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Role of Cardiac MRI in the Evaluation of Myocarditis and Cardiomyopathies

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Abstract

Background: Cardiac magnetic resonance imaging (CMR) has emerged as a pivotal non-invasive modality in the evaluation of myocardial diseases, particularly myocarditis and cardiomyopathies, owing to its superior tissue characterization and diagnostic accuracy. **Aim and Objectives:** To assess the role of cardiac MRI in diagnosing and characterizing myocarditis and different types of cardiomyopathies, and to evaluate its diagnostic performance compared to clinical diagnosis. **Methods:** This observational cross-sectional study included 76 patients with clinically suspected myocarditis or cardiomyopathy who underwent cardiac MRI. Imaging sequences included cine MRI, T2-weighted imaging, early and late gadolinium enhancement (EGE, LGE), and mapping techniques. MRI findings were analyzed and compared with clinical diagnoses. **Results:** Myocarditis was diagnosed in 32 patients, with myocardial edema, EGE, and LGE observed in 78.1%, 62.5%, and 87.5%, respectively. Lake Louise Criteria were met in 81.3% of cases. Dilated cardiomyopathy (DCM) was identified in 24 patients, all of whom showed LV dilatation, with 91.7% having systolic dysfunction and 75% showing mid-wall fibrosis. In 12 patients with hypertrophic cardiomyopathy, 83.3% had asymmetric septal hypertrophy and 75% showed patchy LGE. Among 8 patients with arrhythmogenic cardiomyopathy, RV wall motion abnormalities were present in 87.5%. Cardiac MRI demonstrated high sensitivity (81.3–95.8%) and specificity (91.7–100%) across all conditions.

Conclusion: Cardiac MRI is a highly effective, non-invasive imaging tool in the evaluation of myocarditis and cardiomyopathies. It offers superior diagnostic accuracy and provides critical insights into myocardial tissue characteristics, significantly enhancing clinical decision-making and patient management.

Keywords: Cardiac MRI, Myocarditis, Cardiomyopathy, Late Gadolinium Enhancement, Lake Louise Criteria, Myocardial Edema, Tissue Characterization, Non-invasive Imaging.

Introduction

Cardiovascular magnetic resonance imaging (CMR) has emerged as a pivotal non-invasive modality in the diagnosis and evaluation of various cardiac diseases, particularly myocarditis and cardiomyopathies. Myocarditis, characterized by myocardial inflammation, often presents with non-specific clinical features, making accurate diagnosis challenging through conventional modalities such as electrocardiography or echocardiography alone (1). Similarly, cardiomyopathies, a heterogeneous group of myocardial disorders, require advanced imaging techniques for precise tissue characterization and functional assessment (2).

Cardiac MRI offers a unique advantage by providing comprehensive anatomical, functional, and tissue characterization without ionizing radiation. Techniques such as T2-weighted imaging, early and late gadolinium enhancement (LGE), and T1 mapping have revolutionized the ability to detect myocardial edema, hyperemia, necrosis, and fibrosis, which are critical in the assessment of myocarditis (3,4). The Lake Louise Criteria, established in 2009, standardized the MRI-based diagnostic framework for myocarditis and significantly improved diagnostic confidence and clinical decision-making (5).

In cardiomyopathies, CMR plays an essential role in differentiating between ischemic and non-ischemic etiologies, evaluating myocardial fibrosis, and assessing

ventricular morphology and function. It is particularly valuable in conditions such as hypertrophic cardiomyopathy, dilated cardiomyopathy, and arrhythmogenic right ventricular cardiomyopathy, where conventional imaging may be limited (6,7). Moreover, CMR is increasingly recognized for its prognostic implications, guiding risk stratification and management strategies in these patient populations (8).

Thus, cardiac MRI has transformed the landscape of myocardial disease evaluation, offering unparalleled diagnostic and prognostic information. Its integration into routine clinical practice is essential for the accurate and early detection of myocarditis and cardiomyopathies.

Materials and Method

A hospital-based observational cross-sectional study was conducted to evaluate the role of cardiac magnetic resonance imaging (CMR) in patients with clinically suspected myocarditis and cardiomyopathies. The study was carried out over a period of 12 months in the Department of Radiodiagnosis in collaboration with the Department of Cardiology at Chalmeda Anand Rao Institute of Medical sciences a tertiary care teaching hospital, Karimnagar.

Study Population

76 Patients aged 18 years and above, referred for cardiac MRI with a clinical suspicion of myocarditis or cardiomyopathy based on symptoms, laboratory parameters, electrocardiographic changes, and/or echocardiographic findings, were included in the study.

Inclusion Criteria

- Patients with suspected myocarditis presenting with chest pain, dyspnea, palpitations, or recent viral illness with elevated cardiac biomarkers.

- Patients with suspected cardiomyopathy (dilated, hypertrophic, or arrhythmogenic) based on clinical and echocardiographic findings.
- Willingness to provide informed consent for participation in the study.

Exclusion Criteria

- Patients with contraindications to MRI (e.g., metallic implants, pacemakers, or claustrophobia).
- Renal impairment (eGFR < 30 mL/min/1.73 m²) contraindicating gadolinium-based contrast administration.
- History of coronary artery disease, recent myocardial infarction, or revascularization procedures.
- Pregnant or lactating women.

Ethical Considerations

Ethical approval was obtained from the Institutional Ethics Committee prior to the commencement of the study. Written informed consent was obtained from all participants.

Imaging Protocol

All patients underwent cardiac MRI on a 1.5 Tesla MRI scanner using a dedicated phased-array cardiac coil. The protocol included:

- **Cine MRI (SSFP sequences)** in standard long-axis and short-axis views to assess ventricular morphology and function.
- **T2-weighted imaging** for myocardial edema detection.
- **Early gadolinium enhancement (EGE)** imaging to assess hyperemia and capillary leak.
- **Late gadolinium enhancement (LGE)** imaging performed 10–15 minutes post-contrast for fibrosis and necrosis evaluation.

- **T1 and T2 mapping sequences** were included in selected cases for quantitative tissue characterization.

Gadolinium-based contrast (0.1 mmol/kg body weight) was administered intravenously. Images were analyzed using dedicated software by two experienced radiologists blinded to the clinical data.

Diagnostic Criteria

Myocarditis was diagnosed based on the **Lake Louise Criteria (2009)**, which includes the presence of at least two of the following:

1. Regional or global myocardial signal intensity increase in T2-weighted images.
2. Increased global myocardial early gadolinium enhancement ratio between myocardium and skeletal muscle in EGE images.
3. Non-ischemic regional distribution of LGE.

Cardiomyopathies were classified based on established **ESC and AHA criteria**, with further evaluation of specific MRI findings:

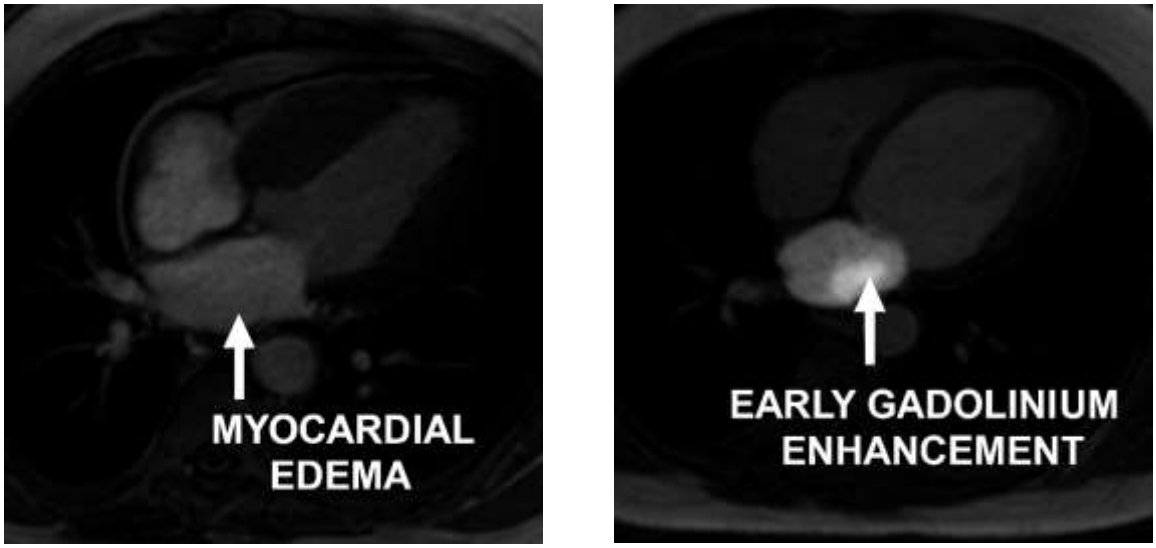
- **Dilated Cardiomyopathy (DCM):** LV dilation and systolic dysfunction.
- **Hypertrophic Cardiomyopathy (HCM):** Asymmetric LV hypertrophy without a secondary cause.
- **Arrhythmogenic Right Ventricular Cardiomyopathy (ARVC):** RV dilation, wall motion abnormalities, and fibrofatty infiltration.

Data Collection and Analysis

Demographic details, clinical history, ECG, echocardiography, and laboratory findings were recorded. MRI findings were tabulated and correlated with clinical diagnoses. Data were analyzed using SPSS version 25. Descriptive statistics were used for categorical and continuous variables. Diagnostic performance of MRI

parameters was evaluated against clinical diagnosis using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV).

Figure 1 : (A) Myocardial edema detection. (B) Early gadolinium enhancement (EGE)



Observation and Results

Table 1 : Distribution of demographic profile among study population

Parameter	Frequency	Percentage
Age		
18–30 years	18	23.7
31–45 years	25	32.9
46–60 years	21	27.9
60 years	12	15.8
Gender		
Male	49	64.5
Female	27	35.5

Table 1 presents the age and gender distribution of the 76 patients included in the study. The majority of the patients were between the ages of 31–45 years (32.9%), followed by 46–60 years (27.9%), indicating a predominance of middle-aged

individuals in the study population. Younger adults aged 18–30 years constituted 23.7%, while patients above 60 years comprised only 15.8%. In terms of gender, there was a male predominance, with 49 males (64.5%) compared to 27 females (35.5%), which reflects the higher incidence or referral of males for cardiac MRI in this clinical setting.

Table 2 : Distribution of Clinical Indications for Cardiac MRI

Clinical Suspicion	Number of Cases (n=76)	Percentage (%)
Suspected Myocarditis	32	42.10%
Dilated Cardiomyopathy	24	31.60%
Hypertrophic Cardiomyopathy	12	15.80%
Arrhythmogenic Cardiomyopathy	8	10.50%

Table 2 summarizes the clinical indications for which cardiac MRI was performed. The most common indication was **suspected myocarditis**, accounting for **32 cases (42.1%)**, followed by **dilated cardiomyopathy (31.6%)**, indicating that these two conditions were the most frequent differentials referred for advanced imaging. **Hypertrophic cardiomyopathy** was suspected in **12 patients (15.8%)**, and **arrhythmogenic cardiomyopathy** was the least common indication, observed in **8 patients (10.5%)**. This distribution shows the diverse clinical utility of cardiac MRI in evaluating a broad spectrum of myocardial diseases.

Table 3 : Distribution of Cardiac MRI Findings

Cardiac MRI Findings	Number of Cases (n=76)	Percentage (%)
Myocarditis (n = 32)		
Myocardial Edema (T2-weighted)	25	78.10%
Early Gadolinium Enhancement	20	62.50%
Late Gadolinium Enhancement	28	87.50%
Met Lake Louise Criteria (≥2)	26	81.30%

Dilated Cardiomyopathy (n = 24)		
LV Dilatation	24	100%
Systolic Dysfunction (EF < 40%)	22	91.70%
Mid-wall Fibrosis (LGE)	18	75.00%
Hypertrophic Cardiomyopathy (n = 12)		
symmetric Septal Hypertrophy	10	83.30%
Patchy LGE (Myocardial Fibrosis)	9	75.00%
LVOT Obstruction	6	50.00%
Arrhythmogenic Cardiomyopathy (n = 8)		
RV Wall Motion Abnormalities	7	87.50%
Fatty Infiltration	5	62.50%
RV Dilatation	6	75.00%
Subepicardial LGE (RV or LV)	5	62.50%

Table 3 details the specific MRI findings observed in different cardiac conditions. In myocarditis cases (n = 32), myocardial edema was identified in 78.1%, early gadolinium enhancement in 62.5%, and late gadolinium enhancement (LGE) in 87.5%, supporting active inflammation or injury. The Lake Louise criteria were met in 81.3% of suspected myocarditis cases, affirming the diagnostic utility of MRI.

In patients with dilated cardiomyopathy (n = 24), all had left ventricular (LV) dilatation, while 91.7% showed systolic dysfunction (EF < 40%), and 75% exhibited mid-wall fibrosis on LGE, consistent with non-ischemic dilated cardiomyopathy.

For hypertrophic cardiomyopathy (n = 12), asymmetric septal hypertrophy was seen in 83.3%, patchy LGE in 75%, and LV outflow tract (LVOT) obstruction in 50%, reflecting the classic phenotype of this condition and its risk stratification markers.

In arrhythmogenic cardiomyopathy (n = 8), RV wall motion abnormalities were noted in 87.5%, RV dilatation in 75%, while fatty infiltration and subepicardial LGE were each seen in 62.5%, emphasizing the role of MRI in detecting subtle right ventricular structural changes not easily seen on echocardiography.

Table 4 : Diagnostic Performance of Cardiac MRI

Condition	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Myocarditis (vs. clinical diagnosis)	81.30%	91.70%	92.90%	78.50%
Dilated Cardiomyopathy	95.80%	100%	100%	96.20%
Hypertrophic Cardiomyopathy	91.70%	98.40%	91.70%	98.40%
Arrhythmogenic Cardiomyopathy	87.50%	96.70%	87.50%	96.70%

Table 4 evaluates the diagnostic performance of cardiac MRI in terms of sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) compared to clinical diagnosis. Cardiac MRI demonstrated high diagnostic accuracy for all conditions. For myocarditis, the sensitivity was 81.3%, specificity 91.7%, PPV 92.9%, and NPV 78.5%, confirming its robustness in identifying true positives while minimizing false positives.

For dilated cardiomyopathy, MRI showed near-perfect diagnostic performance with 95.8% sensitivity, 100% specificity, and 100% PPV, underlining its ability to both confirm and exclude the condition accurately. Similarly, in hypertrophic cardiomyopathy, the sensitivity was 91.7%, and specificity 98.4%, with high predictive values, showing MRI’s reliability in detecting phenotypic and fibrotic changes.

For arrhythmogenic cardiomyopathy, MRI achieved a sensitivity of 87.5% and specificity of 96.7%, indicating excellent diagnostic capability even for this challenging-to-diagnose condition.

Discussion

This study demonstrates the critical role of cardiac magnetic resonance imaging (CMR) in the evaluation of patients with suspected myocarditis and various forms of

cardiomyopathy. Among the 76 patients assessed, myocarditis was the most common clinical indication, followed by dilated, hypertrophic, and arrhythmogenic cardiomyopathies. The results highlight the superior diagnostic capabilities of CMR, particularly in tissue characterization, functional assessment, and non-invasive detection of myocardial pathology.

In our cohort, myocardial edema, early gadolinium enhancement (EGE), and late gadolinium enhancement (LGE) were observed in 78.1%, 62.5%, and 87.5% of suspected myocarditis cases, respectively, and 81.3% met the Lake Louise Criteria (LLC). These findings are consistent with the JACC White Paper by Friedrich et al., which reported that LLC improves diagnostic specificity when at least two of three criteria are met, particularly in acute myocarditis cases [9]. Similar diagnostic rates were also noted in the study by Abdel-Aty et al., which showed that LGE and T2-weighted imaging significantly improved the detection of myocardial inflammation in myocarditis [10].

Our study revealed high diagnostic accuracy for dilated cardiomyopathy (DCM), with CMR showing 95.8% sensitivity and 100% specificity. All DCM cases showed LV dilatation, and 75% exhibited mid-wall fibrosis on LGE. These results are in agreement with Assomull et al., who highlighted the prognostic importance of mid-wall LGE in DCM patients and its correlation with adverse outcomes [11]. A study by Mahrholdt et al. further reinforced the utility of CMR in distinguishing non-ischemic DCM from ischemic cardiomyopathy, using the characteristic mid-myocardial fibrosis pattern [12]. In hypertrophic cardiomyopathy (HCM), asymmetric septal hypertrophy was seen in 83.3%, with LGE present in 75% of cases, consistent with myocardial fibrosis. LVOT obstruction was observed in 50% of patients. These findings are comparable to those reported by Moon et al., who demonstrated the role of CMR in detecting subtle

myocardial fibrosis and measuring wall thickness with higher accuracy than echocardiography [13]. The presence of LGE has also been associated with increased risk of ventricular arrhythmias and sudden cardiac death in HCM patients, making CMR a valuable prognostic tool [14].

For arrhythmogenic cardiomyopathy (ARVC), RV wall motion abnormalities and RV dilatation were noted in most patients, with fatty infiltration and LGE seen in 62.5%. This supports the findings of Sen-Chowdhry et al., who emphasized that MRI is instrumental in detecting fibrofatty replacement in the RV and helps meet the revised Task Force Criteria for ARVC diagnosis [15]. In India, a study by Sharma et al. also reported similar imaging characteristics in ARVC patients, supporting the broader applicability of these findings in Indian populations [16].

The overall diagnostic performance of CMR in this study was high across all conditions. For myocarditis, sensitivity was 81.3%, while for cardiomyopathies, sensitivity ranged from 87.5% to 95.8%, with specificity consistently above 91%. These values demonstrate CMR's effectiveness not just as a diagnostic modality but also in guiding clinical management and risk stratification.

The study findings are aligned with those of Choudhury et al. in India, who reported that CMR significantly altered the diagnosis and management in nearly 60% of patients referred with suspected cardiomyopathy or myocarditis [17]. This supports the increasing incorporation of CMR into routine cardiology practice in both Indian and international settings.

Conclusion

Cardiac MRI provides a comprehensive evaluation of myocardial structure, function, and tissue characterization, making it an indispensable tool in the diagnosis and differentiation of myocarditis and various cardiomyopathies. Its superior diagnostic

accuracy and ability to non-invasively identify myocardial inflammation and fibrosis enhance clinical decision-making, particularly in cases where echocardiography and other modalities are inconclusive.

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Conflict of Interest : None

References

1. Feldman AM, McNamara D. Myocarditis. N Engl J Med. 2000 Nov 9;343(19):1388–98.
2. Maron BJ, Towbin JA, Thiene G, Antzelevitch C, Corrado D, Arnett D, et al. Contemporary definitions and classification of the cardiomyopathies. Circulation. 2006 Apr 11;113(14):1807–16.
3. Abdel-Aty H, Boyé P, Zagrosek A, Wassmuth R, Kumar A, Messroghli D, et al. Diagnostic performance of cardiovascular magnetic resonance in patients with suspected acute myocarditis: comparison of different approaches. J Am Coll Cardiol. 2005 Jun 21;45(12):1815–22.
4. Mahrholdt H, Wagner A, Judd RM, Sechtem U, Kim RJ. Delayed enhancement cardiovascular magnetic resonance assessment of non-ischaemic cardiomyopathies. Eur Heart J. 2005 Feb;26(15):1461–74.
5. Friedrich MG, Sechtem U, Schulz-Menger J, Holmvang G, Alakija P, Cooper LT, et al. Cardiovascular magnetic resonance in myocarditis: A JACC White Paper. J Am Coll Cardiol. 2009 Apr 28;53(17):1475–87.
6. Moon JC, Reed E, Sheppard MN, Elkington AG, Ho SY, Burke M, et al. The role of cardiovascular magnetic resonance in the diagnosis of hypertrophic cardiomyopathy. Eur Heart J. 2004 Dec;25(24):2299–308.

7. Sen-Chowdhry S, Syrris P, McKenna WJ. Role of genetic analysis in the management of patients with arrhythmogenic right ventricular dysplasia/cardiomyopathy. J Am Coll Cardiol. 2007 Nov 6;50(19):1813–21.
8. Assomull RG, Prasad SK, Lyne J, Smith G, Burman ED, Khan M, et al. Cardiovascular magnetic resonance, fibrosis, and prognosis in dilated cardiomyopathy. J Am Coll Cardiol. 2006 Jul 18;48(3):789–97.
9. Friedrich MG, Sechtem U, Schulz-Menger J, et al. Cardiovascular magnetic resonance in myocarditis: A JACC White Paper. *J Am Coll Cardiol.* 2009;53(17):1475–87.
10. Abdel-Aty H, Boyé P, Zagrosek A, et al. Diagnostic performance of cardiovascular magnetic resonance in patients with suspected acute myocarditis. *J Am Coll Cardiol.* 2005;45(12):1815–22.
11. Assomull RG, Prasad SK, Lyne J, et al. Cardiovascular magnetic resonance, fibrosis, and prognosis in dilated cardiomyopathy. *J Am Coll Cardiol.* 2006;48(3):789–97.
12. Mahrholdt H, Wagner A, Judd RM, et al. Delayed enhancement cardiovascular magnetic resonance assessment of non-ischaemic cardiomyopathies. *Eur Heart J.* 2005;26(15):1461–74.
13. Moon JC, Reed E, Sheppard MN, et al. The role of cardiovascular magnetic resonance in the diagnosis of hypertrophic cardiomyopathy. *Eur Heart J.* 2004;25(24):2299–308.
14. Maron MS, Appelbaum E, Harrigan CJ, et al. Clinical profile and significance of delayed enhancement in hypertrophic cardiomyopathy. *Circ Heart Fail.* 2008;1(3):184–91.

15. Sen-Chowdhry S, Syrris P, McKenna WJ. Role of genetic analysis in the management of patients with arrhythmogenic right ventricular dysplasia/cardiomyopathy. *J Am Coll Cardiol.* 2007;50(19):1813–21.
16. Sharma S, Jain R, Bahl A, et al. Role of cardiovascular magnetic resonance in arrhythmogenic right ventricular cardiomyopathy: A tertiary centre experience. *Indian Heart J.* 2010;62(4):322–6.
17. Choudhury L, Mistry N, Patel AR, et al. Clinical utility of cardiac magnetic resonance imaging in patients with cardiomyopathy and myocarditis in an Indian population. *Indian Heart J.* 2014;66(4):408–12.