ORIGINAL

ROLE OF CARDIAC MRI IN ACQUIRED DISEASES OF THE HEART

Wg. Cdr. A Alam, Col. M. N. Sree Ram
Dept. of Radiodiagnosis & Imaging, Armed Forces Medical College, Pune-411 040, India

Abstract : Even though Magnetic Resonance Imaging (MRI) has been in the forefront of imaging for the past two decades; it has only recently been perfected to a point where it can effectively capture the image of a beating heart. This has been possible with the recent development of high speed and high strength magnets, which are capable of providing detailed images of the heart. Cardiac MRI provides an accurate, safe, fast and non-invasive means of evaluation of the heart in congenital as well as acquired diseases; it can assess pericardial, myocardial and endocardial lesions and at the same time offer information about the functional status of the heart. Cardiac MRI was performed in 32 patients of age group ranging from 25 to 78 yrs. The procedure was carried out on a 1.5 Tesla (Siemens Magnetom Symphony) MR system using available protocols for cardiac imaging at a tertiary care centre. The study provided a new approach to the analysis of acquired diseases of the heart. Pericardial disease, damaged myocardium as a result of ischaemic heart disease and cardiomyopathies could be easily identified using this imaging modality. Therapeutic planning whether surgical or medical was to a great extent aided by the anatomic and functional information available from these images.

Conclusion: Cardiac MRI is a rapid, non-invasive and accurate technique for the diagnosis, pre-operative evaluation as well as post–operative assessment of a large number of cardiac diseases. Cardiac MRI has come to stay and with continued improvement in technology it will soon become an integral part of imaging studies of the heart.

INTRODUCTION

Magnetic Resonance Imaging (MRI) is becoming the gold standard for non-invasive assessment of cardiac morphology and function. High contrast between moving blood and myocardium, increased spatial resolution and lack of ionizing radiation make it an outstanding modality for assessment of myocardial anatomy and function. Complex congenital cardiac anomalies can be evaluated and morphological details of various chambers, septum, defects and anomalous connections are depicted accurately. Cardiac MR imaging has further utility in follow up of patients after corrective surgery. Assessment of cardiac function is another field where MRI scores over other available imaging modalities; quantification of ventricular volumes, ejection fractions and assessment of ventricular wall motion for dyskinesia are all possible using wall motion cine images[1]. Cardiac MRI scores over conventional non-invasive imaging modalities in evaluation of cardiomyopathies also. It accurately assesses the myocardium, septal thickness and chamber volume during systole as well as in diastole[2]. Perhaps the greatest advancement in cardiac MRI is its ability to evaluate myocardial viability following myocardial infarction as well to assess the effects of revascularization procedure on myocardial function. MRI is superior to echocardiography in evaluating various types of cardiac tumours with reasonable level of accuracy and it has a particular advantage of differentiating thrombus from tumor[3]. Pericardial disease has been evaluated using echocardiography ever since this modality has been available to clinicians; however its evaluation with echocardiography is limited if no effusion exists or if the effusion is complex. MRI does not have these limitations; instead it has high sensitivity in the diagnosis of pericardial effusion, thickening and most importantly constrictive pericarditis [4].

This article presents our experience with state-of- the- art applications of cardiac MRI in a variety of diseases of the heart and also reviews the current status and future prospects of this relatively new modality of imaging.

Correspondence: **Wg Cdr A Alam,** Associate Professor,
Tel: 020-26306033, 26306204, Fax: 020- 26877542

MATERIAL AND METHODS

Patient population

A total of 32 patients (20 males and 12 females) with age ranging from 25 to 78 yrs were included in this study, which was undertaken from July 2004 to June 2005 at the MRI centre of a tertiary care centre. The various indications for cardiac MRI included pericardial disease (10 cases); cardionyopathy (9 cases) mycardial viability studies(8 cases); evacuation of asshythmises (5cases).

Patient preparation

A detailed history was elicited from each patient including principal symptoms and signs, echocardiographic and cardiac catheterization data and operative status. MR-compatible electrocardiographic leads were placed on the anterior chest wall before imaging and attached to the MR imaging unit to provide electrocardiographic gating. The patient was positioned head- first in supine position with an integrated body array coil attached to the chest and MR imaging performed using breath holding as well as non- breath holding techniques. Detailed instructions regarding breath holding was given to the patients prior to commencement of the MR examination.

Cardiac MRI protocol

MR imaging was performed using 1.5 Tesla Siemens Magnetom Symphony MR equipment using standard protocols for MR imaging. To evaluate myocardial viability post contrast studies were performed using Gadolinium diethylene-triamine-pentaacetic acid (Gd-DTPA) in the dose of 0.2mmol/kg body weight administered intravenously. Initial image acquisition was done immediately after giving the contrast agent and subsequently delayed images were acquired after 12 and 16 minutes.

RESULTS

Data collection and image analysis

Cardiac MRI was performed in 32 patients and the MR images were reviewed by a panel of two radiologists both trained in MRI. The images obtained were evaluated for anatomical details, functional information about flow across valves and defects were assessed. Cine acquisitions provided information in real time regarding myocardial wall thickness and wall motion. The various abnormalities detected

on cardiac MRI in these patients are summarized in Table 1.

Table 1. *Various abnormalities detected on cardiac MRI (N=32)*

Abnormalities	Number of cases
Pericardial Disease	
· Pericardial effusion	4
· Pericardial thickening	3
· Constrictive pericarditis	1
· Normal study	2
Cardiomyopathy	
· Hypertrophic cardiomyopathy	3
· Dilated cardiomyopathy	2
· Normal study	3
Myocardial viability studies	
· Viable myocardium	3
· Irreversible myocardial damage	5
Evaluation of arrhythmias	
· Dysrhythmogenic Rt ventricular Dysplasia	3
· Normal study	3

DISCUSSION

The concept of using MRI as a modality to image the heart was considered a huge challenge till a few years ago; however with the recent development of modern technology and better software this has been overcome and the current state of the art MR machines allow us to image the beating heart non-invasively.

Apart from evaluation of congenital heart disease there are a number of acquired conditions of the heart, which can be accurately assessed using MRI. The pericardium, which has been traditionally, imaged using echocardiography; has now been increasingly imaged using MRI. The visceral pericardium, which consists of a single layer of cells and is not imaged on MRI in normal subjects; the parietal pericardium, which consists of fibrous tissue shows low signal on both T1 and T2, weighted images[5]. In normal patients the pericardium measures 2mm in thickness and is better visualized in systole, due to an increased pericardial space during cardiac ejection. On MRI thickened pericardium appears as a widened pericardial line of low signal on both T1 and T2 weighted images. On cine images a thickened pericardium has a constant width through out the cardiac cycle, whereas the pericardium in pericardial effusion has cyclical changes in width. Pericardial effusions complicated by adhesions or loculations are clearly shown on MRI; transudative effusion appears as low signal intensity on spin echo images and can be differentiated from an exudative or hemorrhagic effusion that has high signal intensity[6]. In addition, cine images can depict diastolic collapse of the chambers, which indicates tamponade. MRI has high sensitivity in the diagnosis of constrictive pericarditis; the presence of pericardial thickening in constrictive pericarditis differentiates it from restrictive cardiomyopathy. In such patients proper diagnosis is vital because although their presentations can be similar, their treatments differ markedly. Constrictive pericarditis requires pericardiectomy; restrictive cardiomyopathy necessitates medical management. In the present study there were four patients who had pericardial effusion,3 had pericardial thickening (Fig 1) and 1 patient had constrictive pericarditis. In all these patients MRI proved to be extremely useful in establishing the diagnosis and helping the clinician in instituting definitive therapy without wasting valuable time.

The cardiomyopathies, which represent muscular disorders of the heart; are subdivided into hypertrophic, dilated and restrictive types, each with unique pathological and physiological characteristics. MRI has been used as an investigative tool that aids in the understanding the anatomy as well as the physiological changes associated with this disorder. In hypertrophic cardiomyopathy MRI identifies the site and extent of hypertrophy. Additional findings that can be demonstrated include increased end-diastolic and decreased systolic thickening of the septal wall and systolic

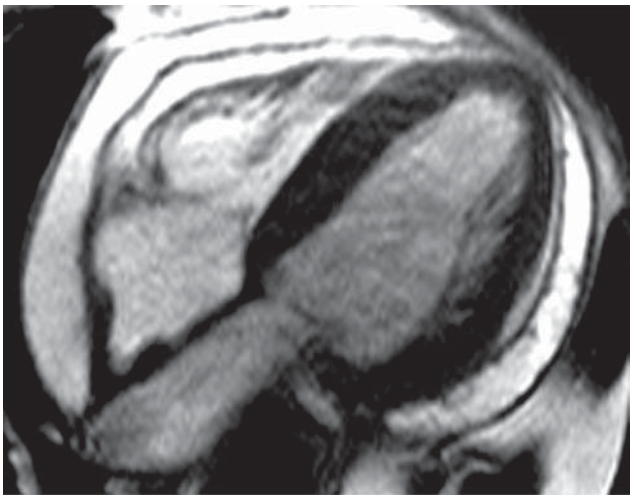

Figure 1. Pericardial thickening.
T2 weighted left ventricular outlet view (LVOT) showing pericardial thickening on the left side with significant pericardial effusion.

anterior motion of the mitral valve[7]. In the present study 3 patients had MR evidence of hypertrophic Cardiomyopathy in the form of apical and septal hypertrophy with increased end-diastolic and decreased systolic thickening of the septal wall. Dilated cardiomyopathy, which is the common end point of a variety of factors like alcohol, toxins, ischemia and viral disease leading to morphological changes of a grossly dilated heart. Pathologically, there is underlying myocardial fibrosis, accounting for the reduced contractility despite the increased muscle mass. MR imaging reveals a dilated heart with reduced ejection fractions. In the present study there were 3 patients who where detected to he having dilated cardiomyopathy (Fig 2). Restrictive cardiomyopathy is uncommon and results from infiltrative conditions leading to myocardial stiffness and restriction. Clinically, this disorder may have a presentation similar to that of constrictive pericarditis and based on hemodynamic studies it may be difficult to differentiate constrictive pericarditis from restrictive cardiomyopathy. MRI can help solve this problem by identifying increased pericardial thickness, which is seen in constrictive pericarditis, thus differentiating it from restrictive cardiomyopathy[8].

Cardiac MRI has been used increasingly in the evaluation of ischaemic heart disease; perhaps the greatest advancement of cardiac MRI is its ability to evaluate myocardial viability following infarction. Interpretation of myocardial viability is based on results from two different techniques; wall-motion using cine acquisitions and contrast enhancement imaging. Wall-motion cine images identify myocardial wall thinning and abnormal wall contraction whereas the presence of delayed myocardial enhancement after administration of gadolinium-based contrast agents accurately delineates irreversibly damaged myocardium and hence predicts areas that will not recover functionally even after revascularization[9]. In the

Figure 2.*Dilated Cardiomyopathy T2 weighted four-chambered view of a diastolic frame from cine acquisition showing dilated left ventricle with thinning of the myocardial wall.*

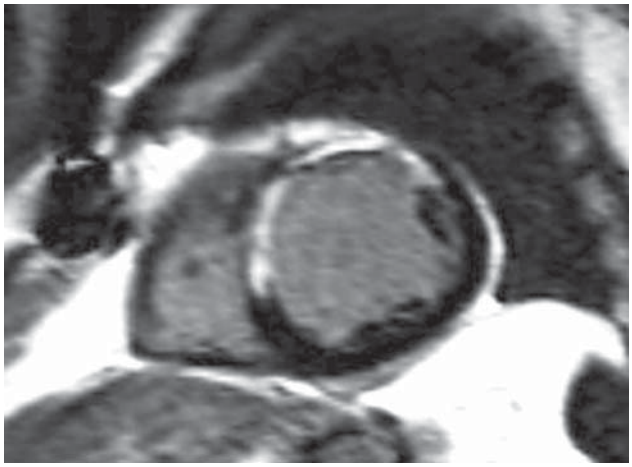

Figure 3. *Non-viable myocardium*
Delayed post contrast short axis MR image showing transmural enhancement of the anterior wall of the left ventricle consistent with non-viable myocardium.

present study 8 patients with documented coronary artery disease on coronary angiography were subjected to cardiac MRI with the aim to evaluate viability of the myocardium. The results based on post contrast delayed studies revealed presence of viable myocardium in 3 patients whereas in 5 patients there was evidence of irreversible myocardial damage (Fig 3).

Initially described in 1977, arrhythmogenic right ventricular dysplasia (ARVD) is a rare and familial disease characterized pathologically by fibrous and fatty replacement of the right ventricular myocardium. Patients generally present with arrhythmias of Rt ventricular origin, which may lead to sudden death. MRI has shown good results in diagnosing ARVD by providing information about regional wall motion, fatty infiltration of the Rt ventricular free wall and myocardial thinning [10]. On T1-weighted images focal areas of increased signal is observed in the Rt ventricular myocardium because of fatty infiltration. In the present study 6 patients were evaluated for suspected dysrhythmogenic Rt ventricular dysplasia by MRI and the same was confirmed in 3 patients whereas 3 were normal.

Latest research has opened up newer horizons in the field of cardiac imaging with a view to image the coronary arteries, which have been known to be one of the most difficult arterial circulations to image. The challenges for MRI in imaging coronary arteries are their inherent complex geometry and tortuosity, their small caliber and their continual displacement by respiratory and cardiac motion. With improvement in technology and continued research into the various techniques of 2 and 3-dimensional MR imaging, it will soon be possible to image the coronary circulation using MRI. Since 20–40% of all diagnostic catheter coronary angiograms reveal no clinically significant stenosis, the development of an accurate and non-invasive technique to image the coronaries using MRI would represent a significant improvement in management of patients with suspected coronary artery disease.

In *conclusion* it is reiterated that cardiac MRI has already emerged as a useful technique in the evaluation of congenital and acquired heart diseases. It has a specific role in myocardial viability studies and is being increasingly used as a "one-stop" comprehensive imaging modality in the morphologic and functional evaluation of the heart. With the continuing shift towards non-invasive diagnostic procedures the applications of cardiac MRI will continue to expand and with the ongoing advancements in equipment and scanning techniques it is not far when MRI will be the leading imaging modality for all types of cardiovascular diseases and in particular ischaemic heart disease.

REFERENCES

1. Pattynama PM, Lamb HJ, van der Velde EA, et al: Left ventricular measurements with cine and spin-echo MR imaging: a study of reproducibility with variance component analysis, Radiology 1993; 187:261-63.
2. Gaudio C, Pelliccia F, Tanzilli G, et al: Magnetic resonance imaging for assessment of apical hypertrophy in hypertrophic cardiomyopathy, Clin Cardiol 1992;15:164-66.
3. Martin DR, Merchant N, MacDonald C: MR imaging of cardiac masses: a review of current application and approach. Appl Radiol 2000; 3: 10-20.
4. Olson MC, Posniak HV, McDonald V: Computed tomography and magnetic resonance imaging of the pericardium. Radiographics 1989 Jul; 9(4): 633-49.
5. Stark DD, Higgins CB, Lanzer P, et al: Magnetic resonance imaging of the pericardium: normal and pathologic findings. Radiology 1984; 150:469-73.
6. W H T Smith, D J Beacock, A J P Goddard, T N Bloomer, J P Ridgway, U M Sivananthan. Magnetic resonance evaluation of the pericardium. British Journal of Radiology 2001; 74:384-92.
7. Sardanelli F, Molinari G, Petillo A, et al: MRI in hypertrophic cardiomyopathy:a morphofunctional study. J Comput Assist Tomogr 1993;17:862-66.
8. Masui T, Finck S, Higgins CB: Constrictive pericarditis and restrictive cardiomyopathy: evaluation with MR imaging. Radiology 1992; 182 (2): 369- 73.
9. Arend F L Schinkel, Jeroen J Bax, Don Poldermans. Clinical assessment of myocardial hibernation. Heart 2005; 91:111-117.
10. Blake L, Scheinman M, and Higgins C: MR features of arrhythmogenic right ventricular dysplasia, Am J Roentgenol 1994; 162:809-11.

CORRIGENDUM

Corrected versions of few spelling mistakes in the abstract of the article: Human Campylobacteriosis - an underdiagnosed etiology of Bacterial Diarrhea in India (April-June 2007 Issue) Vol. 20, No. 2 Page 147 are as under:

Dearrioea	*to be spelled as*	Diarrhoea
Immunocomprimised	*to be spelled as*	immunocompromised
Hort	*to be spelled as*	Host
Culture	*to be read as*	Cultural

Inconvenience caused is highly regretted.

Editor

Next Issue Highlights

Special Issue : Challanges of Diabetes in the Developing World

- Burden of Diabetes in the Developing World
- Young Onset Diabetes Mellitus
- Pre-Diabetes- Detection and Future Implications
- Gestational Diabetes Mellitus in India
- Management of Diabetes Mellitus : Current Perspective
- Diabetes & Coronary Artery Disease – The Twin Epidemic in the Developing World
- Diabetic Foot Disease in the Developing Countries
- Preventing Micro Vascular Complications In Diabetes Mellitus
- Diabetic Education: A Critical Component Of Diabetic Care
- Prevention Of Diabetes: Role Of Lifestyle Interventions
- Future Directions to Meet the Challenges of diabetes in the Indian setting (Innovative Therapies – Stem Cell Therapy, Pancreatic/Islet Cell Transplantation etc)
- Indigenous Drugs in the Treatment of Diabetes in India