RESEARCH PAPER

ASSESSMENT OF RIGHT VENTRICULAR SYSTOLIC FUNCTION USING 2D AND 3D ECHOCARDIOGRAPHY IN PATIENT WITH DILATED CARDIOMYOPATHY

[1]Vishwanath Hesarur [2]Dipa Ratikant Patil [3]Shaik Nafeez Javed [4]Saima Belgaumi

[1]Assistant Professor & Consultant, Dept of Cardiology, Jawaharlal Nehru Medical College and KLES Dr. Prabhakar Kore Hospital & Medical Research Center, Belagavi. ORCID- ID: http://orcid.org/0000-0003-8005-0689
Mo. No: 9480008361, Email: drvishwanathhesarur@yahoo.com
[2]Assistant Professor, Department of microbiology, Jawaharlal Nehru Medical College and KLES Dr. Prabhakar Kore Hospital & Medical Research Center, Belagavi. ORCID- ID: https://orcid.org/0000-0001-5575-7658
Mo. No: 9899097690, Email: deepavh19@gmail.com
[3]Senior Resident, Department of Cardiology, Jawaharlal Nehru Medical College and KLES Dr. Prabhakar Kore Hospital & Medical Research Center, Belagavi. Mo. No: 6362429536, Email*: Saimabelgaumi1997@gmail.com*
[4]M.Sc Echocardiography, Department of cardiology, Jawaharlal Nehru Medical College and KLES Dr.Prabhakar Kore Hospital & Medical Research Center, Belagavi

Corresponding author: Dr. Vishwanath Hesarur, Department of cardiology, Jawaharlal Nehru Medical College, KLE Academy of Higher Education and Research, Belagavi, Karnataka, India. 9480008361
Email: drvishwanathhesarur@yahoo.com
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ABSTRACT

Background: Impaired Right Ventricular (RV) systolic function in patients with Dilated Cardiomyopathy (DCM) carries substantial prognostic significance and predicts cardiovascular death and hospitalization. Therefore, this study is intended to assess RV systolic function in patients with DCM using 2-Dimensional (2D) and 3-Dimensional (3D) Echocardiography.
Aim: To correlate the 2D and 3D echocardiographic modalities for a better calibration for assessment of RV systolic function in patient with dilated cardiomyopathy
Methods and Results: This hospital-based comparative cross-sectional study was conducted at KLE'S Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi, from March 2020 to February 2021. Thirty-five patients who were hospitalized, non-hospitalized or out-patients diagnosed with DCM with or without signs of heart failure were included. This study compared various parameters assessed by 2D and 3D Echo modalities for evaluating RV size, RV volumes and RV ejection fraction (RVEF) in patients with DCM.
Results: Male predominance (68.57%) has been observed in the study. The commonest (31.43%) ECG/EKG finding noted was complete or incomplete Left bundle branch block (LBBB). Severe LV systolic dilation assessed by LV internal systolic dimension (LVISd) by 2D//M-mode echo (LVISd) was noted in most of these patients (68.57%), which strongly indicates Severe LV systolic dysfunction which was present in 51.43% of them. 85.71% of these patients had RV longitudinal systolic dysfunction, i.e 30 out of 35 patients had Tricuspid annular plane systolic excursion (TAPSE) <1.7cm. Global RV systolic dysfunction was present in 82.86% (n=29) that is indicated by RV fractional area change (FAC) < 35%. 30 patients had Right index of myocardial performance (RIMP) less than or equal to 0.54. This result also reflects impaired global RV performance in most of them, just like RV FAC. 88.57% (n=31) of the patients had 3D RV ejection fraction (RVEF) < 45%, indicating Global systolic RV dysfunction in most of the patients with DCM. Significant correlation between 2D TAPSE and 3D RVEF was observed (R^2=0.347; p=0.001); correlation between 2D S' and 3D RVEF was significant as well (R^2=0.450; p<0.001).
Conclusion: LV systolic dysfunction is often associated with RV systolic dysfunction. Multivariable assessment of RV systolic function by 2D Echocardiography is well correlated with 3D RVEF. It was also found that patients who needed hospitalization due to heart failure caused by DCM have more chances to have impaired RV systolic function as compared to non-hospitalized patients.
Keywords: Dilated Cardiomyopathy (DCM), Left Ventricle, Right Ventricle, LV systolic function, RV systolic function, LV ejection fraction (LVEF), RV ejection fraction (RVEF), Tricuspid annular plane systolic excursion (TAPSE), Tricuspid annular peak systolic wave velocity by TDI (S'), Right index of myocardial performance (RIMP), RV Fractional area change (RV FAC), 3D Echocardiography.
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INTRODUCTION

Dilated Cardiomyopathy is described as dilation of LV in association with systolic dysfunction with normal ventricular wall thickness. Eventually, RV dysfunction may develop. DCM patients are at risk of LV failure or RV failure or both. These patients are either asymptomatic or symptomatic with signs of heart failure at rest or on exertion. Those patients who are treated chronically may sometimes present acutely with decompensated heart failure signs and are at high risk of developing life threatening ventricular arrythmias, atrio-ventricular blocks, syncope and sudden cardiac death.[1]

In recent years, many studies have been conducted to explore the structure and function of RV in DCM. RV dysfunction stands to be the second most leading cause for heart failure and a chief indication for cardiac transplantation.[2]

RV Dysfunction adds prognostic information which may be more valuable than LV ejection fraction (LVEF) in advanced heart failure. Irrespective of the modality used in assessment of RV function, the information obtained has demonstrated the prognostic significance in the out-patient setting or during hospitalization for acute presentation of decompensated heart failure. Cardiovascular death and hospitalization can be predicted by impaired RV function in cases of reduced LV systolic function.[3]

Prevalence of dysfunction of RV in Idiopathic DCM patients was found to be 65%.[4] In a recent cardiac magnetic resonance (CMR) imaging study, 34% prevalence was found in a similar population keeping 45% as threshold for RV Ejection Fraction (RVEF).[5] Another study conducted in a mixed population comprised of ischemic and non-ischemic heart failure cases with New York Heart Association (NYHA) class II to III symptoms, RV dysfunction was identified in 51% of cases using multiple echocardiographic variables.[6]

Echocardiographic evaluation of RV

Due to its easy obtainability, echocardiography is utilized as initial imaging modality for evaluation of RV.[7] Yet, there are a few apparent limitations recognized in RV assessment. That is mainly due to its complex shape and also because of lack of an uncomplicated, quick and reproducible parameter with a precise cut-off value to assess RV function. Although, a thorough review of some studies showed contradictory data, without defining a certain cut-off value. Most of the studies depended on 2D-echo assessment of RV. Nonetheless, the complex RV geometry generates clinically unreliable 2D quantification. Therefore, 3D-echo has been identified to be an acceptable tool for assessing RV [8 (9-12)]

MATERIALS AND METHODS

This hospital-based comparative cross-sectional study was conducted at KLE'S Dr. Prabhakar Kore Hospital and Medical Research Centre, Belagavi, from March 2020 to February 2021 in which patients who were hospitalized, non-hospitalized or out-patients diagnosed with DCM were recruited. It is a time bound study, because DCM is a rare disorder. Therefore, the sample size calculation was not required. Fixing time point as one year, all consecutive cases of DCM during this fixed one year were considered. Thus, 35 DCM patients were enrolled for this study.

Inclusion criteria were patients between the age of 18 to 60 years, who had DCM with or without signs of heart failure. Patients who were uncooperative, unstable or with poor acoustic window or had congenital heart disease or valvularheart disease or chronic obstructive pulmonary disease were excluded from study.

All examinations were done by a single operator to reduce inter-observability variations. All patients fulfilling inclusion criteria gave their informed consent for participation in the study. The study had been approved by the institutional ethics committee.

Data collection

The selected patients were interviewed for data such as age, gender, and other clinical information, which was entered in the predesigned proforma. Further, the patients underwent complete Transthoracic echocardiographic examination (TTE) that was performed using Phillips EPIQ-Echocardiographic system, with, 2D Echo, 3D Echo, and M mode. Images were acquired using X5-1 MATRIX probe and stored digitally.

Echocardiography

Echocardiography was performed and interpreted according to the guidelines by American Society of Echocardiography and European Association of Cardiovascular Imaging. [1] LV size was measured by M-mode. The parameters measured through M-mode were: (a) LV internal diastolic dimension (LVIDd), (b) LV internal systolic dimension (LVISd), (c) LV interventricular septum (LVIVS), and (d) LV posterior wall dimension. LV systolic function: LVEF was measured by Modified Simpson's method. The LV volumes obtained by this method were: (a) LV end-diastolic volume (LVEDV), and (b) LV end-systolic volume (LVESV). RV size was evaluated by 2D echocardiography using various measurements like (a) basal RV linear dimension (RV1), (b) mid-cavity RV linear dimension (RV2), (c) longitudinal RV linear dimension (RV3), (d) proximal RV outflow diameter (RVOT prox), (e) distal RV outflow diameter (RVOT distal). RV Global systolic function was evaluated by Fractional area change (FAC) using the formula: RV FAC (%) = 100 X (end diastolic area – end systolic area) / end diastolic area. RV Longitudinal systolic function was evaluated using Tricuspid annular plane systolic excursion (TAPSE) and by Pulsed Tissue Doppler S wave velocity (S').3D LVEF and 3D RVEF was derived using by Full volume method

Statistical Analysis

Statistical analysis was performed using SPSS software version 20.0. The data were expressed in terms of mean ± standard deviation (SD), numbers and percentages. Spearman's correlation coefficient (p) was used in determining correlation between 3D RVEF with 2D TAPSE, 2D RV FAC, 2D RIMP, 2D S' and 3D LVEF. p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical approval for the study was obtained from the Institutional Ethics Committee of Jawaharlal Nehru Medical College and KLE'S Dr. Prabhakar Kore Hospital

and Medical Research Centre, Belagavi, Karnataka, prior to commencement of the study.

RESULTS

Table 1: Baseline demographic and clinical characteristics

Parameters	Patients (N = 35)
Male, n (%)	24 (68.57)
Age (Mean ± SD, years)	49.7 ± 16.40
Age group, n (%)	
19-30	7(20.00)
31-40	5(14.29)
41-50	6(17.14)
51-60	5(14.29)
61-70	9(25.71)
71-80	2(5.71)
81-90	1(2.86)
ECG Findings, n (%)	
NSR	8(22.86)
LBBB	8(22.86)
Sinus Tachycardia	7(20.00)
LVH	3(8.57)
Incomplete LBBB	3(8.57)
VPCS	4(11.40)
AF With FVR	1(2.86)
RVH	1(2.86)
DCM diagnosis, n (%)	
Chronic	20(57.14)
Newly diagnosed	15(42.86)

AF: Atrial fibrillation, FVR: Forearm Vascular Resistance, LBBB: Left Bundle Branch Block, LVH: Left Ventricular Hypertrophy, NSR: Normal Sinus Rhythm; RVH: Right Ventricular Hypertrophy, VPCS: Ventricular premature Complexes

Total 35 patients were included in the study. Mean age was 49.7 ± 16.40 years, and the majority were male 68.57%. The study encompassed both chronic and newly diagnosed patients with DCM but most of them were patients with chronic DCM (57.14%). Majority of them had normal sinus rhythm and left bundle branch block followed by sinus tachycardia in their ECG findings.

Table 2: Baseline echocardiographic data

Variables	Patients (N = 35)
LVIDd (Mean ± SD, cm)	6.28± 0.41
Mild	11(31.43)
Moderate	18(51.43)
Severe	6(17.14)
LVISD (Mean ± SD, cm)	5.02± 0.71
Mild	6(17.14)
Moderate	5(14.29)
Severe	24(68.57)
RV1 (Mean ± SD, mm)	34.60 ± 9.45
25-41, n (%)	20(57.41)
>41, n (%)	15(42.86)
RV2 (Mean ± SD, mm)	26.20 ± 7.16
<35, n (%)	11(31.40)
>35, n (%)	24(68.57)
RV3 (Mean ± SD, mm)	81.20 ± 15.18
<83, n (%)	19(54.20)

>83, n (%)	16(45.71)
RVOT (Proximal) (Mean ± SD, mm)	28.69 ± 5.77
<35, n (%)	6(17.1)
>35, n (%)	29(82.86)
RVOT (Distal) (Mean ± SD, mm)	22.34 ± 3.80
<27, n (%)	33(94.20)
>27, n (%)	2(5.71)
2D LVEF (Mean ± SD, %)	29.07±7.20
Mild, n (%)	2(5.71)
Moderate, n (%)	15(42.86)
Severe, n (%)	18(51.43)
TAPSE (Mean ± SD, cm)	1.29 ± 0.29
<1.70, n (%)	30(85.71)
≥1.70, n (%)	5(14.29)
RV FAC (Mean ± SD, %)	26.47 ± 10.74
<35, n (%)	29(82.86)
≥35, n (%)	6(17.14)
RIMP (Mean ± SD)	0.92 ± 0.34
<0.54, n (%)	5(14.29)
≥0.54, n (%)	30(85.71)
S' (Mean ± SD, cm/sec)	8.57 ± 1.83
<9.5, n (%)	25(71.43)
≥9.5, n (%)	10(28.57)
3D LVEF (Mean ± SD, %)	28.92±6.92
<62, n (%)	35(100)
≥62, n (%)	0(0)
3D RVEF (Mean ± SD, %)	32.64 ± 8.93
<45, n (%)	31(88.57)
≥45, n (%)	4(11.43)

3D LVEF: 3D Left Ventricular Ejection Fraction, 2D LVEF: 2D Left Ventricular Ejection Fraction, LVIDd: Left ventricular Internal Diastolic Dimension, LVISD: Left Ventricular Internal Systolic Dimension, RIMP: Right Index Of Myocardial Performance RV1: Basal Right Ventricular Linear Dimension RV2: Mid -Cavity Right Ventricular Linear Dimension, RV3: Longitudinal Right Ventricular Linear Dimension, 3D RVEF: 3D Right Ventricular Ejection Fraction, RVFAC: Right Ventricular Fractional Area Change, RVOT(distal): Distal Right Ventricular Outflow Diameter, RVOT(prox): Proximal Right Ventricular Outflow Diameter, S': Peak Systolic Velocity, TAPSE: Tricuspid Annular Plane Systolic Excursion

Baseline demographic and clinical characteristics are summarised in Table 1. Mean 3D RVEF was 32.64 ± 8.93%, majority of the patients had TAPSE less than 1.70 cm and peak systolic velocity was less than 9.5 cm/sec. Mean 2D LVEF and 3D LVEF was 29.07 ± 7.20% and 32.64 ± 8.93%, respectively. 57.41% of the patients had RV1 between 25 and 41 mm, 68.57% of the patients had RV2 more than 35 mm and 54.20% had RV3 less than 83 mm.

FIGURES

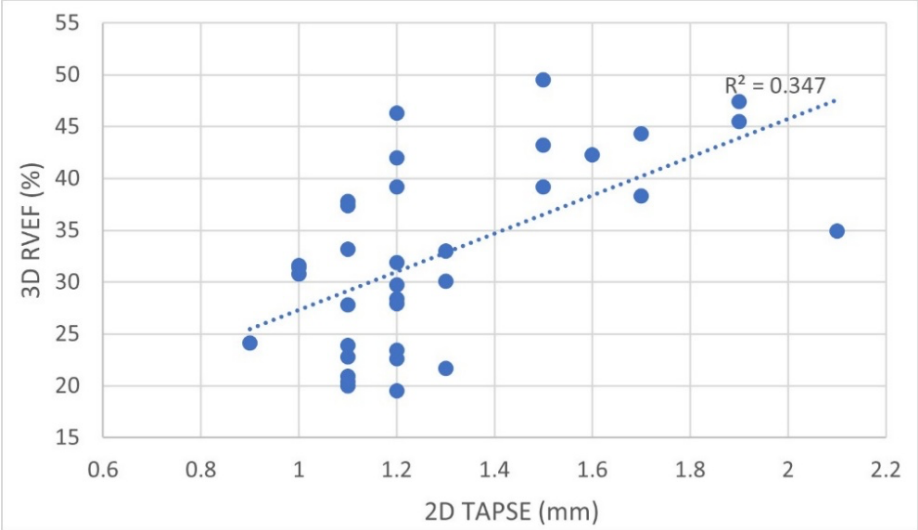


Figure 1: Correlation between 2D TAPSE and 3D RVEF
(R^2=0.347; p=0.001)

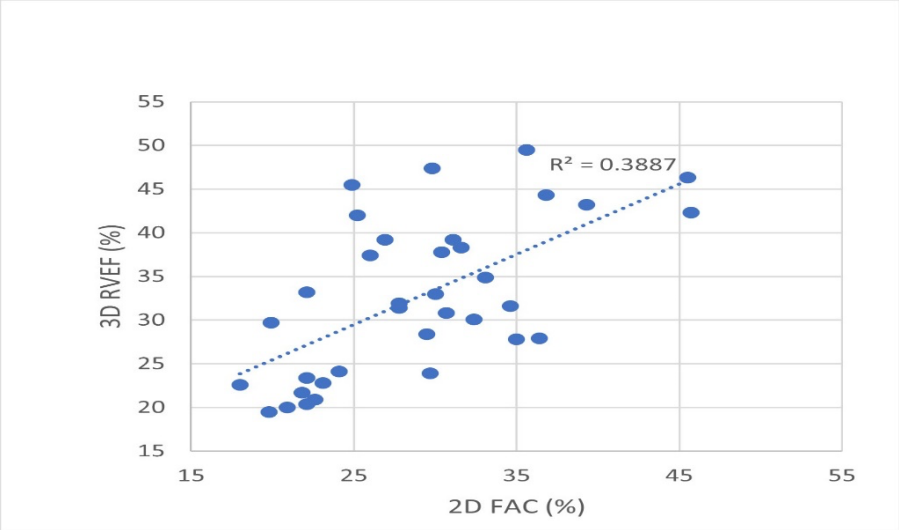


Figure 2: Correlation between 2D RV FAC and 3D RVEF
(R^2=0.388; p=0.128)

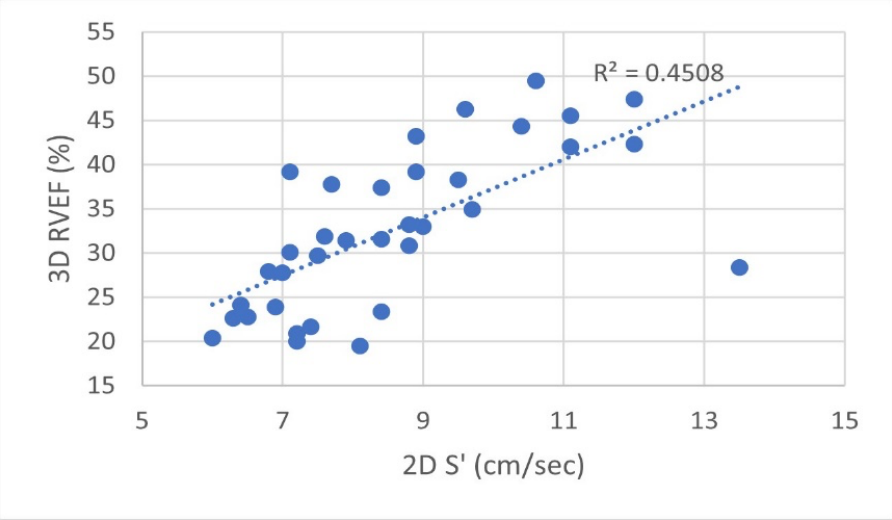


Figure 3: Correlation between 2D S' and 3D RVEF
(R^2=0.450; p<0.001)

Most of the patients (82.86%) had proximal RV outflow diameter more than 35 mm whereas 94.20% of patients had distal RV outflow diameter was less than 27 mm. 51.43% of patients had moderate LVIDd and 68.57% had severe LVISd. The mean of right index of myocardial performance was 0.92 ± 0.34. Mean of RV FAC was 26.47 ± 10.74% which provided the estimation of global RV systolic function. LVEF as assessed by 2D Simpson's method showed severe LV systolic dysfunction in 51.43% of the patients. Baseline echocardiographic data are summarised in Table 2.
Correlation of 3D RVEF was done with various parameters like 2D TAPSE, 2D RV FAC and S' as demonstrated in Figure 1, Figure 2, and Figure 3 respectively. The moderate positive correlation between 2D TAPSE and 3D RVEF was statistically significant (R^2=0.347; p=0.001). There was a weak correlation between 2D RV FAC and 3D RVEF and was statistically insignificant (R^2=0.388; p=0.128). There was a strong positive correlation between 2D S' and 3D RVEF and was statistically significant (R^2=0.450; p<0.001).

DISCUSSION

In this study, comparison of echocardiographic parameters was done for better approaches to the assessment of RV function. Significant correlations were found between estimates of volumes and ejection fraction from echocardiography. In this study, male to female ratio was 2.18:1 which suggests that DCM is more common in males than in females. This result correlates well with the study by Fairweather D, et.al, [13] and Coughlin SS, et.al, [14] that showed predominance in male with ratio of 1.3:1 and 1.4:1, respectively in patients with DCM.
In this study, RV1, RV2 and RV3 dimensions were increased in 42.86%, 68.57% and 45.71% of patients, respectively, RVOT proximal and distal diameter were also increased in 82.86% and 5.71% of patients respectively This result corresponds well with the study by Lewis JF, et. al., [15] that stated, the extent of dilation of RV is suggestive in initiating clinical outcomes in patients with DCM. In this study, RV longitudinal systolic dysfunction as assessed by 2D TAPSE <1.7cm, it was observed in 85.71% of patients. Ghio S, et.al. [16] also concluded that TAPSE augments substantial prognostic evidence in patients with congestive heart failure secondary to ischemic or idiopathic DCM.
Modin D, et.al., [17] reported that with increasing RV dysfunction, as assessed by TAPSE, there is significant increase in the risk of cardiovascular deaths. All these findings suggest that TAPSE adds prognostic value to the evaluation of RV systolic dysfunction. In this study, 2D RV FAC of <35%, indicating global systolic dysfunction, was observed in 83.86% of the patients. This result matched with study by Kawata T, et.al., [18] who concluded that FAC is a parameter that is measured for RV size, whereas TAPSE and S' prompt only longitudinal function. In this study, global RV dysfunction as assessed by 2D RIMP >0.54 was observed in 85.71% of patients. Vizzardi E, et.al.,[19] asserted that RIMP is derived from physiological aspects rather than structural geometry, hence it reflects global function of RV.
In this study, RV longitudinal systolic dysfunction as assessed by 2D S'< 9.5cm/sec, was observed in 71.43% of patients. Meluzín J, et.al., [20] revealed that S' significantly correlates with RVEF assessed by first-pass radionuclide ventriculography. Our study denotes that all the patients who were hospitalized had 3D RVEF <45% which means that hospitalized patients with DCM are more likely to have impaired RV systolic dysfunction. This finding was statistically significant (p<0.001) and also coordinates with the study by Vijiiac A, et.al[21]
The present study is not only the first of its kind where the incidence of RV systolic dysfunction in hospitalized DCM patients, evaluated using 3D RVEF is illustrated but, additionally it also collectively correlates 2D echo parameters (TAPSE, RV FAC, TDI derived S', and RIMP) with 3D RVEF used for the assessment of RV systolic function in patients with DCM.

LIMITATIONS

This was a single-centred, cross-sectional study with a small sample size and hence the findings cannot be generalised. Because DCM is a rare disorder, only 35 patients could be enrolled. During the study follow-up of patients was not performed to assess their clinical status.

CONCLUSION

LV systolic dysfunction is often associated with RV systolic dysfunction. Multivariable assessment of RV systolic function by 2D Echocardiography is well correlated with 3D RVEF. It was also found that patients who needed hospitalization due to heart failure caused by DCM have more chances to have impaired RV systolic function as compared to non-hospitalized patients.

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