Correlation between Echocardiography and MRI in Volumetric Analysis of Dilated Cardiomyopathy - A Cross-Sectional Study from Puttaparthi, Andhra Pradesh

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ABSTRACT

BACKGROUND

Echocardiography is considered as a traditional approach to clinically study dilated cardiomyopathy. Because of poor apical visibility, however, volumetric calculations are difficult to ascertain. In calculating left ventricle volumes and ejection fractions, magnetic resonance (MR) imaging has shown to be more accurate than echocardiography. Due to conflicting literature, the present study was conducted to diagnose dilated cardiomyopathy using 2 D - echocardiography and correlate these echocardiographic findings with magnetic resonance imaging (MRI).

METHODS

This observational cross-sectional study was conducted in the Department of Radio-diagnosis and Imaging, Sri Sathya Sai Institute of Higher Medical sciences, Puttaparthi, Andhra Pradesh, Pin 515134. The study group consisted of consecutive patients who had clinical suspicion of dilated cardiomyopathy. A total of 40 patients underwent both 2 D - echo and cardiac MRI on the same day. All patients underwent 2 - D echo which was performed at the frame rate of 40 - 80 frames per second in the left lateral decubitus position to obtain standard 2, 3, and 4 chambers as well as short axis views (GE Vingmed Vivid 7 Dimensions, Horton, Norway: 2.5 MHz transducer). MRI was performed on a 1.5 T scanner (Mangnetom Aera, Siemens, Erlangen, Germany). For patient monitoring and cardiac synchronization, 3 - lead electrocardiography was used.

RESULTS

In the present study, in comparison to reference standard (cardiac MRI), 2 D - echocardiography showed significant and systematic underestimation of end-diastolic volume (EDV), end-systolic volume (ESV) and stroke volume (SV). Good correlation between 2 D - echo and cardiac MRI was noted for end-diastolic volume ($r = 0.89$), stroke volume ($r = 0.60$) and ejection fraction ($r = 0.75$).

CONCLUSIONS

In summary, magnetic resonance imaging is an accurate, non-invasive, safe and advanced modality for evaluation of global left ventricular function and myocardial scarring. 2 D - echocardiography can be used for screening of the patients with clinically suspected dilated cardiac myopathy (DCM) and their follow up.

KEYWORDS

Echocardiography, MRI, Cardiomyopathy

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BACKGROUND

Dilated cardiomyopathy is characterized by dilated and poor functioning left ventricle or both left and right ventricle in the absence of coronary artery disease[1] or abnormal loading conditions (i. e. hypertension, valve disease, anaemia) which will cause global systolic dysfunction. It is poorly understood disorder and associated with sudden cardiac death.[2] In dilated cardiomyopathy, the interstitium is altered and collagen content is increased.[3,4] Dilated cardiomyopathy is inherited in 20 - 50 % of cases and abnormalities are frequently seen on echocardiography in asymptomatic relatives.[5] Primary form of disease constitutes ~ 50 % cases and has a strong genetic prediction (~ 30 % cases). While in secondary dilated cardiomyopathy, ventricular dilation occurs as a result of extensive myocardial damage. Etiopathogenesis in such cases is extremely heterogeneous and includes group of systemic affections such as autoimmune, cytotoxic or metabolic diseases.[6,7] Incidence of DCM in India, North America and Western Europeans is estimated to be between 5 and 8 per 100,000 person per year and increasing steadily.[8]

Plain radiography can detect dilated cardiomyopathy however cannot provide any further details. Echocardiography is regarded as standard method to clinically study dilated cardiomyopathy. However, volumetric measurements are difficult to determine because of low apical visibility.[9] MR imaging has proved to be more reliable than echocardiography in measuring left ventricle volumes and ejection fraction.[10] In addition, MRI helps in characterization and differentiation of various form of dilated cardiomyopathy which is crucial to target patient's therapy and better risk stratification as different forms of the disease have variable prognosis. Cardiac MR imaging can be used to predict clinical outcome after cardiac resynchronization therapy which is done in patients with heart failure and DCM. Knowing the location, extent, and distribution of scarring help us to predict clinical outcomes with prognosis as shown by recent scientific literature.

Due to conflicting literature, the present study was conducted to diagnose dilated cardiomyopathy using 2D - echocardiography and correlate these echocardiographic findings with MRI.

METHODS

This cross-sectional study was conducted in the Department of Radio-diagnosis and Imaging, Sri Sathya Sai Institute of Higher Medical sciences, Whitefield, Bengaluru - 66, and Department of Radio-diagnosis and Imaging, Sri Sathya Sai Institute of Higher Medical sciences, Puttaparthi, Andhra Pradesh, Pin 515134. This study was done using data collected from June - 2013 to April-2015 for a period of 1 year 11 months. The study group consisted of consecutive patients who had clinical suspicion of dilated cardiomyopathy. The patients presented with various symptoms like acute chest pain, palpitation and stroke like symptoms. All the patients who underwent both the test i.e. echocardiography and cardiac MRI within 24-hour interval were included for the study. A total of 40 patients underwent both 2D - echo and cardiac MRI done on the same day. Concurrence was taken from the chairman, academic committee, scientific committee and ethical committee for the study. Informed consent was taken from patients / guardians for echocardiography and MRI scans.

Inclusion Criteria

1. Patients having ejection fraction < 35 %.
2. Both male and female of any age.

Exclusion Criteria

1. Coronary artery disease
2. Congenital heart disease
3. Significant valve disease
4. Other non-cardiac cause of heart failure (e.g. hyperthyroidism)
5. Contraindication to cardiac MRI study.

Imaging Protocols (Figure 1)

a. 2D echo acquisition protocol and data analysis: All patients underwent 2D echo which had been conducted at the frame rate of 40 - 80 frames per second in the left lateral decubitus position to acquire usual two, three & four chamber as well as short axis views (GE Vingmed Vivid 7 dimensions, Horton, Norway : 2.5 MHz transducer). Manual tracing of the endocardial border at end-systole and end - diastole was performed. Modified biplane Simpson's rule was used to calculate the end-diastolic and end - systolic volumes. All image post processing and analysis was performed by single observer with 8 years of experience.

b. MRI acquisition protocol and data analysis: MRI had been conducted on a 1.5 T scanner (MangnetomAera, Siemens, Erlangen, Germany). For patient monitoring and cardiac synchronization, 3 - lead electrocardiography was used. Using a segmented fast steady state, free precession sequence, cine MRI scan obtained were two, three & four chamber views and short axis orientations from base to apex during the end-expiratory breath-hold. Imaging parameters were repetition time : 2.8 ms, echo time : 1.2 ms, slice thickness : 8mm, no inter slice gap, voxel size : 1.7 x 1.3 x 8 mm 3, acquisition window : 34 ms (24 segments per phase), slice resolution : 100 % and flip angle : 54º. parallel imaging done with using factor 2. Using a single breath hold, 2 slices were acquired along the short axis orientations covering the entire heart from base to apex without gap.

Adenosine stress perfusion MRI was done in all patients to assess intramural microvascular circulation in cardiomyopathy. Study was done using stress / rest protocol by infusing adenosine at a rate of 140 µg / kg of body weight / minute in three minutes. Three long axes were planned along the left ventricle, including 4 - chamber, 2 - chamber

and 3 - chamber view. Care was taken for left ventricular outflow tract to exclude severe aortic stenosis as it is a contraindication for stress testing. A stack of 12 short axis slices covering both the ventricles was acquired. Perfusion sequence was started 30 seconds prior to the end of adenosine infusion with 0.1mmol / kg body weight injection of gadopentetate dimeglumine at a rate of 4 ml / sec. To allow contrast washout, a gap of 10 minutes was given between stress and rest perfusion. In case of completely normal stress perfusion, rest perfusion was skipped.

Delayed contrast improved images were obtained using two - dimensional segmented inversion-recovery prepared gradient-echo sequences in the same views as those used for cine MR imaging (repetition time: 9.8 msec, echo time : 4.4 msec, inversion time : 250 - 320 msec, voxel size : 1.3 x 1.6 x 5 mm 3) 10 - 15 minutes after the 0.2 mmol / kg body weight of gadopentetate dimeglumine.

Analysis of global left ventricular (LV) function was done on workstation (ARGUS version VA60c, Siemens) using Simpson's rule for calculating the end-diastolic volume , end-systolic volume , stroke volume , and ejection fraction . For this, epicardial and endocardial borders were marked on each slice on short - axis, the luminal area was then multiplied by slice thickness and the volumes of the slices were added to get final result. Basal slices with less than a semicircular muscular ring at end-systole was not included, papillary muscles were assigned to LV muscle, and LV outflow tract was also not included. All image post processing and analysis was performed by the single observer with 10 year of experience in cardiac MR imaging. On stress perfusion, segments showing ischemia were noted. Delayed contrast enhanced images showing scar were evaluated for their size, extent and nature (acute and chronic).

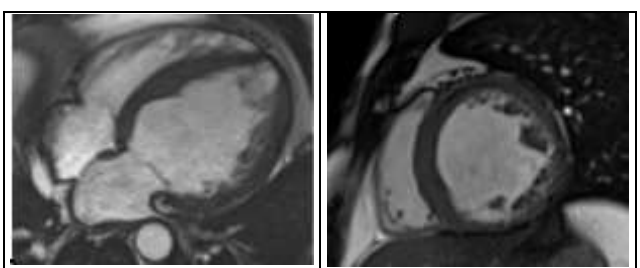

Figure 1. Case of Idiopathic Dilated Cardiomyopathy with Mid Wall Fibrosis. Balanced SSFP Cine Images (a) 4-Chamber and (b) Mid-Short Axis Showing Dilated Left Ventricle. Delayed Gadolinium Enhancement Image

Statistical Analysis

Descriptive and inferential statistical analysis was carried out in present study using SPSS 22.00 for windows (SPSS inc, Chicago, USA). Results on continuous measurements are presented on Mean ± SD (Min - Max) and results on categorical measurements are presented in number (%). Significance is assessed at 5 % level of significance. The following assumptions on data are made:

1. Dependent variables should be normally distributed.
2. Sample drawn from the population should be random and cases of the sample should be independent.

Student t-test (two tailed, dependent) has been used to find out the significance of study parameters on continuous scale within each group. Pearson correlation between study variables is performed to find out the degree of relationship.

RESULTS

The study group comprised of 40 patients, out of which 60 % were males and 40 % were females. In the present study, the peak age of presentation was 31 - 40 years of age (40 %) in both male and females. 22.5 % of patients were in age group > 50 years and 20 % of patients were in age - group 41 - 50 years. 17.5 % of patients are seen in age - group 20-30 years. 7.5 % patients had diabetes (100 % male) and high serum cholesterol level (100 % male). None of the patient gave the family history of similar illness. High normal (121 – 140 mm of Hg) blood pressure was seen in 75 % of male patients. In present study 7.5 % patients are chronic alcoholic (> 10 years of alcohol intake) and all are male. Dyspnoea was the most common symptom, seen in all the patients. Palpitation was the second most common presenting symptom, seen in 85 % of the patients (93.8 % of females and 79.2 % of males). Atypical chest pain was noted as third most common presenting complain and seen in 32.5 % of the patients (18.8 % females and 41.7 % males). 25 % of the patients had all three symptoms at the time of presentation.

82.5 % (75 % females, 87.5 % of males) of the patients were classified as NYHA class II. 15 % of the patients were classified as NYHA class III (18.8 % females and 12.5 % males). Only 2.5 % of patients were classified as NYHA class I at the time of clinical presentation (Table 1).

NYHA	Female	Male	Total
I	1 (6.3 %)	0 (0 %)	1 (2.5 %)
II	12 (75 %)	21 (87.5 %)	33 (82.5 %)
III	3 (18.8 %)	3 (12.5 %)	6 (15 %)
Total	**16 (100 %)**	**24 (100 %)**	**40 (100%)**

Table 1. New York Heart Association (NYHA) Class

Variables	Echocardiography	MRI	Mean Difference	t Value	P Value
Left ventricle end-diastolic volume	133.72 ± 44.65	164.16 ± 45.78	30.440	7.425	< 0.001*
Left ventricle end-systolic volume	109.76 ± 33.23	126.76 ± 35.00	17.000	7.667	< 0.001*
Left ventricle stroke volume	24.16 ± 13.46	34.60 ± 16.15	10.440	3.898	0.001*
Ejection fraction %	17.80 ± 5.74	18.20 ± 6.70	0.400	0.445	0.660

Table 2. Left Ventricle Volumetric Variables Comparison of Echocardiography and MRI

*: statistically significant

In present study, in comparison to reference standard (cardiac MRI), 2D - echocardiography showed significant and systematic underestimation of end-diastolic volume (P < 0.001), end-systolic volume (P < 0.001) and stroke

volume (P = 0.001). No significant over or underestimation of ejection fraction is seen (P= 0.66) as shown in table 2.

Good correlation between 2D - echo and cardiac MRI was noted for end-diastolic volume (r = 0.89), stroke volume (r = 0.60) and ejection fraction (r = 0.75). Excellent correlation was seen for end-systolic volume measurement (r = 0.94) as shown in table 3.

Pearson Correlation	R Value	P Value
E-Left ventricle end-diastolic volume vs M- Left ventricle end-diastolic volume	0.898	< 0.001*
E-Left ventricle end-systolic volume vs M-Left ventricle end-systolic volume	0.949	< 0.001*
E-Left ventricle stroke volume vs M-Left ventricle stroke volume	0.604	< 0.001*
E-Ejection fraction % vs M-Ejection fraction %	0.750	< 0.001*

Table 3. Correlation between 2D-Echo and Cardiac MRI

*: statistically significant

DISCUSSION

Echocardiography is the gold standard for diagnosing dilated cardiomyopathy in the clinic. Due to the poor apical visibility, volumetric dimensions are difficult to ascertain.[9] When it comes to calculating left ventricle volumes and ejection fraction, MR imaging has shown to be more accurate than echocardiography.[10] Furthermore, MRI assists in the classification and distinction of multiple types of dilated cardiomyopathy, which is essential for directing patient treatment and improved risk stratification due to the fact that different forms of the disease have different prognoses. Cardiac MR imaging will help determine how patients with heart failure and DCM will respond to cardiac resynchronization therapy. According to recent science literature, knowing the place, magnitude, and distribution of scarring will help us predict clinical results and prognosis. The current research was performed to identify dilated cardiomyopathy using 2 D - echocardiography and compare these echocardiographic results with MRI due to contrasting literature.

Dilated cardiomyopathy is most common form of non-ischemic cardiomyopathy. Primary form of disease is seen in ~ 50 % of the patients with DCM, and at least 25 - 30 % of patients labelled as idiopathic found to have familial disease. In the present study, 85 % of the patients are found to be idiopathic and none of the patients gave the family history of similar cardiac disease. Inability to detect familial cases could be a potential explanation for the high prevalence of idiopathic cases in present study.

With respect to gender, 60 % and 40 % constituted male and female patients respectively, with the sex-ratio being 1.5:1. The same observation was found by Nallari P et al.[11] unlike few previous studies which report female preponderance.[12] The preponderance of males could be explained on the basis of hormonal variations, genetic background and their different life style. Probably male hormones lead to greater vulnerability to factors altering membrane integrity, as it is well established that oestrogens are cardioprotective.[13] Preponderance of female patients below 20 years of age can be attributed to genetic background, while preponderance of females above 50 years of age can be explained by depletion of oestrogen in menopausal age group. In present study, 40 % of patients belonged to 31-40 years age group, 20 % were between 41-50 years and 22.5 % belonged to the > 50 years age group, indicating the possible role of secondary risk factor like alcohol and smoking or age-related systemic disorders such as diabetes mellitus (7.5 % of patients) and hyperlipidaemia (7.5 % of the patients) in the disease pathophysiology.

Among the secondary form, alcoholic cardiomyopathy is found to be most prevalent and constitutes 7.5 % of the patients. Study done by M Correale et al. showed variable prevalence of alcoholic cardiomyopathy and excessive alcohol intake was reported in 3 % to 40 % of patients with dilated cardiomyopathy.[14] Absence of paediatric population in present study could explain the low prevalence of myocarditis associated DCM which constitutes 2.5 % of patient population. Clinico-radiological diagnosis of sarcoidosis associated DCM is made in 2.5 % of patients who also have evidence of systemic sarcoidosis. Post-partum DCM is rare and seen in 2.5 % of patients in present study.

In previous studies, delayed gadolinium enhancement has been described as being present in 12 – 35 % of DCM patients. In present study, delayed enhancement is seen in 30 % of the patients with DCM. Most common pattern of enhancement is found to be mid wall linear distribution involving the septal segments. In previous studies similar observations were made by Mc Crohon et al. and Assomull RG et al.[15,16] In present study, mid wall pattern of enhancement is seen in 25 % of DCM patients, which is seen in 28 % of DCM patients. In a study done by Mc Crohon et al. Patients who had evidence of infarct / ischemia on adenosine perfusion imaging or transmural pattern of enhancement on delayed enhancement imaging were excluded from the study. Left ventricular intracavitary apical thrombus was seen in 12.5 % of DCM patients which was likely due to sluggish flow in the region of apex. Hypercoagulability is another potential explanation in post-partum DCM patient.

2D - echo has been shown to have improved assessment of global cardiac function parameters in patients with large heart, cardiac aneurysm, dilated cardiomyopathy or after myocardial infarction because of better geometrical representation.[17,18] In present study, 2 D - echocardiography showed significant and systematic underestimation of the left ventricular end-diastolic volume (mean difference 30.4 ml, t value 7.4, P value < 0.001), left ventricular end-systolic volume (mean difference 17 ml, t value 7.6, P value < 0.001) and left ventricular stroke volume (mean difference 10.4 mm, t value 3.89, P value = 0.001). No significant over or underestimation of ejection fraction noted (mean difference 0.4 %, t value 0.44, P value < 0.66). Similar observations were made in a study done by Greupner J et al.[19] Good correlation between 2 D - Echo and cardiac MRI was noted for end-diastolic volume (r = 0.89), stroke volume (r = 0.60) and ejection fraction (r = 0.75). Excellent correlation is seen for end-systolic volume. These results are again in good agreement with those of the study of Greupner J et al.except stroke volume which showed poor correlation (r = 0.31) in their study. Study done by Gardner BI et al. showed moderate correlation between 2 D - echo and cardiac MR (r = 0.54 to 0.75, all P value < 0.001) for measures of volume

and function.[20] Study done by Jenkins et al. in post myocardial infarction patients also showed moderate correlation for left ventricular end-diastolic volume, left ventricular end-systolic volume and left ventricular ejection fraction (r = 0.61 to 0.81, P value < 0.01). Consistent with our observations, there was underestimation of left ventricular end-diastolic volume, left ventricular end-systolic volume and stroke volume. However, differing from our study, there was also underestimation of left ventricular ejection fraction.[21] Larger left ventricular volumes in present study could explain the better assessment by 2 D - echocardiography.

The limitations of the present study are small patient population, lack of genetic testing to evaluate familial cases, lack of screening echocardiography to detect subclinical DCM in first degree relative of patients; myocardial biopsy could not be done to have histopathological confirmation and lack of follow up.

CONCLUSIONS

2 D - echocardiography is significantly and systematically underestimating left ventricular end-diastolic volume, left ventricular end-systolic volume and left ventricular stroke volume. No significant over or underestimation of ejection fraction was seen. Good correlation between 2 D - echocardiography and cardiac MR imaging is noted for left ventricular end-diastolic volume, left ventricle stroke volume and left ventricle ejection fraction. Excellent correlation was seen for end-systolic measurement. In summary, magnetic resonance imaging is an accurate, non-invasive, safe and advanced modality for evaluation of global left ventricular function and myocardial scarring. 2 D -echocardiography can be used for screening of the patients with clinically suspected DCM and their follow up. However, given its greater accuracy, cardiac MR imaging may be preferred when small to moderate serial changes in global ventricular function are clinically important.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
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