (n)
Type of pain	
Typical	90.3% (56)
Atypical	9.7% (6)
Intensity of the pain	
Mild	1.61% (1)
Moderate	70.96% (44)
Intense	27.43% (17)
Circumstance of occurrence	
At rest	67.7% (42)
During exertion	25.8% (16)
Inaugural	62.6% (39)
Blood pressure	
Normal	75.80% (47)
High blood pressure	12.90% (8)
Hypotensive	11.29% (7)
Heart rate	
Normal	62,92 % (39)
Bradycardia	4,83 % (3)
Tachycardia	32,25 % (20)
Respiratory rate	
Normal	90,32 % (56)

Tachypnea	9,67% (6)
Bradypnea	0
SpO₂ (O₂ saturation)	
Normal	88,70 % (55)
Desaturation	11,30 % (7)

3.3 Paraclinical and Angiographic Characteristics

Electrocardiographic analysis showed that the anterior and inferior walls were the most frequent infarct locations, followed by anteroseptal-apical and lateral territories (Table 3). Angiographic findings showed a predominance of single-vessel disease, most often involving the left anterior descending artery. A small proportion of patients had multi-vessel disease, while a minority presented with angiographically normal coronary arteries. This angiographic profile is consistent with reports from young STEMI cohorts internationally, where limited coronary involvement and LAD predominance are common. The finding of normal coronary arteries in nearly 10% of patients highlights the role of alternative mechanisms such as coronary spasm, dissection, or microvascular dysfunction in this age group.

Table 3: Paraclinical and angiographic characteristics

Single-vessel disease was predominant (85.7%), most commonly affecting the left anterior descending artery.

Caractéristiques	% (n)
ST-segment elevation	100 % (62)
Necrosis Q wave	33% (21)
Infarct territory	
Anterior	33,87 % (21)
Inferior	30,64 % (19)
ASA (antero-septal apical)	27,41 % (17)
Lateral	27,41 % (17)
Basal	17,74 % (11)
Right	0 %
Number of affected arteries	
Single-vessel disease (1 artery)	85,71 % (48)
Two-vessel disease (2 arteries)	10,71 % (6)
Three-vessel disease (3 arteries)	3,57 % (2)
Culprit artery	
LAD (left anterior descending)	67,7 % (42)
Right coronary artery	22,6 % (14)
Circumflex artery	16,1 % (10)
Normal coronary angiography	9,7 % (6)

3.4 Therapeutic Strategy, Outcomes, and Patient Prognosis

The cornerstone of management was revascularization. The majority of patients (66.0%, n=35) underwent percutaneous coronary intervention (PCI) with balloon angioplasty and the placement of at least one stent. In contrast, a smaller proportion (8.0%, n=4) received surgical revascularization via coronary artery bypass grafting (CABG).

For patients who did not undergo invasive revascularization, pharmacological therapy with thrombolysis was the chosen strategy (26.0%, n=14). It should be noted that the revascularization strategy was not specified for 9 patients. (figure 1)

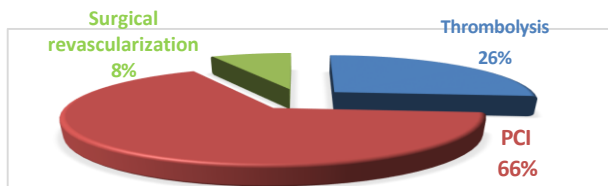


Figure 1: Revascularization strategy.

Percutaneous coronary intervention (66%) was the preferred approach, while thrombolysis remained used in about one quarter of cases.

3.5 In-Hospital Outcomes and Prognosis

During hospitalization, complications arose in 29.0% (n=18) of patients, while the clinical course was favorable for the majority (70.97%).

Specifically, 22.58% of STEMI cases (n=14) were complicated by left ventricular failure, and cardiogenic shock was observed in 9.68% of patients (n=6). Conduction disorders were noted in 4.84% of cases (n=3), and one death was reported. (figure 2)

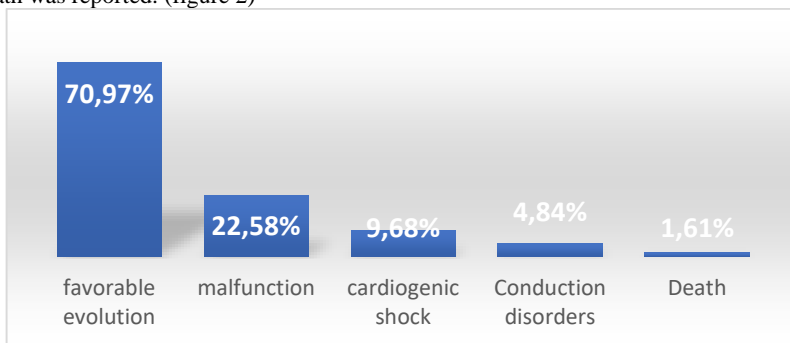


Figure 2: Evolution of patients during hospitalization

Although 71% of patients had a favorable outcome, nearly one third developed complications, mainly left ventricular failure and cardiogenic shock.

At discharge, the most frequently prescribed medications were aspirin, clopidogrel, and statins, with respective prescription rates of 88.7%, 80.6%, and 51.6%. These were followed by beta-blockers, proton pump inhibitors (PPIs), aldosterone antagonists, and antidiabetic drugs (ADOs), with respective rates of 32.3%, 30.6%, 17.7%, and 17.7%. Other medications, such as ACE inhibitors, diuretics, and anticoagulants, were less commonly prescribed, with rates of 6.5% or lower. (table 4)

Table 4: Discharge treatment

Aspirin, clopidogrel, and statins were the most frequently prescribed drugs, reflecting adherence to international recommendations.

Traitement	%
Aspirin	88,70%
Clopidogrel	80,64%
Statin	51,61%
Beta-blockers	32,25%
PPI (proton pump inhibitors)	30,94%
Aldosterone antagonist	17,74%
oral antidiabetics	17,74%
Diuretic	6,45%
Anticoagulant	6,45%
ACE inhibitors	6,45%

4. Discussion

This study characterized a cohort of 62 patients aged ≤ 45 years admitted with ST-segment elevation myocardial infarction (STEMI) in Morocco. Among 609 total MI admissions during this period, the proportion of young patients was 10.18%, a prevalence consistent with international reports. Similar frequencies have been documented across diverse populations, 11% in an Algerian study including men ≤ 45 and women ≤ 55 years [6], 11.2% in a French young MI registry, and 11.6% in a Saudi Arabian series [7].

The demographic profile observed in our population corresponds to trends commonly reported in international studies on young STEMI, with an average age of 41 years, comparable to the 38–40 years range described elsewhere. A marked male predominance was observed (sex ratio: 3.4:1), reinforcing a well-documented epidemiological characteristic of young-onset MI. This finding corresponds with both international literature reporting typical sex ratios of 3:1 to 4:1, and previous national research, including a Moroccan study that documented 79.6% male representation [8]. The consistent underrepresentation of women (22.6%) in our cohort; 25% in is principally explained by two factors, the cardioprotective effects of estrogen in premenopausal women and the higher prevalence of modifiable risk factors, particularly smoking, among young men [9].

Tobacco use was the most frequent cardiovascular risk factor identified, affecting nearly two-thirds of the cohort. Its harmful influence on young individuals is widely recognized in international research. The prospective Australian study by [10], demonstrated that current smokers have a 2.45-fold higher risk of MI and a 2.79-fold higher MI-related mortality compared to non-smokers. This magnitude of association is consistent with findings from the major international INTERHEART study, conducted across 52 countries, which reported an odds ratio of 2.95 (95% CI 2.77–3.14) for non-fatal MI among active smokers [11]. An encouraging aspect of the tobacco-MI relationship is the rapid reversibility of excess cardiovascular risk upon cessation. A significant reduction in the incidence of acute MI and stroke has been consistently observed within the first year of smoking abstinence.

The notable prevalence of cannabis use (24.2%) warrants particular attention, given its increasingly implicated role in triggering acute coronary syndromes in the young via mechanisms such as coronary artery spasm and thrombogenesis [5].

Regarding traditional metabolic risk factors, our study revealed a relatively moderate prevalence of diabetes (29.0%) and hypertension (14.5%) compared to older populations, a pattern consistently reported in this age group. However, this diabetic prevalence appears to be increasing in recent studies, as illustrated by the Saudi series [7] which reported a prevalence of 46.7% among young patients with acute coronary syndrome. This suggests a concerning epidemiological transition in developing countries, potentially linked to lifestyle changes and accelerated urbanization in recent decades.

In our series, the majority of patients presented with typical chest pain (90.3%), consistent with literature identifying constrictive retrosternal pain as the cardinal symptom of acute coronary syndrome [12]. However, a non-negligible proportion (9.7%) presented with atypical pain, underscoring the importance of maintaining vigilance in differential diagnosis, particularly among women and older subjects where

presentations can be misleading [13]. Regarding pain intensity, our study revealed a predominance of moderate pain (71.0%), followed by severe pain (27.4%). These findings align with the work of [14], who emphasize that initial pain intensity is not solely correlated with the severity of coronary lesions but may influence time to presentation and thus prognosis.

Coronary angiography revealed a predominance of single-vessel disease (85.7%), with the left anterior descending artery (LAD) being the most frequent culprit vessel (67.7%). The predominance of single-vessel disease in our young cohort, as opposed to the more diffuse atherosclerosis seen in older adults, suggests the involvement of alternative processes. These may include the rupture of a single vulnerable plaque, coronary vasospasm, or spontaneous arterial dissection [15]. The presence of angiographically normal coronary arteries in 9.7% of patients is a notable finding. This necessitates consideration of non-atherosclerotic etiologies such as coronary microvascular dysfunction, emboli, vasculitis, or coagulopathies, which may be more prevalent in this age group.

Our study demonstrated that the revascularization strategy primarily relied on primary percutaneous coronary intervention (PCI) (66.0%), in accordance with current international guidelines that favor this approach as the gold standard for STEMI management [12]. The reliance on thrombolysis in 26.0% of cases likely stems from organizational barriers, such as delays in accessing timely catheterization and the initial management of patients at non-PCI-capable facilities.

The in-hospital complication rate was significant (29.0%), dominated by left ventricular failure (22.6%) and cardiogenic shock (9.7%), confirming that MI in young adults remains a potentially severe pathology despite the absence of multiple comorbidities. The relatively low mortality rate (1.6%) corroborates data from large international series reporting a better prognosis in young patients compared to older populations, likely due to greater cardiac reserve and fewer comorbidities. This observation is consistent with US registry data showing lower in-hospital mortality among young adults hospitalized for MI [1].

Beyond the clinical characterization of young STEMI patients, our findings carry important public health implications. The overwhelming prevalence of smoking and the significant rate of cannabis use underscore the urgent need for prevention programs specifically targeting youth. National anti-tobacco campaigns should be reinforced with a stronger focus on young adults, while awareness campaigns on the cardiovascular risks of cannabis use—often underestimated—are equally necessary. In addition, the frequent delays in presentation and the reliance on thrombolysis in a quarter of cases highlight systemic gaps in prehospital organization and access to catheterization facilities. Improving emergency networks and strengthening referral pathways are essential to ensure equitable access to timely reperfusion therapy across Morocco.

4.1 Study Limitations

Several limitations must be acknowledged. First, the retrospective design is subject to potential biases related to data completeness and accuracy. Second, as a single-center study conducted at a national referral hospital, the population studied may not reflect the full spectrum of young STEMI patients across Morocco, particularly those treated in non-tertiary settings. These factors may limit the external validity of our findings. Nevertheless, the study provides valuable insights as it represents the first comprehensive description of this population in a Moroccan tertiary care context.

5. Conclusion

This study offers the first dedicated characterization of young STEMI patients in Morocco, based on data from the nation's primary cardiology referral center. Our findings reaffirm a significant male preponderance and identify smoking and cannabis use as the predominant modifiable risk factors in this demographic. While mortality was low, the substantial rate of in-hospital complications underscores the critical importance of improving both early diagnosis and acute care protocols. The value of this research is in delivering context-specific data on a neglected patient group within the national landscape. The evidence points to three key imperatives: implementing robust youth-focused prevention campaigns against smoking and substance use; enhancing public awareness to shorten patient delay; and fortifying emergency cardiac care networks to ensure rapid access to reperfusion therapy. Pursuing these objectives is essential to mitigating the impact of premature cardiovascular disease in Morocco.

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