



RESEARCH ARTICLE

CHARACTERISATION OF HYPERTROPHIC CARDIOMYOPATHY BY CARDIAC MAGNETIC RESONANCE IMAGING

Dr. Nava Udaya N.R, Dr. Ramiah Rajesh Kannan, Dr. Srikanth Moorthy, Dr. Resmi Sekhar, Dr. Amol Anil Kulkarni and Dr. Chandiri Anvesh Reddy

Department of Radiodiagnosis, Amrita School of Medicine, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham, Kochi, Kerala, India.

Manuscript Info

Manuscript History

Received: 25 September 2021

Final Accepted: 27 October 2021

Published: November 2021

Key words:-

Cardiac MRI, Hypertrophic
Cardiomyopathy, Left Ventricle
Hypertrophy, Morphology, Myocardial
Scar

Abstract

Background: There are many causes of left ventricular hypertrophy which can result in arrhythmias and sudden cardiac death. Hypertrophic cardiomyopathy (HCM) is one of the commonly encountered cause of sudden cardiac death in young adults.

Aim: Identifying the role of Cardiac MRI in characterising the diagnostic parameters of HCM.

Materials and methods: 125 patients with clinical suspicion or genetic evidence of HCM referred for cardiac MRI between June 2013 to June 2021 were included under the study. Image interpretations were done by fellowship qualified cardiac imaging radiologist. Categorical variables were expressed using frequency and percentage. Numerical variables were presented using mean and standard deviation.

Results: Out of the total population, 119 patients (95 %) had LV wall thickness > 13 mm, 48 patients (38.4%) had Left ventricle outflow tract obstruction (LVOTO) and 32 patients (25.6 %) had mid cavity obstruction, 39 patients (37.9 %) had myocardial scar > 15 % and asymmetric septal hypertrophy was the most frequently encountered left ventricle morphology

Conclusion: Cardiac MRI detected HCM has a statistically significant association with the final diagnosis (histopathological and genetic correlation). CMRI hence serves as a reliable tool in identifying and characterising the various diagnostic and non-diagnostic parameters of HCM.

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Introduction:-

Left ventricular hypertrophy results in various adverse effects like arrhythmias, diastolic heart failure, systolic heart failure and sudden cardiac death. Out of the various causes, Hypertrophic cardiomyopathy is one of the most common genetic cause of left ventricular hypertrophy leading to sudden cardiac death. It is usually identified by a LV wall thickness > 13 mm. Most of the patients have associated left ventricle outflow tract (LVOT) obstruction with outflow tract gradient > 30 mm hg. Usually, 2 D echocardiography is the first line tool used in patients with suspicion of any LVH. However, it has certain limitations, particularly in obese patients with poor acoustic window. CMR on the other hand provides a better clarity of anatomical structures. It can also support with

Corresponding Author:- Dr. Nava Udaya NR

Address:- Department of Radiodiagnosis, Amrita School of Medicine, Amrita Institute of Medical Sciences, Amrita Vishwa Vidyapeetham, Kochi, Kerala, India.

information regarding myocardial fibrosis. The final confirmatory diagnosis of HCM is possible with histopathological and genetic correlation.

Materials & Methods:-

Study setting:

Department of Radiology, Amrita Institute of Medical Sciences

Duration of study:

For seven years duration starting from June 2013 to June 2021 after the date of approval from the thesis protocol review committee (Scientific, Ethical & Financial), Amrita Institute of Medical Sciences and Research Centre, Kochi, Kerala.

Study Design:

Cross Sectional analytical study (Combined prospective and partly retrospective cases)

Study population:

Patients with clinical suspicion/ genetic evidence of HCM undergoing cardiac MRI in Amrita Institute of Medical Sciences.

Inclusion criteria:

Cases referred for cardiac MRI with clinical suspicion/ genetic evidence of HCM.

Exclusion criteria:

Patients with cardiac pace makers/ renal failure / contrast allergy.

Sample size:

Based on the results of Mean and S.D of left ventricle wall thickness (22.5 ± 9.6) by cardiac MR in assessing HCM among patients suspected of having HCM observed in an earlier publication (Rickers, Carsten, et al. "Utility of cardiac magnetic resonance imaging in the diagnosis of hypertrophic cardiomyopathy." *Circulation* 112.6 (2005): 855-861) and with absolute precision of 2 units and 95% confidence, the minimum sample size comes to 89.

Objective:-

To assess the utility of cardiac MRI in assessing the diagnostic parameters of HCM.

Technical aspects:

Patients are instructed to practice breath holding before going into the MRI scanner. ECG leads are attached to the patient's chest wall. A respiratory trigger that assesses the abdominal wall and chest wall movements is tied on the patient. MRI is done in supine position using multiarray cardiac coil. Images are taken in 2 chamber, 4 chamber, short axis and outflow views. Then 0.2 mmol /kg gadolinium contrast is given through the intravenous cannula. Post contrast images are taken.

Image Interpretation:

Cardiac MRI image interpretation was done by a fellowship qualified cardiac imaging radiologist. The patients were categorised according to their causes of LVH. Their morphological parameters were described in detail which included the following data:

1. LV wall thickness > 13 mm and > 30 mm
2. Left ventricular cavity obstruction:
 - 2 a. Left Ventricle Outflow Tract Obstruction (LVOT):
 - 2 b. Mid cavity obstruction
3. Myocardial Delayed Enhancement (MDE): myocardial scar detection and quantification.
4. Myocardial T1 and T2 values (Normal myocardial T1 value: 1200 to 1250 msec, Normal myocardial T2 value: 40 to 45 msec)
5. Mitral valve abnormalities: Elongated anterior mitral leaflet (AML) length / Systolic anterior motion (SAM).
6. LV morphology

7. Additional LV morphology:
 - 8a. LV apical aneurysm
 - 8b. LV apical clots
8. Papillary muscle anatomy

Being a partial retrospective and partial prospective study, T1 & T2 mapping could not be performed for all patients. Data was available only in 27 patients with MRI taken after 2019.

Statistics:

Statistical analysis was performed using IBM SPSS version 20.0 software. Categorical variables were expressed using frequency and percentage. Numerical variables were presented using mean and standard deviation.

Results:-

Out of total 125 patients (100%) detected to have HCM, 119 patients (95.2 %) were found to have LV wall thickness > 13 mm. The 6 patients with LV wall thickness < 13 mm were genotype positive and phenotype negative patients. Out of 119 patients with wall thickness > 13 mm, 6 patients (5 %) had LV wall thickness > 30 mm. The mean LV wall thickness in HCM patients is 23.2 mm with S.D : 5.9

Out of total 125 patients finally detected to have HCM, 48 patients (38.4%) were having LVOTO and 32 patients (25.6 %) were found to have mid cavity obstruction, 7 patients (5.6 %) had left ventricular apical aneurysm, 54 patients (43.2 %) had mitral valve abnormalities, 5 patients (4%) had papillary muscle abnormality, 37 patients (29.6%) were found to have left atrial dilatation, 2 patients (1.6 %) were having LV clots.

Table1:- Distribution of CMR parameters in HCM patients.

Morphological parameters	% of HCM patients
LV wall thickness >13 mm	95.2
LV wall thickness > 30 mm	5
Obstructive HCM	64
Left atrial dilatation	29.6
Mitral valve abnormality	43.2

The most frequently encountered LV morphology was asymmetric septal hypertrophy seen in 79 persons (63.2%).

Table 2:- Distribution of LV morphology in HCM patients.

LV morphology	% of HCM patients
Normal LV morphology (Genotype positive, phenotype negative)	2.4
Concentric symmetric LVH	12
Sigmoid septal contour	0.8
Asymmetric septal hypertrophy	63.2
Apical hypertrophy	11.2
LVH with mid myocardial predominance	5.6
Biventricular asymmetric hypertrophy	4.8

Out of total 125 patients detected to have HCM, data regarding presence of myocardial scar was not available for 1 patient (due to late stage renal failure contrast imaging was deferred). Out of the 124 patients with data available, 97 (78.2 %) patients were having scar. The most common form of scar pattern was midmyocardial scar with septal involvement seen in 83 % of patients. Rest 17 % patients had mid myocardial scar without septal involvement. 39 patients (37.9 %) had myocardial scar > 15 %. Out of these 39 patients with myocardial scar > 15 %, maximum percentage of HCM patients had LV morphology of asymmetric septal hypertrophy (66.6%). Out of total 125 patients detected to have HCM, 27 patients had CMR data regarding Myocardial T1 values available, out of which 24 patients (88.9%) were having elevated myocardial T1 values.

Table 3:- Distribution of CMR parameters specific for myocardial viability in HCM patients.

CMR parameters specific for myocardial viability	% of HCM patients
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Myocardial scar	78.2
Mid myocardial scar with septal predominance	83
Scar >15 %	37.9

Discussion:-

LV wall thickness > 13 mm:

It seems to be the most frequently encountered finding in patients with HCM (90.4 %). Yet there were few patients with genetically proven HCM having LV wall thickness < 13 mm. These patients mostly belonged to younger age group (< 20 years) and are phenotype negative patients. LV wall thickness > 13 mm is the most important diagnostic parameter for the diagnosis of HCM. (16) As described by Rafaela Soler et al, the phenotypic expression of HCM is variable and present in subclinical forms where the LV wall thickness can be < 13mm. The left ventricular wall thickness > 13 mm might develop at latter periods of life in these patients (13). In our study population, most of the patients with HCM had LV wall thickness > 13 mm. Whereas few of them, particularly those belonging to relatively younger age group were having LV wall thickness < 13 mm. These patients might have sub clinical form of HCM who might develop increased LV wall thickness at latter periods of life.

LVOT obstruction and mitral valve abnormalities:

The next commonly encountered parameters in HCM patients are LVOT obstruction (38.4%) and mitral valve abnormalities (43.2 %). The presence of LVOTO can be due to presence of basal septal hypertrophy or systolic anterior movement of mitral valve or associated abnormal papillary muscle anatomy. Usually it is seen as a result of combination of these conditions (22) Out of the total HCM patients in our study population, those who had basal hypertrophy / mitral valve abnormalities like systolic anterior movement / papillary muscle hypertrophy were found to have LVOTO. Patients with other forms of HCM which does not involve basal septum, those with less severe forms of septal hypertrophy/ systolic anterior movement of mitral leaflet did not have LVOT obstruction.

Mid cavity obstruction and left ventricular apical aneurysm:

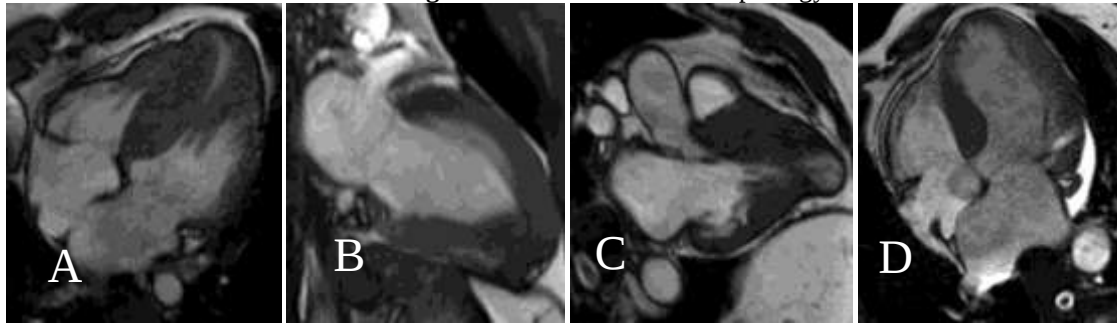
Mid cavity obstruction (25.6 %) is completely associated with patients having mid cavity HCM. Few of these patients with mid cavity obstruction found to have left ventricular apical aneurysm (5.6 %). Left ventricular apical aneurysm can be seen in patients with mid cavity HCM/ mid cavity obstruction (64). Mid cavity obstruction can be seen in patients with asymmetric left ventricular hypertrophy, particularly with the presence of mid myocardial predominance (65). Left ventricular apical aneurysm can also be seen as a complication in patients with apical HCM.(66) In our study all the patients with mid cavity obstruction were found to have LVH with mid myocardial predominance and few of these patients were found to have left ventricle apical aneurysm. None of the patients with apical HCM in our study population had left ventricle apical aneurysm.

Left atrial dilatation:

Left atrial dilatation is another important parameter seen in nearly one third (29.6%) of patients with HCM diagnosis. Almost all patients with left atrial dilatation had clinical / imaging manifestations of HCM, none of them were in the sub clinical stage. Left atrial dilatation is commonly seen in HCM patients and is an important parameter that identifies the risk for development of arrhythmia.(17) Though left atrial dysfunction / dilatation can be rarely seen in patients with subclinical HCM, left atrial dilatation is commonly encountered in patients with manifest form of HCM.(67) In agreement with statements of the above mentioned articles, all the HCM patients with left atrial dilatation were having manifest form of HCM.

Left ventricle morphology:

The most frequently encountered pattern of LV morphology in HCM patients of our study population is asymmetric septal hypertrophy. The least commonly encountered morphological pattern was sigmoid septal contour. Few genetically proven HCM patients were having normal left ventricular morphology (genotype positive, phenotype negative).

Figure 1:- Left ventricular morphology.

A) Cardiac MRI cine SSFP sequence, 4 chamber view in diastole showing asymmetric septal hypertrophy in HCM. B) Cardiac MRI cine SSFP sequence, 2 chamber view in diastole showing apical hypertrophy of left ventricle in HCM. C) Cardiac MRI cine SSFP sequence, left ventricle outflow tract view in systole showing mid ventricular hypertrophy with apical aneurysm in HCM. D) Cardiac MRI cine SSFP sequence, 4 chamber view in diastole showing sigmoid septal contour in HCM

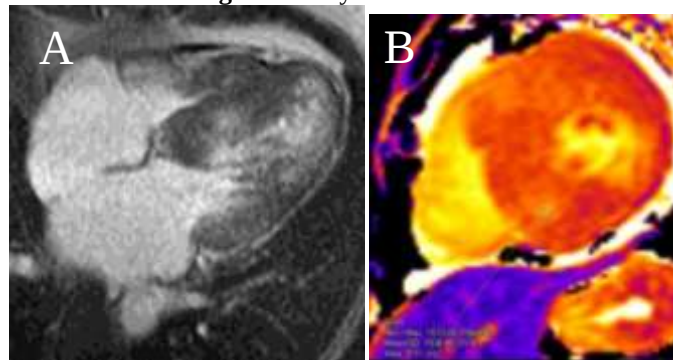
Radwa A Noureldin et al have suggested that asymmetric septal hypertrophy is the most common form of HCM.(23) In our study population highest proportion of HCM patients were found to have asymmetric septal hypertrophy which is in agreement with findings of Radwa A Noureldin et al. As discussed earlier even genetically proven HCM patients can have normal LV morphology in very early years of life, since most patients manifest with morphological features of HCM at or beyond middle age.

Myocardial scar:

Out of the HCM patients who underwent contrast enhanced CMR imaging, majority of them were found to have myocardial scar. Most of the patients with myocardial scar were found to have asymmetric septal hypertrophy. Analysis of the available scar quantification data showed that scar percentage > 15 % was seen in HCM patients with asymmetric septal hypertrophy. Lubna Choudhury et al have suggested that myocardial scar characterised by late gadolinium enhancement is frequently seen in areas of massive LV hypertrophy (68) Ameya Jagdish Baxi et al have suggested that asymmetric septal hypertrophy and concentric asymmetric LVH are the two most common forms of HCM with LV wall thickness > 15 mm (69). The results of our study population seems to be in agreement with the above mentioned articles.

T1 mapping:

Out of the limited group of people with T1 mapping data, most of them were found to have elevated myocardial T1 values. Myocardial T1 values are usually elevated in areas of fibrosis where there is expansion in extra cellular volume. This is a common finding in cardiomyopathies. (70) The findings of our study population is similar to the results of the study done by Swoboda et al.

Figure 2:- Myocardial scar.

(A) Cardiac MRI 4 chamber view, post contrast images: shows late gadolinium enhancement, suggesting fibrosis. (B) Cardiac MRI short axis view, T1 mapping in HCM patient: shows raised T1 values in hypertrophied myocardium suggesting underlying fibrosis.

Limitations:

Since it was a partially retrospective study, all the imaging parameters to be studied were not available for certain patients. T1 and T2 mapping could not be performed for all the patients. Contrast enhanced imaging could not be done for all the patients.

Conclusion:-

HCM happened to be the most common form of left ventricular hypertrophy in our study population. Presence of myocardial scar > 15 % which is a risk factor for development of sudden cardiac death is frequently associated with HCM. CMRI hence serves as a reliable tool in identifying and characterising the various diagnostic and non-diagnostic parameters of HCM. CMRI also proves to be an important imaging modality in detecting the patients at risk for sudden cardiac death.

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