Review Article

Myocarditis versus Myocardial Infarction with Non-Obstructive Coronary Arteries (MINOCA): The Role of Cardiac Magnetic Resonance in Differential Diagnosis

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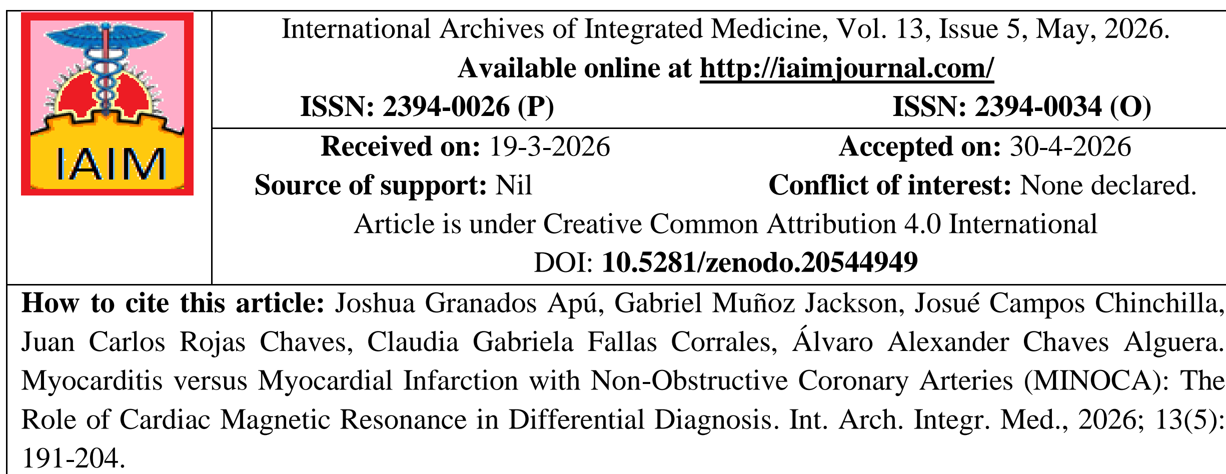
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Abstract

Myocardial infarction with non-obstructive coronary arteries represents a heterogeneous subset of acute coronary syndromes characterized by clinical evidence of myocardial infarction in the absence of significant epicardial coronary obstruction. This entity accounts for approximately 5–15% of acute myocardial infarction cases and is more frequently observed in women and younger patients. Its diverse etiologies, including coronary vasospasm, microvascular dysfunction, thromboembolism, and transient occlusion with spontaneous reperfusion, create substantial diagnostic complexity. Moreover, its clinical presentation often overlaps with that of acute myocarditis, as both conditions may manifest with chest pain, elevated cardiac biomarkers, and electrocardiographic abnormalities. Conventional

diagnostic tools, including coronary angiography and biomarker assessment, are frequently insufficient to establish a definitive etiological diagnosis. Cardiac magnetic resonance has emerged as a pivotal non-invasive modality for differentiating ischemic from inflammatory myocardial injury. Through multiparametric tissue characterization using T1 and T2 mapping and late gadolinium enhancement patterns, cardiac magnetic resonance enables identification of subendocardial or transmural enhancement consistent with ischemic injury, as well as subepicardial or mid-myocardial enhancement typical of myocarditis. Early implementation of cardiac magnetic resonance following coronary angiography significantly enhances diagnostic accuracy, facilitates appropriate therapeutic selection, and improves prognostic stratification based on the extent of myocardial involvement. Despite limitations related to accessibility and cost, cardiac magnetic resonance plays a central role in the integrated diagnostic algorithm for patients presenting with myocardial injury and non-obstructive coronary arteries. Its use supports precise etiological classification and contributes to more individualized and evidence-based clinical management.

Key words

Tissue characterization, Late gadolinium enhancement, T1 mapping, T2 mapping, Microvascular dysfunction, Inflammatory cardiomyopathy.

Introduction

Myocardial infarction with non-obstructive coronary arteries represents a clinically relevant subset of acute coronary syndromes, accounting for approximately 5–15% of all cases of acute myocardial infarction. Notably, its prevalence is higher among women and younger patients when compared to individuals with obstructive coronary artery disease, underscoring its distinct epidemiological profile [1, 2]. The defining feature of this condition - the absence of significant coronary artery obstruction - poses a substantial diagnostic challenge. Rather than representing a single pathological entity, it encompasses a heterogeneous spectrum of underlying mechanisms, including coronary vasospasm, microvascular dysfunction, and thromboembolism, each contributing to myocardial injury through different pathophysiological pathways [3, 4].

The diagnostic complexity is further compounded by the considerable clinical overlap between myocardial infarction with non-obstructive coronary arteries and other causes of acute myocardial injury, particularly myocarditis. Both conditions may present with acute chest pain, elevation of cardiac biomarkers, and electrocardiographic abnormalities, making initial clinical differentiation difficult [5, 6]. In many cases, the presentation of myocardial infarction with non-obstructive coronary arteries closely resembles that of a traditional myocardial infarction, thereby requiring a systematic and comprehensive diagnostic evaluation to exclude alternative etiologies such as myocarditis and Takotsubo syndrome [3, 7].

Given this overlap, distinguishing ischemic from non-ischemic myocardial injury becomes a central clinical objective. Accurate differentiation is essential not only for establishing the correct diagnosis but also for guiding therapeutic decision-making and optimizing patient outcomes [1, 8]. Misclassification may result in inappropriate treatment strategies, potentially exposing patients to unnecessary interventions or withholding targeted therapies, which highlights the need for precise and reliable diagnostic tools [7, 9].

In this context, advanced tissue characterization has emerged as a critical component of the diagnostic pathway. Cardiac magnetic resonance is a non-invasive imaging modality capable of providing detailed myocardial tissue assessment,

enabling differentiation between ischemic and non-ischemic injury patterns through the evaluation of late gadolinium enhancement distribution [1, 5]. Its clinical impact is substantial; in one study, cardiac magnetic resonance led to modification of the initial diagnosis in more than half of patients with suspected myocardial infarction with non-obstructive coronary arteries, with consequent implications for management and prognosis [5]. Reflecting this growing body of evidence, contemporary clinical guidelines increasingly recognize the role of cardiac magnetic resonance in the differential diagnosis of myocardial infarction with non-obstructive coronary arteries, particularly in identifying conditions such as myocarditis and Takotsubo syndrome [1, 10].

The objective of this article is to evaluate the role of cardiac magnetic resonance in differentiating acute myocarditis from myocardial infarction with non-obstructive coronary arteries, emphasizing its value in myocardial tissue characterization, diagnostic accuracy, and its impact on clinical decision-making and prognosis.

Methodology

This manuscript was developed as a structured narrative review aimed at providing an updated and clinically integrated analysis of the differential diagnosis between acute myocarditis and myocardial infarction with non-obstructive coronary arteries, with particular emphasis on the diagnostic value of cardiac magnetic resonance imaging and its implications for management and prognosis. The review was conducted in accordance with the SANRA (Scale for the Assessment of Narrative Review Articles) framework and followed a predefined methodological protocol established prior to literature screening. Given the heterogeneous etiological spectrum encompassed by myocardial infarction with non-obstructive coronary arteries and the substantial clinical overlap with non-ischemic myocardial injury syndromes, a narrative interpretative synthesis was selected over quantitative pooling in order to integrate clinical presentation, angiographic findings, biomarker profiles, and advanced tissue characterization into a coherent and clinically applicable diagnostic framework. Special attention was given to contemporary definitions and diagnostic criteria for myocardial infarction with non-obstructive coronary arteries, the revised Lake Louise criteria for myocarditis, the role of mapping techniques and late gadolinium enhancement patterns, and the impact of early cardiac magnetic resonance on etiological reclassification, treatment selection, and risk stratification. The objective was to provide a structured synthesis capable of supporting accurate diagnostic reasoning and multidisciplinary decision-making in patients presenting with acute myocardial injury and non-obstructive coronary arteries.

A comprehensive literature search was conducted in PubMed, Scopus, and Web of Science, including peer-reviewed articles published in English or Spanish between January 2020 and December 2026. The final search was performed in December 2026. This timeframe was selected to capture contemporary advances in cardiac magnetic resonance protocols, the widespread adoption of parametric mapping, the consolidation of updated myocarditis diagnostic criteria, evolving myocardial infarction with non-obstructive coronary arteries consensus definitions, and the emergence of guideline recommendations supporting early imaging-based etiological classification. Foundational studies were incorporated when necessary to contextualize diagnostic criteria evolution, pathophysiological concepts, or historical changes in the classification of acute myocardial injury. The search strategy combined MeSH and free-text terms using Boolean operators related to myocardial infarction with non-obstructive coronary arteries, myocardial infarction, acute coronary syndrome, myocarditis, cardiac magnetic resonance, late gadolinium

enhancement, T1 mapping, T2 mapping, extracellular volume, Lake Louise criteria, diagnostic algorithm, Takotsubo syndrome, microvascular dysfunction, coronary vasospasm, plaque disruption, spontaneous coronary artery dissection, and prognostic outcomes. Searches were conducted in titles and abstracts as well as indexed subject headings to maximize sensitivity.

The initial search yielded 212 records. After removal of duplicates, 168 articles remained for title and abstract screening. Of these, 97 underwent full-text evaluation, and 54 studies were included in the final synthesis. Selection was performed independently by two authors, with disagreements resolved through discussion and consensus. Exclusion criteria comprised non–peer-reviewed publications, isolated case reports, editorials without outcome data, purely technical imaging descriptions lacking diagnostic performance or clinical endpoints, redundant datasets, and studies not directly addressing the differential diagnosis of myocardial infarction with non-obstructive coronary arteries, myocarditis, or the diagnostic contribution of cardiac magnetic resonance imaging.

Eligible studies included randomized controlled trials, large observational cohorts, systematic reviews, meta-analyses, expert consensus statements, and contemporary international guidelines from cardiology, cardiovascular imaging, and emergency medicine societies. Priority was assigned to multicenter investigations, studies applying standardized definitions of myocardial infarction with non-obstructive coronary arteries and myocarditis, and research evaluating diagnostic yield, etiological reclassification rates, imaging timing, and associations between cardiac magnetic resonance patterns and clinical outcomes. Extracted variables included study design, patient selection criteria, timing of cardiac magnetic resonance after presentation, angiographic findings, cardiac magnetic resonance protocol components, presence and distribution of late gadolinium enhancement, parametric mapping findings, fulfillment of revised Lake Louise criteria, final etiological diagnosis, therapeutic implications when reported, and prognostic endpoints such as major adverse cardiovascular events, heart failure hospitalization, arrhythmias, and mortality. Methodological quality and internal validity were assessed narratively, considering risk of bias, sample size, follow-up duration, diagnostic reference standards, protocol reproducibility, and consistency of definitions across studies. In cases of conflicting evidence, greater interpretative weight was assigned to higher-level evidence and guideline-supported recommendations.

Reference lists of included studies were manually screened to identify additional relevant publications. Given its narrative design, this review is subject to potential selection bias and does not provide pooled quantitative estimates. Artificial intelligence–based tools were used exclusively to assist in literature organization and structural coherence, whereas critical appraisal, synthesis, and final interpretation were conducted independently by the authors to preserve methodological rigor.

Definitions and Diagnostic Criteria

Myocardial infarction with non-obstructive coronary arteries accounts for approximately 5–15% of all cases of acute myocardial infarction and demonstrates a higher prevalence in women and younger patients compared with those presenting with obstructive coronary artery disease [1, 11]. The absence of significant coronary artery obstruction constitutes its defining feature and simultaneously represents a major diagnostic dilemma, as this entity encompasses a heterogeneous group of pathologies with diverse etiologies, including coronary vasospasm, microvascular dysfunction, and thromboembolism [3, 4].

This heterogeneity contributes directly to the clinical complexity observed at presentation, particularly because both myocarditis and myocardial infarction with non-obstructive coronary arteries may manifest with acute chest pain, elevated cardiac biomarkers, and electrocardiographic abnormalities, thereby complicating the initial clinical assessment [5, 6]. In fact, the clinical presentation of myocardial infarction with non-obstructive coronary arteries frequently mimics that of traditional myocardial infarction, which necessitates a comprehensive and systematic diagnostic approach to exclude alternative causes such as myocarditis and Takotsubo syndrome [3, 4].

Within this context, accurate differentiation between ischemic and non-ischemic myocardial injury becomes essential for determining the appropriate therapeutic strategy and improving patient outcomes [1, 8]. Failure to establish the correct diagnosis may result in inappropriate treatment, reinforcing the need for precise diagnostic tools and well-defined strategies capable of distinguishing between these overlapping clinical entities [7, 9].

Advanced tissue characterization therefore assumes a central role in the diagnostic pathway. Cardiac magnetic resonance is a non-invasive imaging modality that provides detailed myocardial tissue assessment, allowing differentiation between ischemic and non-ischemic injury through the evaluation of late gadolinium enhancement patterns [1, 5]. Its clinical relevance is underscored by evidence demonstrating that cardiac magnetic resonance led to modification of the initial diagnosis in more than half of patients with suspected myocardial infarction with non-obstructive coronary arteries, with significant implications for management and prognosis [5]. Accordingly, cardiac magnetic resonance is increasingly recognized in clinical guidelines for its role in the differential diagnosis of myocardial infarction with non-obstructive coronary arteries, particularly in facilitating identification of conditions such as myocarditis and Takotsubo syndrome [1, 10].

Pathophysiological Mechanisms: Ischemic versus Inflammatory Injury

Ischemic injury in myocardial infarction with non-obstructive coronary arteries may arise from transient coronary occlusion followed by spontaneous reperfusion, resulting in myocardial damage despite the absence of persistent significant epicardial obstruction. This mechanism is frequently associated with coronary artery spasm or microvascular dysfunction, both of which can produce temporary reductions in coronary blood flow sufficient to induce ischemia. The ischemic insult may occur without angiographically evident fixed stenosis, thereby explaining the apparent discrepancy between clinical presentation and coronary anatomy [3, 4].

A central component of this process is microvascular obstruction and endothelial dysfunction. Microvascular dysfunction represents a hallmark feature of myocardial infarction with non-obstructive coronary arteries and contributes to ischemic injury by impairing perfusion at the level of the coronary microcirculation. This alteration in vascular regulation can be present across different subtypes of the condition and is commonly evaluated using angiography-based indices that assess coronary flow and microvascular resistance [12].

Among these regions, the subendocardium is particularly susceptible to ischemia due to its elevated metabolic requirements and relatively limited perfusion reserve. During episodes of reduced coronary flow, this layer becomes the first to experience hypoperfusion and subsequent injury, which explains the characteristic subendocardial pattern observed in ischemic myocardial damage [3]. When perfusion deficits persist or recur, myocyte necrosis may ensue, a

process reflected clinically by elevation of cardiac biomarkers and further characterized through imaging modalities such as cardiac magnetic resonance [13, 14].

In contrast, inflammatory injury in myocarditis is primarily mediated by immune mechanisms. The condition often follows viral infection, which triggers an immune response directed against myocardial tissue and results in significant inflammation and structural injury. In addition to immune-mediated damage, certain viruses are capable of directly infecting myocardial cells, exerting cytotoxic effects that further contribute to tissue injury and amplify the inflammatory cascade [15].

The inflammatory response in myocarditis is characterized by the release of cytokines, which promote myocardial edema and necrosis. This cytokine-driven process may intensify myocardial damage and, in severe cases, contribute to the development of heart failure. Unlike ischemic injury, which typically conforms to specific coronary artery territories, myocardial injury in myocarditis demonstrates a patchy distribution that does not correspond to a single vascular supply region. This non-coronary pattern of involvement reflects the diffuse and multifocal nature of the inflammatory process and represents a key distinguishing feature between inflammatory and ischemic myocardial injury [15].

Clinical Presentation and Initial Diagnostic Workup

Both myocarditis and myocardial infarction with non-obstructive coronary arteries commonly present with chest pain, although certain demographic differences may assist in clinical orientation. Patients with myocardial infarction with non-obstructive coronary arteries are often younger and more frequently female compared with those with obstructive coronary artery disease, reflecting a distinct epidemiological pattern [3, 16]. In contrast, myocarditis may affect a broad age range and is frequently associated with preceding infectious symptoms. Hemodynamic presentation also differs between the two conditions. Myocarditis is more often associated with hemodynamic instability due to potential global ventricular dysfunction, whereas myocardial infarction with non-obstructive coronary arteries typically presents with more stable hemodynamics unless complicated by severe coronary spasm or significant microvascular dysfunction [4].

Electrocardiographic findings further illustrate the overlap between these entities. Both conditions may demonstrate ST-segment elevation or depression and T-wave inversions, yet these changes lack specificity and can substantially overlap, limiting their diagnostic utility when considered in isolation. In myocarditis, electrocardiographic abnormalities are more frequently diffuse, reflecting widespread inflammatory involvement. In contrast, myocardial infarction with non-obstructive coronary arteries may exhibit regional changes that correspond to the underlying mechanism, such as coronary spasm or microvascular dysfunction [3, 4].

Biomarker assessment similarly presents challenges. Elevated troponin levels are characteristic of both conditions; however, their temporal profile may differ. In myocarditis, troponin elevation often demonstrates a more gradual rise and decline, consistent with ongoing inflammatory injury. In addition, inflammatory markers such as C-reactive protein may be elevated in myocarditis, providing supportive evidence of an inflammatory process, whereas these markers are less commonly increased in myocardial infarction with non-obstructive coronary arteries unless an associated inflammatory component is present [4].

Echocardiographic findings also contribute to the differential assessment. Myocarditis typically manifests as global left ventricular dysfunction

due to diffuse myocardial involvement. In contrast, myocardial infarction with non-obstructive coronary arteries more commonly presents with regional wall motion abnormalities in the absence of significant epicardial coronary obstruction [4]. The preservation of left ventricular ejection fraction may be observed in myocardial infarction with non-obstructive coronary arteries and can serve as a distinguishing feature, whereas myocarditis frequently leads to reduced ejection fraction secondary to more extensive myocardial injury [16].

Despite these clinical, electrocardiographic, and echocardiographic distinctions, conventional diagnostic testing has inherent limitations. Coronary angiography, while essential for excluding obstructive coronary disease, may not identify the underlying mechanism in myocardial infarction with non-obstructive coronary arteries because it primarily detects significant epicardial stenoses. Consequently, advanced imaging modalities such as cardiac magnetic resonance are critical for identifying non-ischemic causes, including myocarditis [1, 14]. Furthermore, troponin elevation alone cannot reliably differentiate between these conditions, as both are associated with myocardial injury. Cardiac magnetic resonance provides additional diagnostic clarity by detecting myocardial edema and fibrosis patterns characteristic of myocarditis, thereby enhancing etiological classification and supporting appropriate clinical management [17].

Technical Principles of Cardiac Magnetic Resonance

Cardiac magnetic resonance enables detailed myocardial tissue characterization through a combination of complementary sequences that provide insight into the presence of inflammation, edema, fibrosis, and irreversible injury. Among these, T2-weighted imaging and T2 mapping play a central role in detecting myocardial edema, a hallmark of acute inflammation. While traditional T2-weighted sequences allow visualization of increased myocardial water content, T2 mapping offers a quantitative assessment, thereby providing a more reliable and reproducible evaluation of tissue changes. This quantitative approach is particularly valuable in the diagnosis of acute myocarditis, as it permits early detection of myocardial injury and may identify inflammatory alterations even before the full clinical expression of symptoms [18, 19].

Complementing T2-based techniques, native T1 mapping and extracellular volume quantification further enhance tissue characterization by assessing changes in myocardial composition. Native T1 mapping is sensitive to both edema and fibrosis, allowing differentiation between inflammatory and ischemic patterns of injury. In the context of distinguishing myocarditis from myocardial infarction with non-obstructive coronary arteries, these parameters provide critical diagnostic information. Extracellular volume quantification refines this assessment by estimating the degree of interstitial expansion associated with fibrosis or active inflammation, thereby contributing additional specificity to the diagnostic process [19, 20].

Late gadolinium enhancement constitutes another fundamental component of cardiac magnetic resonance evaluation. This technique identifies areas of irreversible myocardial injury and enables differentiation between ischemic and non-ischemic damage based on the distribution and pattern of enhancement. The presence and specific configuration of late gadolinium enhancement are pivotal in distinguishing myocardial infarction with non-obstructive coronary arteries from myocarditis, as ischemic injury typically follows a vascular territory while inflammatory injury does not. Importantly, recognition of these patterns has been shown to significantly modify the initial diagnosis and directly influence clinical management [5, 14].

The diagnostic performance of these sequences is further strengthened by the updated Lake Louise criteria, which integrate both T1- and T2-based markers to improve sensitivity and specificity in the diagnosis of myocarditis. This multiparametric framework allows for a comprehensive assessment of myocardial inflammation by combining evidence of edema with markers of tissue injury or fibrosis, thereby reducing reliance on a single imaging parameter. Establishing defined diagnostic thresholds for T1 and T2 values enhances accuracy and supports differentiation not only between acute and chronic myocarditis but also between myocarditis and alternative causes of myocardial injury, including myocardial infarction with non-obstructive coronary arteries [19, 20].

In addition to sequence selection and parameter thresholds, the timing of cardiac magnetic resonance relative to symptom onset is of critical importance. Early imaging increases the likelihood of detecting transient inflammatory changes and myocardial edema that may resolve over time. Evidence suggests that performing cardiac magnetic resonance within the first few days after symptom onset significantly improves diagnostic yield and contributes to more accurate prognostic assessment [21, 22].

Cardiac Magnetic Resonance Patterns in Myocarditis and MINOCA

Cardiac magnetic resonance demonstrates characteristic imaging patterns that facilitate differentiation between myocarditis and ischemic myocardial infarction with non-obstructive coronary arteries. In myocarditis, late gadolinium enhancement typically appears in a subepicardial or mid-myocardial distribution, representing a key distinguishing feature from ischemic injury. This enhancement pattern is most frequently observed in the inferolateral segments of the myocardium and does not conform to a specific coronary vascular territory, which contrasts with the territorial distribution seen in infarction. The non-coronary distribution of enhancement reflects the inflammatory and patchy nature of myocardial involvement in this condition [1, 23].

In addition to late gadolinium enhancement, myocardial edema constitutes another central imaging feature of myocarditis. Cardiac magnetic resonance can identify edema through T2-based techniques, and this edema similarly demonstrates a distribution that does not follow coronary artery territories. The presence of diffuse or patchy myocardial edema further supports an inflammatory etiology and is critical in distinguishing myocarditis from ischemic heart disease [23]. Importantly, myocarditis does not typically exhibit the subendocardial late gadolinium enhancement pattern that characterizes infarction. The absence of subendocardial involvement serves as an additional differentiating element, as subendocardial enhancement is strongly associated with ischemic necrosis [24].

In contrast, ischemic myocardial infarction with non-obstructive coronary arteries demonstrates imaging features consistent with infarction despite the absence of significant epicardial stenosis. In these cases, late gadolinium enhancement is commonly subendocardial or transmural and aligns with the anatomical territory of a specific coronary artery. This territorial distribution is indicative of myocardial infarction and supports an ischemic mechanism even when angiography does not reveal obstructive coronary disease [1, 5].

Cardiac magnetic resonance may also identify microinfarcts and regional perfusion defects in ischemic myocardial infarction with non-obstructive coronary arteries, findings that further substantiate the presence of ischemic damage. These perfusion abnormalities reinforce the interpretation of a supply–demand mismatch or transient occlusive event as the underlying mechanism [3]. Additionally, evidence of microvascular obstruction may be detected, providing further support for an ischemic event

occurring at the microcirculatory level despite non-obstructive coronary arteries [1].

Integrated Diagnostic Algorithm and Clinical Implications

Coronary angiography represents the initial step in the evaluation of patients with suspected myocardial infarction with non-obstructive coronary arteries because it confirms the absence of significant epicardial coronary obstruction and establishes the working diagnosis that requires further etiological clarification [3, 25]. Once angiography has excluded obstructive coronary disease, cardiac magnetic resonance is recommended as a subsequent investigation to refine the diagnostic classification, given its ability to identify alternative non-ischemic causes of acute myocardial injury, including myocarditis and Takotsubo syndrome [1, 26].

Within this stepwise approach, the timing of cardiac magnetic resonance is a critical determinant of diagnostic performance. Cardiac magnetic resonance should be performed early, ideally within a few days of the acute event, in order to maximize diagnostic yield and capture transient tissue changes that may diminish over time [22, 25]. Early imaging improves the capacity to differentiate ischemic from non-ischemic myocardial injury, which is essential for establishing an accurate diagnosis and guiding subsequent management decisions [13, 17].

The principal diagnostic contribution of cardiac magnetic resonance in this context lies in its ability to distinguish true ischemic injury from inflammatory cardiomyopathy through tissue characterization. This differentiation is achieved by evaluating late gadolinium enhancement patterns in combination with quantitative markers of edema such as T2 mapping values, which together provide a multiparametric profile of myocardial injury [5, 22]. Myocarditis demonstrates a late gadolinium enhancement pattern that differs from ischemic injury and therefore supports etiological reclassification when clinical and angiographic findings are inconclusive [17].

This diagnostic distinction has direct therapeutic implications. When cardiac magnetic resonance supports an ischemic mechanism, treatment strategies may include antithrombotic therapy, whereas identification of myocarditis shifts management toward immunomodulation when appropriate and supportive care focused on hemodynamic stabilization and heart failure prevention [2, 3]. Consequently, accurate etiological classification through cardiac magnetic resonance can prevent unnecessary antithrombotic therapy in patients whose presentation reflects non-ischemic myocardial injury rather than myocardial infarction [17].

Beyond diagnosis and treatment selection, cardiac magnetic resonance provides prognostic stratification based on injury pattern and the extent of fibrosis. The presence and magnitude of late gadolinium enhancement have been associated with an increased risk of major adverse cardiovascular events, reinforcing the prognostic relevance of myocardial scarring detected by this modality. In addition, patients demonstrating significant late gadolinium enhancement together with abnormal T2 mapping values appear to carry a higher risk of adverse outcomes, underscoring the combined diagnostic and prognostic value of cardiac magnetic resonance in myocardial infarction with non-obstructive coronary arteries [22].

Limitations, Emerging Technologies, and Future Directions

Despite the diagnostic value of advanced imaging modalities, accessibility and cost remain significant limitations in routine clinical practice. Cardiac magnetic resonance and intracoronary imaging techniques, although highly effective for etiological clarification, are not universally available, thereby restricting their widespread implementation in many healthcare settings [1,

27]. These limitations are further compounded by economic disparities and social determinants of health, which may influence both access to timely diagnosis and overall outcomes, particularly in conditions such as myocarditis where early recognition can be critical [28].

In addition to structural and economic constraints, important diagnostic challenges persist, especially in early or mild disease presentations. Both myocarditis and myocardial infarction with non-obstructive coronary arteries may initially manifest with non-specific symptoms that overlap with other cardiovascular or systemic conditions, complicating early recognition [8, 29]. The intrinsic heterogeneity of myocardial infarction with non-obstructive coronary arteries further complicates this process, as its diverse pathophysiological mechanisms require a comprehensive and systematic approach to identify the underlying cause and tailor treatment appropriately [7].

Within this evolving landscape, quantitative mapping techniques have emerged as valuable tools for enhancing myocardial tissue characterization. T1 and T2 mapping sequences in cardiac magnetic resonance allow for objective and reproducible assessment of myocardial composition, thereby facilitating differentiation between inflammatory and ischemic injury patterns [22]. Beyond conventional imaging, artificial intelligence and machine learning algorithms are increasingly being explored as adjunctive tools to improve diagnostic accuracy and predict clinical outcomes in both myocarditis and myocardial infarction with non-obstructive coronary arteries [28].

However, the incorporation of these emerging technologies into clinical practice requires robust validation. There is a critical need for prospective multicenter studies to evaluate the diagnostic and prognostic performance of advanced cardiac magnetic resonance techniques and artificial intelligence–based models in diverse patient populations [30]. Such investigations could contribute to the development of standardized imaging protocols, strengthen external validity, and enhance the generalizability of findings across healthcare systems [13].

Ultimately, the integration of advanced imaging modalities and artificial intelligence into clinical workflows holds promise for advancing personalized cardiovascular medicine. By aligning diagnostic tools with the specific pathophysiological mechanisms underlying myocardial injury in each patient, clinicians may be able to tailor interventions more precisely [30]. This precision-based approach has the potential not only to improve clinical outcomes but also to reduce the broader socioeconomic burden associated with myocarditis and myocardial infarction with non-obstructive coronary arteries [29].

Conclusions

Myocardial infarction with non-obstructive coronary arteries represents a heterogeneous and diagnostically challenging entity that frequently overlaps clinically with myocarditis, as both conditions may present with chest pain, biomarker elevation, and electrocardiographic abnormalities despite distinct underlying pathophysiological mechanisms. The absence of significant epicardial obstruction does not exclude ischemic injury, which may arise from transient coronary occlusion, microvascular dysfunction, or endothelial impairment, whereas myocarditis is characterized by immune-mediated inflammatory damage with a non-coronary distribution. Given this complexity, accurate differentiation between ischemic and inflammatory myocardial injury is essential to avoid misdiagnosis and inappropriate treatment.

Cardiac magnetic resonance plays a central role in the diagnostic algorithm by providing comprehensive tissue characterization through

T1 and T2 mapping and late gadolinium enhancement patterns, enabling reliable distinction between ischemic and non-ischemic injury. Its early use after coronary angiography significantly improves diagnostic accuracy, guides therapeutic decision-making, and offers prognostic stratification based on the extent and pattern of myocardial involvement. Despite limitations related to accessibility and cost, the integration of advanced imaging techniques and emerging technologies such as artificial intelligence holds substantial promise for refining etiological classification and advancing personalized cardiovascular care.

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