Original Article

Understanding Acute Myocarditis in Colombia: Clinical, Imaging, and Etiological Perspectives from a Colombian Multicenter Study

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Abstract

Background: **Acute myocarditis (AM) exhibits heterogeneous clinical presentations, diverse etiologies, and variable outcomes. In Latin America, particularly Colombia, data remain limited regarding multimodal imaging and etiological evaluation.**

Objectives: **To characterize the clinical, imaging, and etiological features of AM in a Colombian multicenter cohort.**

Methods: **We conducted a descriptive cross-sectional study including adults diagnosed with AM at two referral centers in Bogotá, Colombia, between January 2013 and June 2024. Cases identified through ICD-10 codes were included if they met European Society of Cardiology criteria for suspected or confirmed myocarditis. Clinical, laboratory, electrocardiographic, echocardiographic, and cardiac magnetic resonance (CMR) data were extracted, and in-hospital outcomes were assessed. A p-value < 0.05 was considered statistically significant.**

Results: **A total of 205 patients were included (72.1% male; median age 38 years, IQR 29–53). The most common comorbidities were hypertension (19.5%), active smoking (15.6%), and obesity (15.6%). Chest pain was the predominant presenting symptom (84.9%), followed by dyspnea (37.6%). CMR was performed in 47.8% of patients, with subepicardial or midwall late gadolinium enhancement in 78.6% of those evaluated. An etiological diagnosis was established in 28.8% of cases, most commonly related to SARS-CoV-2 infection and Chagas disease. In-hospital complications included pericarditis (28.8%), acute heart failure (15.1%), and fulminant myocarditis (4.9%). The in-hospital mortality rate was 5.39%.**

Conclusions: **In this Colombian cohort, AM showed clinical characteristics comparable to global reports, but access to advanced imaging and etiologic testing was limited. Complication and mortality rates remain substantial, underscoring the importance of improving diagnostic workflows and early risk stratification.**

Keywords: **Myocarditis; Magnetic Resonance Imaging; Cardiomyopathies; Epidemiology; Prognosis.**

Introduction

Acute myocarditis (AM) is an inflammatory disease of the myocardium with diverse infectious and non-infectious etiologies, a heterogeneous clinical presentation, and an evolution ranging from mild to fulminant forms.[1] Its epidemiological characterization remains challenging due to the variability of clinical manifestations and the absence of a universally accepted definition for a confirmed case.[1]

To address these limitations, the European Society of Cardiology (ESC) introduced the concept of suspected clinical myocarditis (SCM), enabling a syndromic diagnostic approach. Additionally, the incorporation of cardiac magnetic resonance (CMR) as an alternative confirmatory tool to endomyocardial biopsy (EMB) has significantly improved diagnostic accuracy and disease characterization.[2,3]

Globally, AM predominantly affects young adults, particularly men, with incidence peaking between 35 and 39 years.[4] Mortality increases with age and comorbidities, with rates of up to 1 death per 17–19 cases in individuals aged 80–84 years.[4]

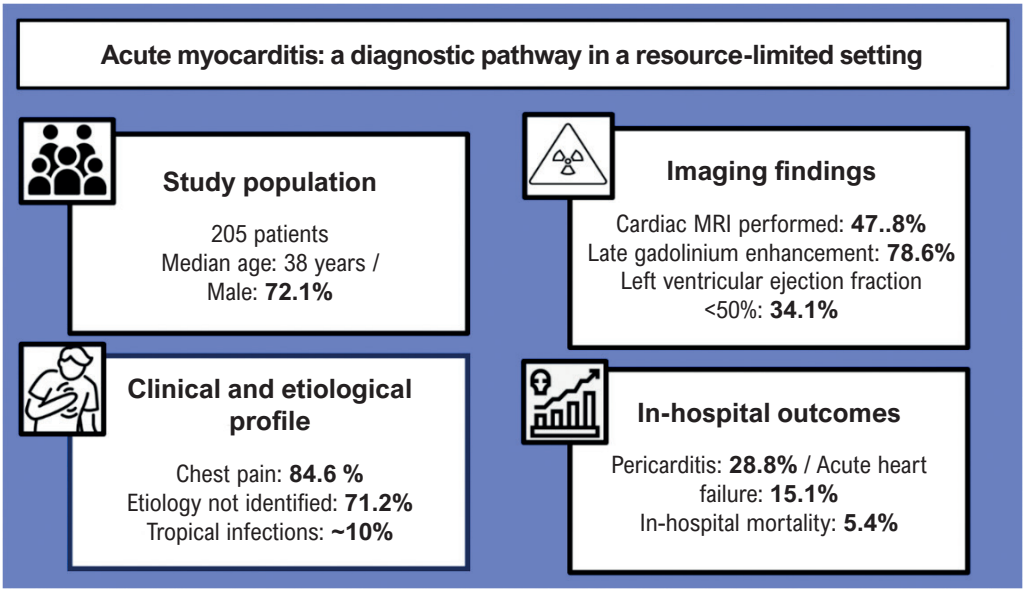
In Latin America, however, epidemiological data on AM are limited. Geographic diversity, climatic variations, altitude, and vector distribution contribute to a heterogeneous etiological profile, even within the same country.[5,6] Endemic conditions such as Chagas disease, dengue, malaria, and leptospirosis represent important etiologies in this region.[7,8] More recently, AM associated with SARS-CoV-2 infection and post-vaccination events has modified the local epidemiological landscape.[9]

Despite this diversity, the clinical behavior and outcomes of AM in Latin America remain poorly characterized. Existing

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Central Illustration: Understanding Acute Myocarditis in Colombia: Clinical, Imaging, and Etiological Perspectives from a Colombian Multicenter Study



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Main results of acute myocarditis in a Colombian multicenter.

studies are limited by small sample sizes and single-center designs, complicating efforts to generate robust conclusions about disease evolution and prognosis.

To address this gap, we conducted a descriptive study evaluating the clinical presentation, etiological profile, and outcomes of AM in two tertiary referral centers in Bogotá, Colombia, which receive patients from multiple regions of the country. To our knowledge, this represents the largest descriptive cohort of AM reported in Latin America and provides key data to better understand its behavior in this region.

Methods

This cross-sectional study included patients ≥18 years who were hospitalized with a diagnosis of AM between January 2013 and June 2024. Potential cases were identified through ICD-10 codes related to AM and its subcategories (I400, I401, I408, I409, I41, I410, I411, I412, I418, I514). Medical records were reviewed, and only patients who met the ESC criteria for SCM were included. Differential diagnoses were excluded through an exhaustive clinical evaluation performed by the cardiologists participating in the study, ensuring that all included cases met the syndromic definition of AM and that only patients whose overall clinical, laboratory, and imaging findings were considered highly compatible with AM were included in the final cohort. Cases in which an alternative diagnosis was considered more likely after clinical review were excluded from the analysis. The exclusion of significant coronary artery disease was performed according to the clinical judgment of the treating physicians, considering patient age, cardiovascular risk profile, clinical presentation, and electrocardiographic and imaging findings. In patients with low pretest probability of coronary artery disease, invasive coronary angiography was not systematically performed. Attribution of SARS-CoV-2 infection as the probable etiological agent was based on a combination of clinical and laboratory criteria, including: (1) confirmed SARS-CoV-2 infection by PCR or antigen testing, (2) compatible clinical manifestations of infection with a temporal relationship between the infectious episode and the onset of cardiac symptoms, and (3) the absence of an alternative identifiable cause of myocarditis after clinical and imaging evaluation.

Statistical analysis

Clinical, laboratory, electrocardiographic, and imaging variables were extracted from electronic medical records using a standardized data collection instrument, and a database was created differentiating continuous and categorical variables before analysis. Continuous variables were summarized using measures of central tendency and dispersion: normally distributed variables were reported as mean and standard deviation, whereas non-normally distributed variables were reported as median and interquartile range. Normality of continuous variables was assessed using the Shapiro–Wilk test. Categorical variables were expressed as absolute and relative frequencies.

Exploratory univariable analyses were performed to evaluate potential associations between clinical variables and in-hospital mortality, with a hypothesis-generating purpose.

Pearson's chi-square test was used for independence testing. Confidence intervals and multivariable modeling were not reported due to the very low number of in-hospital deaths, which precluded the construction of reliable estimates and was consistent with the descriptive—not inferential—objective of the analysis. For each categorical variable, contingency tables with absolute and relative mortality frequencies were constructed. Age was categorized into <65 and ≥65 years. A p-value <0.05 was considered statistically significant. All statistical analyses were performed independently by the investigators using STATA version 14 under a licensed version owned by the author.

The study protocol was approved by the institutional ethics committees of both participating centers and complied with the principles of the Declaration of Helsinki.

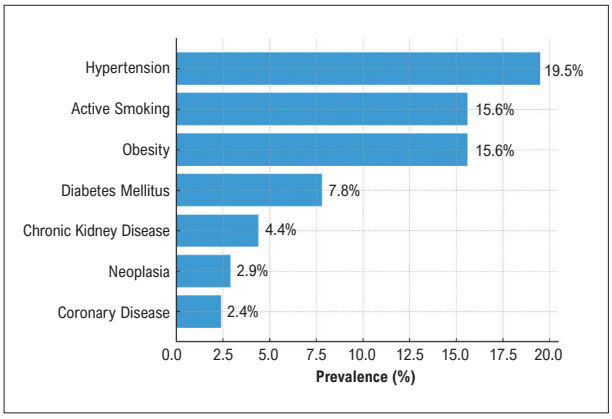


Figure 1 – *Distribution of the most prevalent cardiovascular risk factors in the study population.*

Results

During the study period, 205 patients diagnosed with AM who met the inclusion criteria were included. Most patients were male (72.1%), and the median age was 38 years (IQR: 29–53). The most prevalent comorbidities were hypertension, smoking, and obesity (Figure 1).

The most common clinical presentation was chest pain, followed by dyspnea, upper respiratory symptoms, and fever. Syncope and sudden cardiac death as the initial presentation were uncommon. Laboratory abnormalities included elevated high-sensitivity troponin, C-reactive protein, and leukocytosis. High-risk arrhythmias included ventricular fibrillation, ventricular tachycardia, and atrial fibrillation, while no cases of advanced atrioventricular block were recorded (Table 1).

All patients underwent transthoracic echocardiography. Left ventricular ejection fraction <50% was observed in approximately one-third of cases, and right ventricular dysfunction was less frequent. Pericardial effusion was present in a minority of patients, with no cases of cardiac tamponade. CMR was performed in nearly half of patients and demonstrated late gadolinium enhancement in 78.6% and myocardial edema in 67.3% of those evaluated. Coronary angiography was performed in a subset of patients and identified obstructive coronary disease in only one case (Table 2).

A specific etiology could not be determined in 71.2% of patients. Among cases with an identified cause, SARS-CoV-2 infection accounted for 10.2% and Chagas disease for 3.9% (Figure 2).

The most common in-hospital complications were acute pericarditis, acute heart failure, and fulminant myocarditis (Figure 3). In-hospital mortality was 5.39%. All deaths occurred during the index hospitalization and were related to complications of AM, including cardiogenic shock, malignant ventricular arrhythmias, and hypoxemic respiratory failure. In exploratory univariable analyses, fulminant myocarditis, life-threatening arrhythmias, and age ≥65 years were associated with in-hospital mortality (Table 3).

The median length of hospitalization was 5 days (IQR: 5–9), and the median ICU stay was 3 days (IQR: 0–4). The annual distribution of cases is shown in Figure 4, and a summary of the main findings is presented in the Central Illustration.

Discussion

According to recently published evidence, the incidence of AM has increased by 1.6-fold compared to data from the 1990s, with Asia, Western Europe, and the United States being the most affected regions. In Latin America, the estimated incidence ranges between 14 and 15 cases per 100,000 person-years.[10] However, robust epidemiological data remain limited, and most publications describe small single-center cohorts. The largest cohort to date, from the *Instituto Nacional de Cardiología Ignacio Chávez* in Mexico City, included 49 patients over a decade; however, during that period CMR was not available for diagnostic confirmation, and only one case underwent EMB.[11]

This study compiled 205 cases of patients who met the ESC criteria for clinically suspected myocarditis or who had a diagnosis confirmed by CMR. Cases were identified over 11 years in two referral centers in Bogotá, Colombia, which receive patients from various regions of the country. To ensure appropriate exclusion of differential diagnoses, a detailed clinical and imaging review was performed by the research team. However, reliance on ICD-10 coding for case identification and the relatively low use of confirmatory tools such as CMR and EMB may have limited our ability to fully exclude mimicking conditions, potentially affecting the precision of clinical and etiological characterization. In addition, the study period encompassed the COVID-19 pandemic, which may have influenced both the incidence and etiological distribution of AM in our population.

AM affects individuals across a wide age spectrum; however, it is more frequently observed in young adults, with a clear male predominance. In our cohort, 72.1% of AM cases occurred in men, mainly in the fourth decade of life, resulting in a male-to-female ratio of 2.5:1. These demographic characteristics are similar to those reported in major international registries.[12,13] This pattern is consistent with the low prevalence of traditional cardiovascular comorbidities in this clinical population. Nonetheless, a larger sample size is

needed to explore potential associations between factors such as smoking and obesity in young adults, and their potential contribution to the development of this condition.

The clinical spectrum of AM is broad, ranging from subclinical forms to fulminant presentations with cardiogenic shock secondary to uni- or biventricular dysfunction, and may even be identified incidentally in autopsies of patients with sudden cardiac death.[14,15] In our cohort, the most frequent symptom was chest pain (84.9%), which was typically nonspecific and often clinically indistinguishable from an acute coronary syndrome (ACS), prompting coronary angiography in 72 patients (38.2%). Only one angiographic study revealed a significant coronary lesion, which did not require percutaneous intervention, supporting the importance of considering AM within the differential diagnosis of ACS-like presentations in young patients. A history of respiratory or gastrointestinal symptoms was documented in approximately half of the cases, a lower proportion compared with the >80% reported in the European registry by Ammirati et al. Syncope and acute heart failure were among the least frequent initial manifestations, a finding that aligns with previous reports showing an incidence between 6% and 22%.[13]

Despite advances in cardiovascular imaging and molecular biology, AM remains a diagnostic challenge due to its heterogeneous clinical presentation and the limited availability of confirmatory tools.[16] Although EMB is considered the gold standard, its use is now restricted to selected scenarios given its limited availability, technical complexity, and risk of complications, particularly in low-volume centers.[17,18] In our cohort, only two patients underwent EMB, and neither yielded a definitive etiological diagnosis.

Multimodal cardiac imaging has largely replaced the need for routine EMB. Echocardiography and CMR are now central to the diagnostic approach.[19] CMR enables noninvasive tissue characterization, improving the ability to confirm AM and exclude differential diagnoses with acceptable diagnostic accuracy.[20] However, in our cohort, only 98 patients (47.8%) underwent CMR, reflecting important limitations in diagnostic availability during the study period.

There is increasing recognition of the value of establishing a specific etiological diagnosis in AM to guide targeted therapy, exclude infections that contraindicate immunosuppression, identify entities with disease-specific treatment, and define

Table 1 – Baseline clinical, laboratory, and electrocardiographic characteristics of the study population (N = 205)

Clinical Manifestation	n	Prevalence (%)
Chest Pain	174	84.9
Dyspnea	77	37.6
Upper Respiratory Symptoms	53	25.9
Fever	46	22.4
Diarrhea	46	22.4
Palpitations	37	18.0
Lower Respiratory Symptoms	21	10.2
Syncope	8	3.9
Sudden Death	2	1.0
Laboratory Parameter	**Median**	**IQR**
Initial Troponin (ng/L)	888.7	(105.875 - 4222.5)
C-Reactive Protein (mg/L)	1.12	(0.32 - 4.79)
Highest Leukocyte Count (x10^9/L)	9620	(7690 - 12102.5)
Electrocardiographic Finding	**Number of Patients**	
Ventricular Tachycardia	4	
Ventricular Fibrillation	5	
Atrial Fibrillation	4	
Second-Degree AV Block (Mobitz II)	0	
Complete AV Block	0	

AV: atrioventricular; IQR: interquartile range.

Table 2 – Cardiac imaging and angiographic findings

Echocardiographic Parameter	Value
Left Ventricular Ejection Fraction (Mean ± SD)	54.0 ± 13.7
Left Ventricular Dysfunction (n, %)	70.0 (34.1%)
Right Ventricular Dysfunction (n, %)	23.0 (11.2%)
Pericardial Effusion (n, %)	36.0 (17.6%)
Cardiac MRI Parameter	**Value**
Left Ventricular Ejection Fraction (Mean ± SD)	53.1 ± 14.3
Late Gadolinium Enhancement (n, %)	77.0 (78.6%)
Myocardial Edema in T2 (n, %)	66.0 (67.3%)
Coronary Angiography Parameter	**Value**
Patients who underwent coronary angiography (n, %)	78 (38.0%)
Patients with significant angiographic lesions (n, %)	1 (1.3%)

Echocardiography was performed in all patients (N = 205). CMR findings correspond to patients who underwent CMR (n = 98), and angiography findings correspond to those who underwent coronary angiography (n = 78). CMR: cardiac magnetic resonance; LGE: late gadolinium enhancement; SD: standard deviation

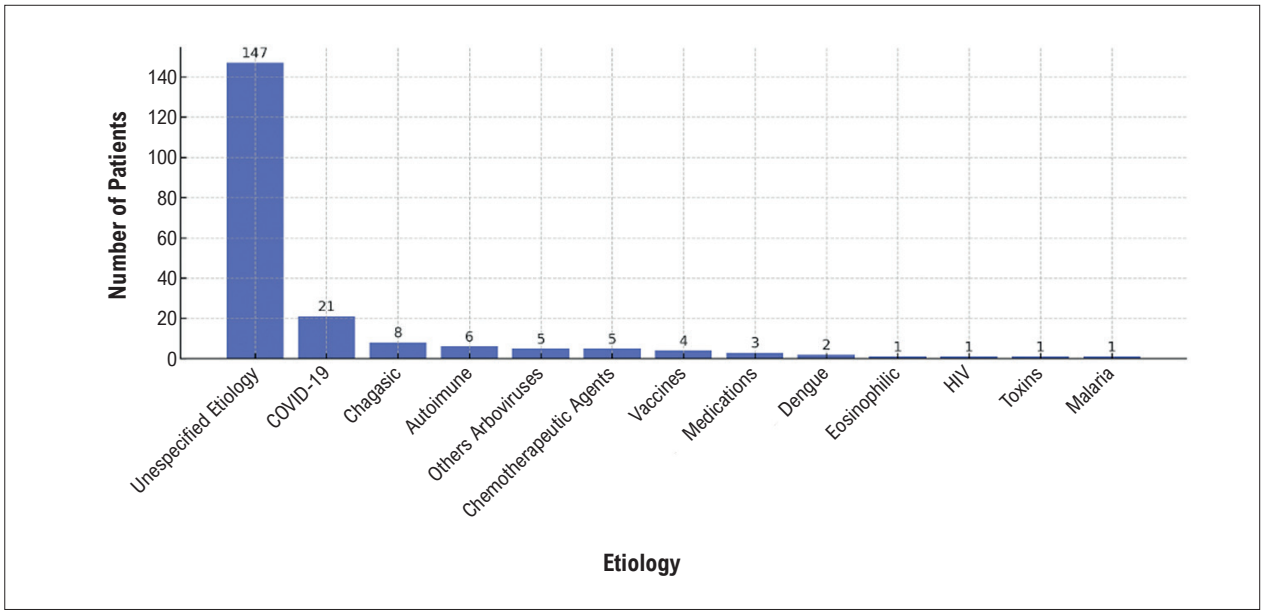


Figure 2 – *Identified etiologies of acute myocarditis.*

both short- and long-term prognosis, including the risk of progression to dilated cardiomyopathy (DCM).[21,22] The high proportion of idiopathic cases (71.2%) represents a central limitation of our study. Limited access to molecular testing and the very low rate of EMB likely contributed to this high proportion, restricting the generalizability of our findings and limiting our ability to accurately characterize the etiological spectrum of AM in our setting. Standardization of etiological workup and clearer definition of the clinical scenarios in which high-cost diagnostic tools provide meaningful benefit remain unmet needs, particularly in resource-limited environments.[16,23]

In several regions of Latin America, geographic and environmental factors favor the circulation of vectors and infectious agents capable of causing AM with aggressive and sometimes fatal presentations, including dengue fever, Chagas disease, toxoplasmosis, and leptospirosis.[24] In our cohort, approximately 1 in 10 cases was attributed to tropical infections, a markedly higher proportion than that reported in European studies. These findings highlight the importance of incorporating these etiologies into the diagnostic approach in endemic areas. Furthermore, our etiological analysis included a previously documented outbreak of acute Chagas disease due to oral transmission in 2021,[25] reinforcing the significance of this parasitic infection within the etiological spectrum of AM in Latin American settings.

The in-hospital mortality rate in our study was 5.39%, closely mirroring the rates reported in major international registries.[12,13] Using an exploratory univariable approach, we found higher mortality among patients aged ≥65 years, those with fulminant myocarditis, and those presenting with severe ventricular arrhythmias—findings that are consistent with prior literature linking these variables to adverse outcomes. However, given the retrospective and descriptive design, and the absence of multivariable adjustment, these associations should be interpreted as hypothesis-generating rather than prognostic. In addition, the lack of longitudinal follow-up prevented assessment of long-term outcomes, including potential progression to DCM.

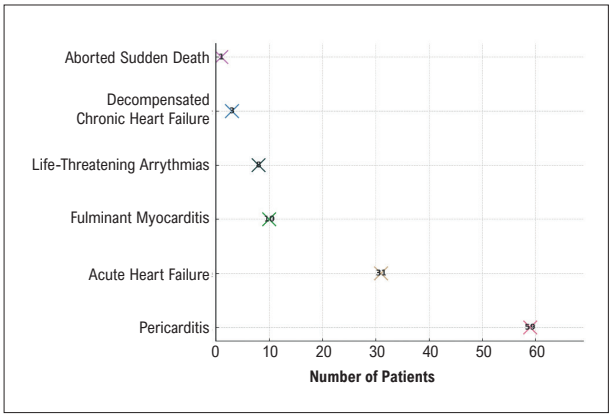


Figure 3 – *In-hospital complications in patients with acute myocarditis.*

Table 3 – Exploratory univariable associations with in-hospital mortality

Variable	Mortality (%)	p-value
Age ≥ 65 years	2.45%	**0.007**
Severe arrhythmias	45%	**0.021**
Fulminant myocarditis	60%	**0.031**

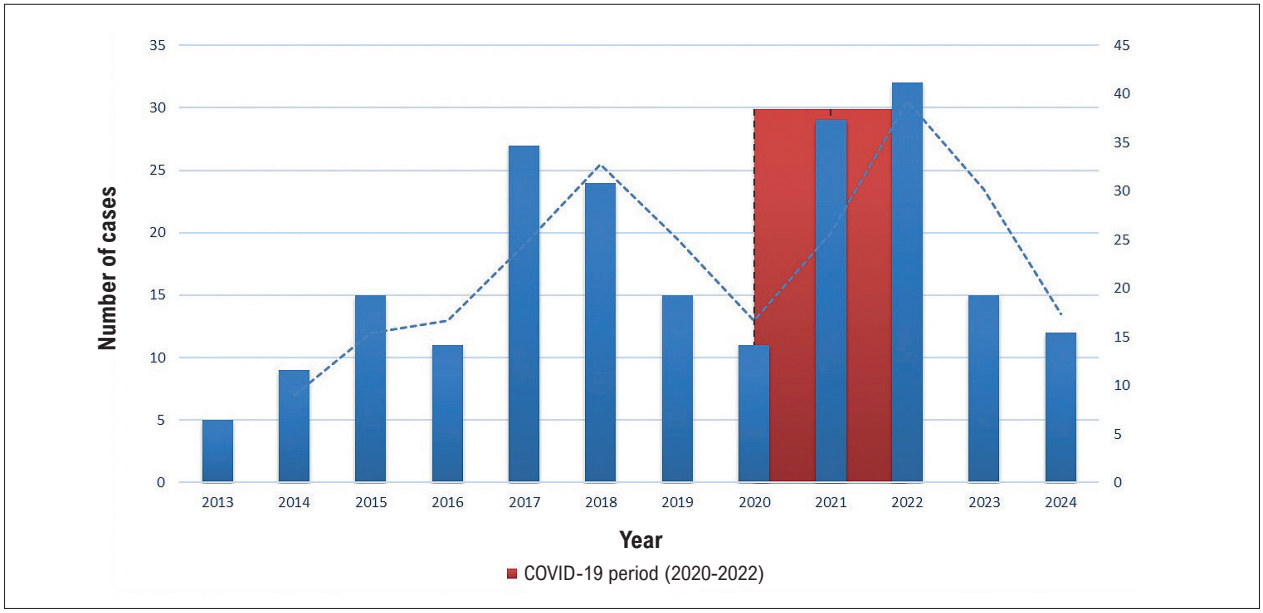


Figure 4 – *Annual distribution of acute myocarditis cases (2013–2024).*

In an international multicenter registry, Ammirati et al. analyzed 220 patients with AM and left ventricular dysfunction and found that the composite outcome of cardiac death or transplantation was markedly higher among those with fulminant presentations (27.8%) compared with non-fulminant cases (1.8%).[26] Similarly, using U.S. national databases, Pahuja et al. described trends in mortality, cardiogenic shock, and the use of mechanical circulatory support between 2005 and 2014. Despite an increasing incidence of cardiogenic shock, overall in-hospital mortality remained stable at 4.43%, with advanced age, female sex, African American race, and comorbidities showing strong associations with fatal outcomes.[27]

One of the most consistent aspects of AM management is the need for continuous monitoring during the early phase of the disease. As reported by Kragholm et al., severe ventricular arrhythmias—although infrequent and often unpredictable—carry a high risk of mortality and justify the substantial proportion of patients requiring intensive care unit (ICU) admission.[28] In our cohort, all patients were monitored in the ICU, with a median stay of three days, underscoring the significant healthcare and economic burden that AM imposes on the Colombian health system.

Limitations

The cross-sectional, retrospective nature of this study inherently limits causal inference and prevents assessment of long-term outcomes, including late ventricular remodeling or progression to DCM. Consequently, the associations observed with in-hospital mortality should be regarded as exploratory and hypothesis-generating, particularly given the absence of multivariable adjustment and the small number of events. Additionally, complication rates may be subject to under- or overestimation, underscoring the need for prospective, multicenter studies to validate these findings.

The use of ICD-10 codes as an initial screening strategy carries an inherent risk of diagnostic misclassification. Although a rigorous case-by-case clinical review allowed exclusion of non-eligible cases and improved diagnostic accuracy, residual misclassification cannot be fully excluded and should be considered a potential source of bias.

Although all patients diagnosed by CMR fulfilled the modified Lake Louise Criteria, more than half of the cohort did not undergo CMR or EMB, limiting our ability to confirm the diagnosis with gold-standard tools. This limitation was partially mitigated by a detailed clinical review based on ESC criteria; however, the limited availability of advanced diagnostic modalities may have increased the risk of including mimicking conditions.

A further limitation is the low rate of etiological characterization, with only 30% of patients achieving a definitive cause. This reflects structural and resource-related constraints in our healthcare system, and restricts the generalizability of our findings regarding the etiological spectrum of AM in Colombia. Future studies should prioritize standardized etiological evaluation and incorporate molecular diagnostics and pathogen-specific serologies to improve diagnostic yield.

The long study period, which spanned more than a decade and included the COVID-19 pandemic, introduces temporal heterogeneity. No formal time-trend analysis was performed, and therefore potential changes in incidence, etiology, or clinical presentation over time cannot be fully assessed. In addition, given the high prevalence of SARS-CoV-2 infection during the pandemic, establishing a definitive causal relationship remains challenging, and some cases classified as SARS-CoV-2–associated myocarditis may represent coincidental infection rather than a direct causal relationship.

Sex and gender biases were not specifically analyzed because this retrospective descriptive study was not designed to evaluate sex-based differences.

Finally, the study was conducted in two referral centers in Bogotá, which, although they receive patients from diverse regions of the country, may not fully represent the heterogeneity of clinical presentations, endemic infections, and diagnostic resources across Colombia. Thus, our findings should be interpreted as reflecting the experience of two major Colombian centers, providing valuable but not exhaustive insight into the national landscape of AM.

Conclusions

The clinical and sociodemographic profile of our cohort is consistent with that reported in international registries. Etiological characterization remained limited, with an increased burden of cases during the COVID-19 pandemic and the presence of tropical infections in a subset of patients. Variable diagnostic certainty and limited etiological definition restrict a full understanding of the disease spectrum in our setting. Despite advances in diagnosis and management, in-hospital mortality and complication rates have remained unchanged. The analysis of mortality presented here is descriptive and not intended to support prognostic inference.

This study provides the largest descriptive characterization of AM in two tertiary centers in Bogotá, contributing to the scarce regional evidence available. Its findings reflect the experience of Colombian referral centers and are not intended to represent the broader Latin American population. We hope this work serves as a foundation for future prospective registries on AM in Colombia and the region.

Author Contributions

Conception and design of the research and Critical revision of the manuscript for intellectual content: Toledo RR, Ortega D, Ramos CC, Jaimes MC, Culma AR, Alvarez M, Buitrago A; Acquisition of data: Toledo RR, Ortega D, Ramos CC, Culma AR; Analysis and interpretation of the data: Toledo RR; Statistical analysis: Toledo RR, Jaimes MC; Writing of the manuscript: Toledo RR, Ortega D, Alvarez M, Buitrago A.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Preprint

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Availability of Research Data

All datasets supporting the results of this study are available upon request from the corresponding author.

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