International Journal of Research and Review
www.ijrrjournal.com E-ISSN: 2349-9788; P-ISSN: 2454-2237

Original Research Article

Comparative Assessment of Wall Motion Score Index and Left Ventricular Ejection Fraction in Patients with Ischemic Heart Disease Using Transthoracic: 2 D Echocardiography and Cardiac MRI

Dr. Saikat Bhattacharjee[1], Dr. Narendra Kumar Jain[2], Dr. Samar Chatterjee[2], Dr. Nitin Bajaj[3], Dr. Rajesh Uddandam[2]

[1]Department of Radiology, Military Hospital Cardiothoracic Center Pune.
[2]Department of Radiology, Armed Forces Medical College, Pune.
[3]Department of Cardiology, Command Hospital (NC), Pune.

Corresponding Author: Dr. Narendra Kumar Jain

ABSTRACT

Purpose: To compare the Left Ventricular Wall Motion Abnormalities (LVWMA) and Left Ventricular Ejection Fraction(LVEF) using transthoracic echocardiography with Cardiac Magnetic Resonance Imaging (CMRI) in patient with myocardial infarction.
Materials and methods: In this prospective, observational, comparative study fifty patients with ischemic heart disease (IHD) detected to have regional wall motion abnormality (RWMA) on echocardiography were subjected to CMRI. Left ventricle was divided into seventeen segments. LVWMA was calculated for each of these seventeen segments using both the modalities. LVWMA and LVEF calculated using both echocardiography and CMRI were compared using appropriate statistical tools.
Results: CMRI detected RWMA in all fifty patients. Segment wise comparison of WMA for each of the seventeen segments between CMRI and 2D showed a significant correlation. The distribution of total score of seventeen segments for RWMA on CMRI varied from 19 to 42 with a mean score of 29.2, while on echocardiography the score varied from 17 to 39 with a mean score of 26.52.On 2 D echo 34(68%) patients had an abnormal ejection fraction and 16(32%) patients had a normal ejection fraction. On MRI 39(78%) patients had an abnormal ejection fraction and 11(22%) had a normal ejection fraction. The distribution of calculated ejection fraction on MRI varied from 21 % to 68% with a mean ejection fraction value of 42.38, while the distribution of calculated ejection fraction on ECHO varied from 35 % to 69% with a mean ejection fraction value of 48.68%. A significant association was found between CMRI and 2d Echocardiography in the calculation of ejection fraction.
Conclusion: The study shows that CMRI can be used to assess the RWMA abnormalities and ejection fraction, which have prognostic implications in patients of IHD, with a very high degree of sensitivity, specificity and accuracy.
Keywords: *Cardiac MRI, Left ventricular ejection fraction, Regional wall motion abnormality, Ischemic heart disease*

INTRODUCTION

IHD is the primary cause of morbidity and mortality in the industrialized countries. The reported prevalence of coronary heart disease (CHD) in adult surveys has risen 4-fold over the last 40 years. CHD has now become the leading cause of mortality in India. A quarter of all mortality is attributable to CHD. [1] IHD involves a broad clinical spectrum, ranging from stable angina to sudden cardiac death. IHD leads to left ventricular dysfunction/ wall motion abnormalities.

Regional left ventricular wall motion dysfunction is a major consequence of myocardial ischemia, and its extent determines long-term prognosis. Accurate and reproducible analysis of left ventricular dysfunction is therefore useful for risk stratification and patient management. [2]

The imaging modalities currently used for the evaluation of left ventricular function are 2D echocardiography, CMRI and nuclear cardiology. Both 2D Echocardiography and contractile response by MRI have been used to identify viability of myocardium.

2-D Echocardiography has been traditionally used for the assessment of LVWMA because it is a real time imaging modality, can be used without respiratory or ECG gating and has excellent spatial and temporal resolution. Limitations of 2D Echocardiography are suboptimal visualization in subjects with poor acoustic window, patients with advanced COPD or open chest cardiac surgery and obese patients. Also, echocardiography is operator dependant and thus suffers from poor reproducibility. [3, 4]

Advances in cardiac magnetic resonance imaging have enabled capturing of the beating heart. There is high contrast between moving blood and myocardium, increased spatial resolution and lack of ionizing radiation. CMRI is used for quantification of ventricular wall motions (including RWMA), ventricular volumes, ejection fraction, for assessing myocardium viability, septal thickness and chamber volumes.

Literature comparing the LVWMA and LVEF using transthoracic echocardiography and CMRI is sparse. Aim of this study was to compare the LVMWA and LVEF data using transthoracic echocardiography with CMRI in patient with myocardial infarction. [5, 6]

MATERIALS AND METHODS

The study was carried out in departments of Radiodiagnosis and Cardiology of two tertiary care referral hospitals and was prospective, observational, comparative study. Fifty consecutive patients between June 2016 to Aug 2018 with clinical history of ischemic heart disease (IHD) and having ECG/stress test /angiographic evidence of IHD were subjected to 2D Echocardiography evaluation and those patients detected to have regional wall motion anomalies/ LV dysfunction were subjected to Cardiac MRI. Patients having contraindications to MRI examination, patients with uncontrolled atrial fibrillation, those detected to have significant valvular involvement on 2D echocardiography and those patients who could not satisfactorily hold their breath for more than 13 seconds (required for cine imaging) were excluded from the study. Informed consent was obtained from all patients prior to echocardiography and CMRI. Detailed information regarding history, clinical examination findings, ECG, cardiac enzymes, other investigations like angiography were obtained and recorded.

Echocardiography protocol

All echocardiography examinations were performed by two experienced cardiologists using Philips EPIQ 5 echocardiography machine. (Koninklijke Philips N.V) Parasternal long- and short-axis views, apical two, three, and four chamber views, were acquired for each patient in left lateral decubitus position.

For the analysis of contractile function, the left ventricle was divided into 17 segments according to the model of the American Heart Association. [7] Three representative short-axis slices obtained at the level of the apex, mid ventricle, and base were divided into four, six, and six segments, respectively. The apical segment (segment 17) was assessed on the apical 2 chamber and 4 chamber views. For each segment scoring was done using the following scoring system: X- Unable to interpret; 1- Normal; 2- Hypokinetic; 3- Akinetic; 4- Dyskinetic; 5- Aneurysmal.

Cardiac MRI protocol:

MR imaging was performed within 7 days of Echocardiography. Patients were examined with a 1.5-T MR scanner (Siemens MAGNETOM Symphony, Erlangen Germany) with a phased array body coil placed around the patient's chest. ECG gating and breath hold were used during the acquisition of the images. After 2 rapid surveys to determine the exact heart axis, 3 short-axis planes (apical, equatorial, basal) and a 4- and 2-chamber views was acquired. Cine images were acquired for the 2 chamber, 4 chamber and the short axis views.

The short axis views were obtained at more than three levels. However the three mandatory levels obtained were at the level of the mitral valve, at the mid cavity level (papillary muscle level) and at the level just short of the apex. Following pulse sequences were used - Trufiloc multi-gradient echo sequence, Hastetransverse dark blood TSE seq, Trufi2-chamber, Trufi 4-chamber, Trufishort axis, Trufi cine 2 chamber and 4 chamber.

For analysis, the MR images were transferred to ARGUS software. Images were displayed as continuous cine loops. All images were viewed on a computer console after removal of identifying information and were presented in random order. Endocardial movement and systolic wall thickening were evaluated off-line. Segmental wall motion were graded as normokinesia with score of 1, hypokinesia having score of 2, akinesia with score of 3, dyskinesia with score of 4 and aneurysmal given a score of 5. Left ventricular segmentation was done using AHA criteria into 17 segments. [7] The scoring of each segment was done and the scores were recorded.

The ejection fraction was calculated by using the area length equation [8] for calculation of volumes in both systole and diastole. The following equation used for the calculation of ventricular volume:- Ventricular volume = $(8 \times A_2 \times A_4) / (3\pi \times L_{min})$ where A_2 is the left ventricular area computed from the 2 chamber view, A_4 is the left ventricular area calculated from the 4 chamber view and L_{min} is the length of a line from the apex to the mitral valve plane. Ventricular volumes were calculated for the left ventricle in systole and diastole and the ejection fraction was calculated as:-Ejection fraction (%) = {(LV volume in diastole-LV volume in systole)/LV volume in diastole} x 100.

The time taken for the study (image acquisition and interpretation) was also recorded. The image quality was graded as very good, good, moderate or poor.

Statistical analysis

Statistical package for Social Sciences (SPSS) Software Version 23.0 was used for statistical analysis. Continuous variables were expressed as mean value±1 SD. Group differences were tested with a Student's t test for continuous variables and the Chi square test or Fisher's exact test for noncontiguous categorical variables. Results were considered significant if $P<0.05$. Sensitivity, specificity, accuracy, and predictive values (positive and negative) were calculated according to standard definitions and compared between groups.

Following variables were compared; Image categorization as satisfactory/unsatisfactory, difference in total scores, difference in mean scores of segment by segment comparison, difference in mean of score of seventeen segments comparison and difference in ejection fraction comparison.

OBSERVATIONS AND RESULTS

Cardiac MRI evaluation of 50 patients detected to have wall motion abnormalities on 2D Echocardiography was done. There were 49 males (98%) and 01 female (2%) in the study group. The youngest patient was 31 years old and the oldest patient was 75 years old. The mean age group was 60 + 15.5 yrs with maximum number of patient being in 61-70 years age group.

On 2 D echo 34(68%) patients had an abnormal ejection fraction and 16(32%)

patients had a normal ejection fraction. On MRI 39(78%) patients had an abnormal ejection fraction and 11(22%) had a normal ejection fraction. The distribution of calculated ejection fraction on MRI varied from 21 % to 68% with a mean ejection fraction value of 42.38, while the distribution of calculated ejection fraction on ECHO varied from 35 % to 69% with a mean ejection fraction value of 48.68%. A significant association was found between CMRI and 2d Echocardiography in the calculation of ejection fraction as p value was <0.05. (Table 1)

Table 1: Association between MRI & 2D Echo in the assessment of ejection fraction in the study group. (Percentages are given in parenthesis)

MRI	2D Echo		Total
	Abnormal	Normal	
Abnormal	34 (68)	5 (10)	39 (78)
Normal	0 (0)	11 (22)	11 (22)
Total	34 (68)	16 (32)	50 (100)

$\chi^2 = 26.09$, $P < 0.0001$, Sensitivity 100%, Specificity 68.75%, PPV 87.18 %, NPV-100%

As a part of the inclusion criteria all 50(100%) patients had RWMA on 2D Echocardiography. On evaluation with CMRI all these 50 patients (100%) were shown to have RWMA in one or more segments as well. (Figure 1-3)There is a strong association between CMRI and 2D Echocardiography in the calculation of total RWMA scores. Segment wise comparison of WMA scores was done for each of the seventeen segments between CMRI and 2D and a significant correlation with p value < 0.05 was found in each of these seventeen segments. The distribution of total score of seventeen segments for wall motion abnormalities on CMRI varied from 19 to 42 with a mean score of 29.2, while on echocardiography the score varied from 17 to 39 with a mean score of 26.52. (Table2)

Table 2: Comparison of total WMA scores of seventeen segments between MRI & 2D Echo. (Percentages are given in parenthesis)

Serial No	Scores	ECHO	CMRI
1	11- 20	6(12%)	6(12%)
2	21- 30	33(66%)	28(56%)
3	31- 40	11(22%)	13(26%)
4	41- 50	0(0%)	3(6%)
5	Total	50(100%)	50(100%)

There is a significant difference in the time taken for the completion of a study for evaluation of regional wall motion abnormalities and ejection fraction between 2D Echocardiography and CMRI. In our study CMRI took a mean time of 41.58 ± 2.38 min as compared to 2D Echocardiography which took a mean time of 27.4 ± 2.57 min.

Out of fifty patients, 7(14%) patients on the 2DEchocardiography had poor images in at least one segment. All fifty patients (100%) on Cardiac MRI had adequate quality images on CMRI. No statistical significant difference was seen for visibility of endocardial border on MRI and 2D Echo in the study group.(Table 3)

Table 3: Visibility of endocardial border on MRI and 2D Echo in study group

MRI	2D Echo			Total
	Poor	Good	Very good	
Moderate				
Good	2	12	13	27
Very good	5	7	11	23
Total	7	19	24	50

$\chi^2 = 2.57$, $P > 0.05$

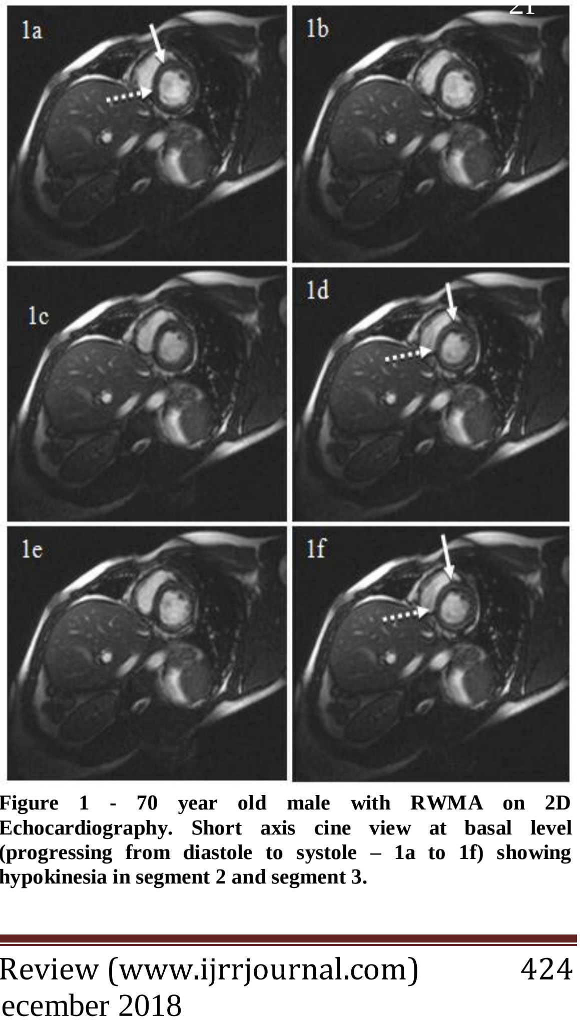

Figure 1 - 70 year old male with RWMA on 2D Echocardiography. Short axis cine view at basal level (progressing from diastole to systole – 1a to 1f) showing hypokinesia in segment 2 and segment 3.

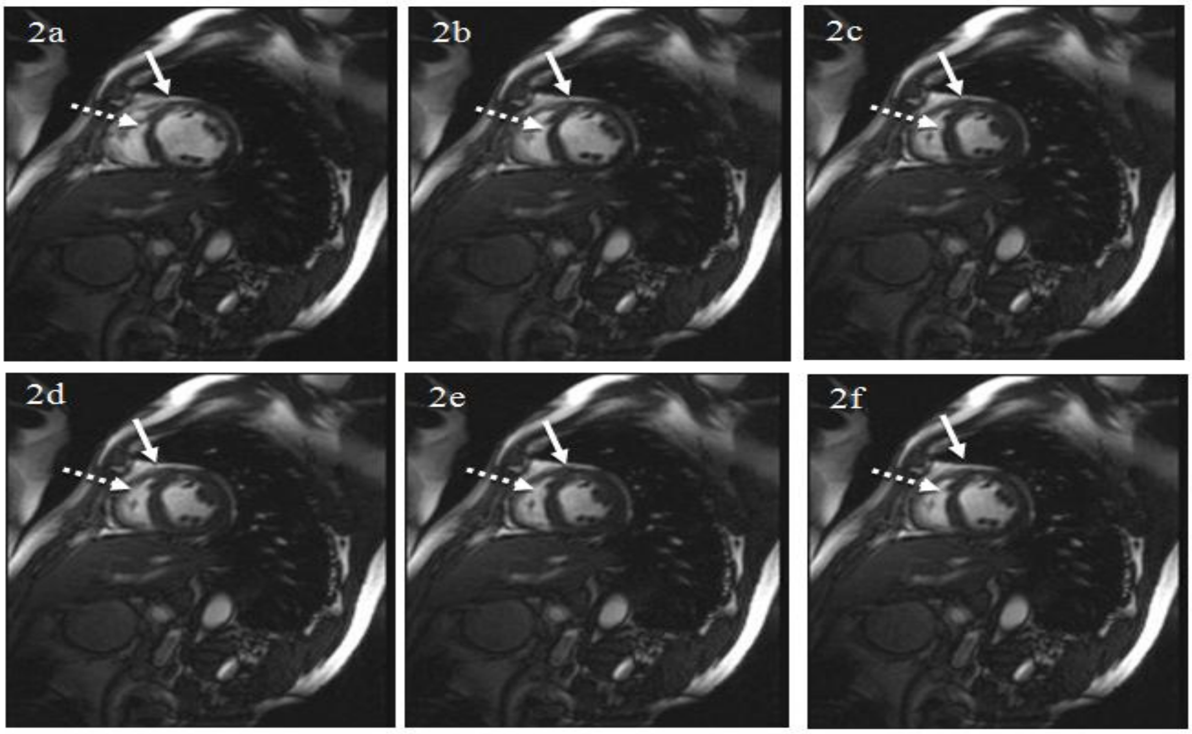

Figure 2- 65 year old patient with RWMA on 2 D Echocardiography. Short axis view at mid cavitary level (progressing from diastole to systole- fig 2a to 2f) showing hypokinesia and akinesia in segments 7 and 8 respectively.

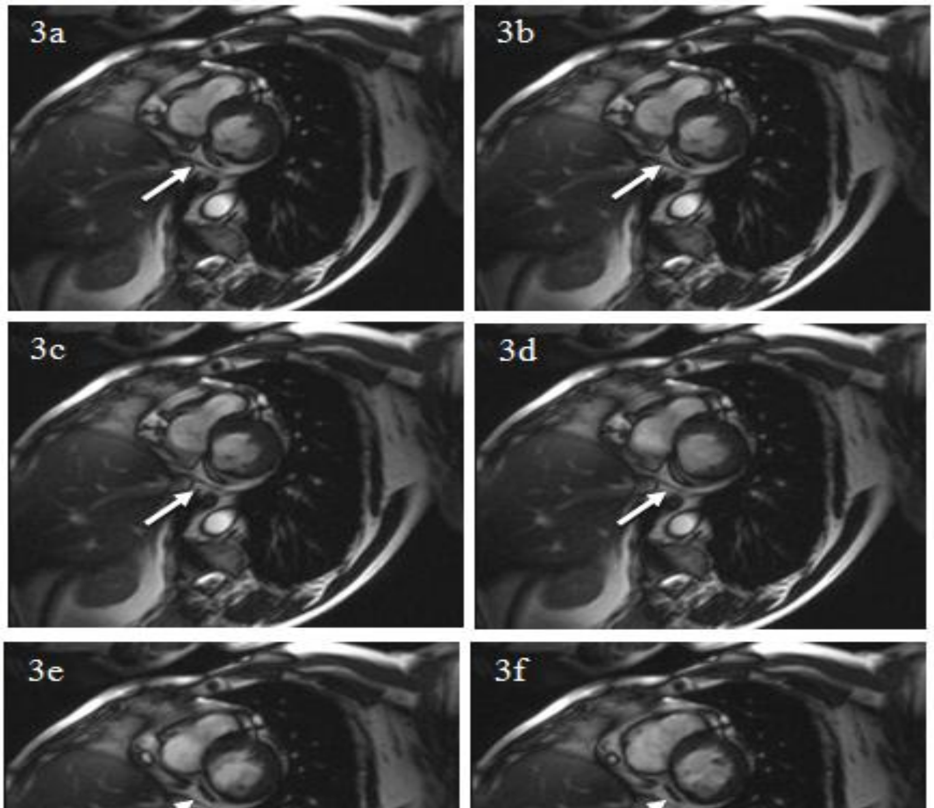

Figure 3. 69 year old patient with RWMA on 2 D Echocardiography. Short axis cine view at the mid cavitary level (progressing from diastole to systole- fig 3a to 3f) showing dyskinesia in segment 9.

DISCUSSION

IHD is the leading cause of morbidity and mortality in developed countries. [1] It leads to left ventricular dysfunction/wall motion abnormalities. Regional left ventricular wall motion dysfunction is a major consequence of myocardial ischemia, and its extent determines long-term prognosis. [2] Accurate and reproducible analysis of left ventricular dysfunction therefore has considerable implications for risk stratification, patient management and prognosis. 2-D ECHO has been traditionally used for the assessment of LVWMA because it is a real time imaging modality, can be used without respiratory or ECG gating and has excellent spatial and temporal resolution. [3,4] With the advent of recent advances in MR imaging hardware and faster MR sequences, CMRI is being used for quantification of ventricular wall motions (including RWMA) and ejection fractions. [5,6] The present study was done to determine the accuracy of CMRI in the detection of cardiac wall motion abnormalities in patients of ischemic heart disease who were detected to have RWMA on 2D Echocardiography.

In the study group, all 50 (100%) patients had wall motion abnormality involving one or more segments on 2D Echocardiography according to the inclusion criteria. On the CMRI of these 50 patients, an abnormal total score of more than 17, implying a regional wall motion abnormality in one or more segments was seen in all the patients (100%).The association between CMRI and echocardiography in the calculation of total score of wall motion abnormality was high and statistically significant.

The values of ejection fractions of the study population were compared between CMRI and 2D Echocardiography, considering a value of an ejection fraction above 55% normal. Thirty nine (78%) patients had an abnormal ejection fraction on CMRI as compared to 34 patients (64%) by 2D Echocardiography. The study shows a highly significant association between the ejection fraction as calculated by 2D Echocardiography and CMRI. This is in consonance with a previous multicenter trial by Hoffmann et al involving 55 patients comparing non contrast 2D Echo with MRI where significant correlation was established between the two modalities. [9] Marc Dewey et al also found a similar correlation between 2D Echocardiography and CMRI in a study of 33 patients comparing the calculation of left ventricular ejection fraction between a number of imaging modalities. [10]

It was also observed in our study that there was a tendency to underestimate the ejection fraction by CMRI as compared to 2D Echocardiography. Animal experiments and human studies have shown a very high accuracy of CMRI estimates of ventricular volumes and ejection fraction. [11-13] It is therefore likely that this difference in assessment of ventricular volumes and ejection fraction is due to the lower accuracy of the echocardiography to assess ejection fraction. It is felt that in view of the available experimental and clinical evidence, the ejection fraction assessment by CMRI may actually be more reliable in view of its accuracy and reproducibility with minimal intra- and inter-observer variability. [14-16]

In our study, the association between the assessment of RWMA by 2D Echocardiography and CMRI for all of the seventeen segments was statistically significant. Dewey et al also found a similar correlation between 2D Echocardiography and CMRI in the evaluation of regional left ventricular function. [10] In cases where the total score on CMRI and 2D Echocardiography differed, the CMRI score was higher in all patients except three of the fifty patients compared. Thus the scoring was estimated higher by CMRI. In view of the superior visualization of endocardial and myocardial borders by CMRI. [17] This is probably due to relatively inaccurate visualization of segments in some regions on 2D Echocardiography.

In a comparison between the time taken for the completion of the two studies for each patient a significant difference was found in the present study, with CMRI taking a longer time for the completion of the study. The mean time taken by CMRI for one study was 41.5±2.38 min as compared to 27.4 ±2.57 min for a single study on 2D Echocardiography. The longer time taken for CMRI studies is likely compensated by its objective nature and the fact that it is not affected by patient body habitus.

In our study, each segment was scored in all the fifty patients by both the modalities. Many segments were poorly visible on 2D Echocardiography. There were no studies deemed "too poor to score" by the cardiologist. However, the accuracy of the scoring is low for these studies, and these are listed as "poor" in the results. There were 07(14%) patients out of 50 that had poor studies on 2D echocardiography. CMRI obtained adequate visualization of all segments of the left ventricle in all 50(100%) cases. Cases deemed to be of "poor" diagnostic quality on 2D echocardiography were thus well assessed on CMRI. This has impacted the specificity measure of CMRI as the 2D echocardiography scores, though often obtained from poor quality studies, were considered as a true positive for analytical purposes. Poor visualization of segments on 2D Echocardiography was in all cases attributed to a poor sonographic window (scarring on the thoracic wall- one patient, obesity – 6 patients). This is in agreement with a previous study by Himelmann et al where the variability in evaluation of RWMA was found to be magnified in patients who were technically difficult to image due to reasons such as obesity, poor acoustic window and inability to achieve proper positioning during the examination. [18] The effect of poor imaging conditions and suboptimal acoustic window were also documented as compromising the determination of RWMA in many other previous studies. [19-22] The quality of the images of a patient on 2D Echocardiography had no correlation with qualities of images obtained on the CMRI. This means that the factors causing degradation of image quality on 2D Echocardiography had no such effect on the image quality on CMRI. This suggests that CMRI has an advantage over 2D Echocardiography in terms of image quality and thereby diagnostic content, where getting a sonographic window is a concern. This advantage somewhat compensates for the increased time taken for CMRI image acquisition.

The study has some limitations. This study has a relatively small sample size of fifty patients. The assessment of RWMA was a qualitative one with subjective assessment by the observers in both the modalities. As only a single observer assessed the images in each modality, no estimation of inter-observer variability could be made which may have an impact in clinical imaging in day to day practice. This study has excluded patients with arrhythmias and other conditions that limit the use of CMRI. Though this population constitutes a minority of patients with IHD, however, this limitation implies that the clinical impact of CMRI in these patients may be reduced.

CONCLUSION

Regional left ventricular wall motion dysfunction is a major consequence of myocardial ischemia resulting from ischemic heart disease, and its extent determines long-term prognosis. Accurate and reproducible analysis of left ventricular dysfunction therefore has considerable implications for risk stratification, patient management and prognosis. 2-D ECHO has been traditionally used for the assessment of RWMA. The study shows that CMRI can be used to assess the RWMA abnormalities and ejection fraction, which have prognostic implications in patients of IHD, with a very high degree of sensitivity, specificity and accuracy. Although the time taken for the study is longer than that taken for 2D Echocardiography, it is still practically acceptable for use in clinical practice. The quality of images acquired by CMRI are always good and do not suffer from limitations of poor sonographic window faced in echocardiography.

REFERENCES

1. Prabhakaran D, Jeemon P, Roy A. Cardiovascular Diseases in India Current Epidemiology and Future Directions. Circulation. 2016; 133:1605–1620.
2. Cleland JG, Torabi A, Khan NK. Epidemiology and management of heart failure and left ventricular systolic dysfunction in the aftermath of a myocardial infarction Heart 2005; 91: 7-13.
3. Horowitz RS, Morganroth J, Parrotto C, Chen CC, Soffer J, Pauletto FJ. Immediate diagnosis of acute myocardial infarction by two-dimensional echocardiography. Circulation. 1982; 65: 323–329.
4. Nishimura RA, Tajik AJ, Shub C, Miller FA Jr, Ilstrup DM, Harrison CE. Role of two-dimensional echocardiography in the prediction of in-hospital complications after acute myocardial infarction. J Am Coll Cardiol. 1984; 4: 1080–1087.
5. Mistry N, Halvorsen S, Hoffmn P t al Assessment of left ventricular function with magnetic resonance vs. echocardiography, and SPECT in patients with recent ST-elevation myocardial infarction.. European Journal of Echocardiography. 2010; 9(11); 793-800
6. Matthew S, Gandy SJ, Nicholas RS et al. Quantitative analysis of cardiac left ventricular variables obtained by MRI at 3T: a pre and post contrast comparison. Br J Radiol. 2012; 85(1015):e343-e347.
7. Cerqueira MD, Weissman NK, Dilsizian AK et al. Standardized myocardial segmentation and nomenclature for tomographic imaging of the heart. A statement for healthcare professional from the cardiac imaging committee of the council of the ClinicalCardiology of the AmericanHeart Association. Circulation, 105 (2002) pp 539-542.
8. Lawson MA, Blackwell GG, Davis ND, et al. Accuracy of biplane long-axis left ventricular volume determined by cine magnetic resonance imaging in patients with regional and global dysfunction. Am J Cardiol1996; 77:1098-104.
9. Hoffmann R, von Bardeleben S, ten Cate F, et al. Assessment of systolic left ventricular function: a multi-centre comparison of cineventriculography, cardiac magnetic resonance imaging, unenhanced and contrast-enhanced echocardiography Eur Heart J 2005; 26:607-616.
10. Dewey M, Müller M, Eddicks S, et al.Evaluation of Global and Regional Left Ventricular Function With 16-Slice Computed Tomography, Biplane Cineventriculography, and Two-Dimensional Transthoracic Echocardiography: Comparison With Magnetic Resonance Imaging J Am Coll Cardiol, 2006; 48:2034-2044
11. Koch JA, Poll LW, Godehardt E, et al. Right and left ventricular volume measurements in an animal heart model in vitro: first experiences with cardiac MRI at 1.0 T. Eur Radiol 2000; 10(3): 455-8.
12. Nahrendorf M, Hiller KH, Hu K, et al. Cardiac magnetic resonance imaging in small animal models of human- heart failure. Med Image Anal 2003; 7(3):369-75.
13. Holman ER, Vliegen HW, van der Geest RJ, et al. Quantitative analysis of regional left ventricular function after myocardial infarction in the pig assessed with cine magnetic resonance imaging. Magn Reson Med 1995; 34:161-9.
14. S. de Haan, K. de Boer, J. Commandeur et al. Assessment of left ventricular ejection fraction in patients eligible for ICD therapy: Discrepancy between cardiac magnetic resonance imaging and 2D echocardiography. Neth Heart J. 2014 Oct; 22(10): 449–455.
15. Michael A, Witcik M, Raghavendra M, et al. Comparison of left ventricle ejection fraction by echocardiography and cardiac magnetic resonance imaging in day to day clinical practice. Journal of Cardiovascular Magnetic Resonance2009; 11 (Suppl 1) :P270
16. Lebeau R , Serri K, Morice MC et al. Assessment of left ventricular ejection fraction using the wall motion score index in cardiac magnetic resonance imaging. Archives of Cardiovascular disease (2012)105, 91-98.
17. Barkhausen J, Ruehm SG, Goyen M, et al. MR evaluation of ventricular function: true fast imaging with steady-state precession versus fast low-angle shot cine MR

imaging: feasibility study. Radiology 2001; 219:264-9.
18. Himelman RB, Cassidy MM, Landzberg JS, Schiller NB.Reproducibility of quantitative two-dimensional echocardiography. Am Heart J. 1988 Feb; 115(2):425-31.
19. Hoffmann R, Lethen H, Marwick T, et al. Analysis of interinstitutional observer agreement in interpretation of dobutamine stress echocardiograms. J Am Coll Cardiol 1996; 27:330–6.
20. Nagel E, Lehmkuhl H-B, Bocksch W, et al. Noninvasive diagnosis of ischemia-induced wall motion abnormalities with the use of high-dose dobutamine stress MRI. Comparison with dobutamine stress echocardiography. Circulation 1999; 99:763–70.
21. Omoto R. Echocardiographic evaluation of left ventricular size, shape and function-advantages and limitations of this method. Circ J. 1982 Oct; 46(10):1121-6.
22. Hundley WG, Kizilbash AM, Afridi I, et al. Administration of an intravenous perfluorocarbon contrast agent improves echocardiographic determination of left ventricular volumes and ejection fraction: comparison with cine magnetic resonance imaging. J Am Coll Cardiol1998; 32:1426 – 32.

How to cite this article: Bhattacharjee S, Jain NK, Chatterjee S et.al. Comparative assessment of wall motion score index and left ventricular ejection fraction in patients with ischemic heart disease using transthoracic: 2 D echocardiography and cardiac MRI. International Journal of Research and Review. 2018; 5(12):421-429.

******