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Comparison of Cardiac Function Evaluation by 128-Slice Single Source Retrospectively Gated Cardiac CT and 2D/M- mode Echocardiography

Pankaj Goyal[1*], Mansi Jain[2], Rohit Khisti[3] and Kapisoor Singh[4]

[1]Resident at K.G Hospital, Coimbatore, Tamil Nadu, India.
[2]Consultant at Life Line Hospital, Bhopal, Madhya Pradesh, India.
[3]B. J. Government Medical College and Sassoon General Hospital, Pune, India.
[4]Consultant Radiologist, K.G. Hospital and Post Graduate Institute, Coimbatore, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author KS designed the study and oversaw the CTA studies. Author PG wrote the protocol for study, performed CT LVEF functional assessment, collected and evaluated all data and wrote the draft of the manuscript. Author MJ managed the literature searches. Author RK managed the statistical analysis of experimental process. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aims: To study the correlation of Cardiac function/ejection fraction derived from 128 slice MDCT (multi detector computed tomography) results with those of functional data from 2D/M-mode echocardiography.
Study Design: Retrospective, comparative study with empirical data.
Place and Duration of Study: Department of Radiology at K. Govindaswamy Naidu Medical Trust hospital, Coimbatore, between May 2013 and October 2013.
Methodology: For this study, 44 patients (M: F = 35: 9; mean age = 49 years) were randomly chosen who had come between May 2013 and October 2013. All the patients were referred to our department from cardiology as well as non-cardiology OPD's for coronary CT angiography. Ejection fraction data was obtained using two methods; M-mode echocardiography and 128-slice

**Corresponding author: E-mail: pgoyal75@gmail.com;*

MDCT using retrospective ECG gated coronary angiographic study.
Results: The mean of LVEF (left ventricle ejection fraction) by echo is 64.73 with standard deviation of +/- 5.48 and the mean of LVEF by cardiac CT is 65.18 with standard deviation of +/- 8.70 with *P*- value of 0.770 (P value ranges from 0-1) which shows good correlation. The evaluation of LVEF by linear regression analysis show good correlation between LVEF by echo and MDCT. (r= 0.486). [r value ranges between -1 and +1].
Conclusion: This study shows the cardiac function evaluation using 128 slice MDCT is as good as the 2D- echocardiography thus the results are interchangeable between the modalities.

Keywords: Cardiac function; 128- slice MDCT; echocardiography; left ventricle ejection fraction.

1. INTRODUCTION

"As the heart generates the driving force to propagate the blood through the vascular system, assessment of its performance (cardiac function) is crucial since many diseases have an impact on the performance of the heart.

Moreover, functional parameters such as ejection fraction have been shown to yield a prognostic value. Although ejection fraction, expressing the relative amount of blood ejected by a ventricle during each cardiac contraction, is definitely the functional parameter with which we are most familiar, it is important to emphasize that cardiac function assessment cannot be reduced or simplified to a single parameter, and that several other parameters need to be considered. Different pathways and strategies to quantify global and regional cardiac performance have been explored, using a variety of techniques ranging from the injection of dye for determining the cardiac output to assessment of myocardial deformation by implantation of metallic beads. The advent of non-invasive cardiac imaging modalities, in particular of echocardiography, opened the door toward routine assessment of cardiac function in daily clinical practice" [1].

Other imaging modalities like echocardiography, radionuclide ventriculography, and gated perfusion single-photon emission CT are also used to determine left ventricular function. However, these methods are hampered either by low spatial or temporal resolution or, in regard to echocardiography, image acquisition is operator- and acoustic window–dependent [2]. Left ventricular function parameters can be measured by electron beam CT [3], but access to this modality is restricted by the number of scanners available. Cardiac MR imaging provides excellent temporal and spatial resolution, image acquisition in any desired plane, and a high degree of accuracy and reproducibility concerning quantitative measurements [4,5].

Multidetector CT (MDCT) is a promising alternative coronary artery imaging method providing excellent longitudinal spatial resolution with image reformation in any desired plane (four chamber, short axis and vertical long axis) views.

Systolic and diastolic images can be produced from the same MDCT data set. Left ventricular volumes can be measured from diastolic and systolic MDCT images; thus, assessment of left ventricular ejection fraction seems possible.

The objective of our study was to investigate the feasibility of left ventricular function assessment from MDCT coronary angiography.

2. MATERIALS AND METHODS

2.1 Study Design and Population

This study was performed on 128-slice multi-detector CT (Siemens Somatom AS+) and echocardiography machine (Philips iE-33 xMATRIX). We retrospectively analyzed 44 patients (M: F = 35:9; mean age = 49 years) who were referred to our department for coronary CT angiographic study by cardiologists as well as non-cardiologists from their respective Outpatient Department (OPD) between May 2013 and October 2013. All the patients underwent echocardiography prior to undergoing CCTA (coronary CT angiography). Both the investigations were done on the same day, Echocardiagraphy typically done 2-5 hours before CTA. Patients were made to fill a proforma/questionnaire containing a set of clinical history including presenting complaint, traditional risk factors for CAD, known allergy to any drug/substance, asthma and certain clinical/Laboratory parameters like body weight, Serum Creatinine, Lipid profile and Random/Fasting blood glucose).

The patients with acute coronary syndrome, arrhythmias were excluded. None of the patients were hypersensitive to the drugs used in the examination. All the patients had good renal function prior to the study (serum creatinine level < 1.5 mg/dL). All patients signed informed consent forms for CCTA and echocardiography and the Institutional Review Board approved this study.

Table 1. Patient characteristics

Total cases	44
Symptomatic	25/44
Having risk factors	36/44

2.1.1 Clinical characteristics of study population

Out of total 44 patients, 25 were clinically symptomatic; symptoms including chest pain (19), left arm pain (2), dizziness (1), dyspnea (5). Rest 19 were asymptomatic for cardiovascular disease (see Fig. 1).

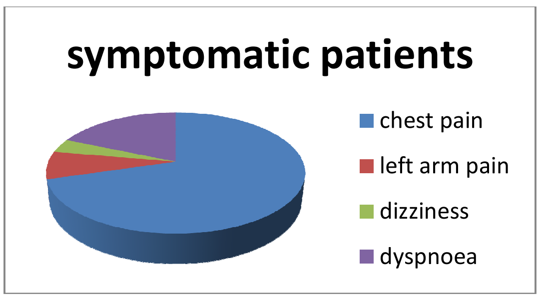

Fig. 1. Patient symptoms

Out of total 44 patients, 36 were having known risk factors for cardiovascular disease including type II diabetes mellitus(10), hypertension(15), dyslipidemia(17), smoking(10), excessive alcohol consumption(9) and family history of coronary artery disease (10). Rest 8 were not having any risk factors (see Fig. 2).

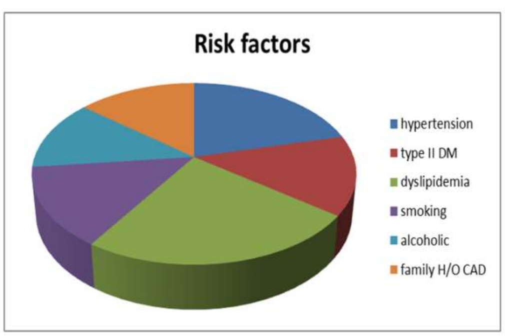

Fig. 2. Patient risk factors

2.2 Patient Preparation

Short-acting beta-blocker (metoprolol oral 50 mg 45-60 min before Cardiac CT with top-up on CT table 5-15 mg I.V. metoprolol when needed) was administered in order to obtain a heart rate below 65 beats per minute. Additional 5mg of sublingual isosorbide dinitrate was administered 5-15 minutes prior to examination for removing any spasmodic element of narrowing of coronary arteries. Vital signs including heart rate/ECG, blood pressure, oxygen saturation of finger/toe capillary blood were monitored in the scanning room.

Multi-Detector CT Scanning Protocol Coronary CT angiography examinations were performed on a 128-slice MDCT (Definition As+, Siemens Medical Solutions, Germany). Gantry Rotation time of 300 ms and a slice collimation of 128 × 0.6 mm were used with a continuous helical scan Caredose® technique. Automatic bolus tracking technique was used to start the scan with the region of interest placed into the ascending or proximal descending aorta. A delay of 6sec was used after the contrast has reached the ascending aorta (threshold of 65 HU was used). A dual-head power injector was used to administer a dual-phase bolus at a rate of 6-6.5 mL per second. 70-90 mL depending on body weight of iohexol-350 mgI/ml (omnipaque-350, GE healthcare) was administered followed by administration of 30 mL of saline. Retrospective CCTA with Caredose® was performed. Automatic Pitch selection of 0.16-0.22 (based on prevailing heart-rate) was used.

2.3 128-Slice Multi-detector Angiography Image Reconstruction and Analysis

A slice thickness of 0.75 mm was used for multi-phasic reconstruction of images with 5% increment from 25-90% of the R-R interval for assessment of LV function and volume. A soft kernel (30s) algorithm was used for reconstruction and the images were studied on a dedicated cardiac workstation (Circulation-2008" Siemens Medical Solutions).

Using 3D-multiphase data loading, the end-systolic and end-diastolic phases were identified and labeled, following which a semi-automated LV endocardial and epicardial contour detection technique was used and manual corrections were made as and when necessary in both the end-systolic as well as end-diastolic contours. The papillary muscles were included in LV-cavity volume. The Radiologist performing LV function assessment by CT was blinded to the Echocardiographically assessed functional data.

2.4 Two-dimensional Transthoracic Echocardiography

Two-dimensional transthoracic echocardiography (2D-TTE) was performed with one machine (Philips iE-33 xMATRIX) in left lateral decubitus position as a standard reference for the evaluation of LV function. Images were obtained in the standard 4- and 2-chamber apical views with a 3.5-MHz transducer by a technician with 15 years of experience and blinded to the MDCT data. LV function was estimated using 2D echo mode and M-mode simultaneously, according to the modified Simpson's method [6].

2.5 Radiation Dose

The mean radiation doses were 3.99±1.85 mSv.

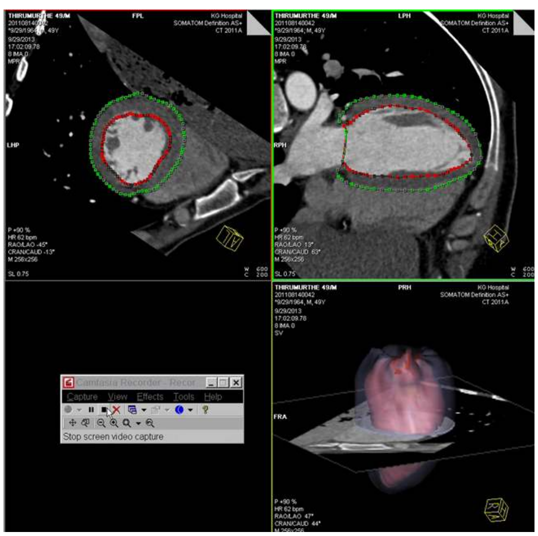

Fig. 3. Calculation of ventricular volumes in two dimensions

2.6 Statistical Analysis

The data are reported as the mean +/- SD. The differences in quantitative variables between groups were assessed by means of the unpaired t test (student-t test). Comparison between groups was made by the Non parametric Mann - Whitney test. The chi square test was used to assess differences in categorical variables between groups. A p value of <0.05 using a two-tailed test was taken as being of significance for all statistical tests. All data were analyzed with a statistical software package (SPSS, version 16.0 for windows).

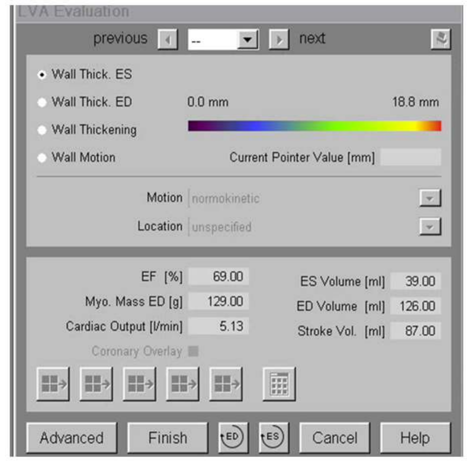

Fig. 4. Table showing results of calculation

The mean of LVEF by echo is 64.73 with standard deviation of +/- 5.48 and the mean of LVEF by cardiac CT is 65.18 with standard deviation of +/- 8.70 with P= 0.770(P value ranges from 0-1) which shows good correlation [Table 2].

The evaluation of LVEF by linear regression analysis show good correlation between LVEF by echo and MDCT. (r= 0.486). [r value ranges between -1 and +1] [Fig. 6].

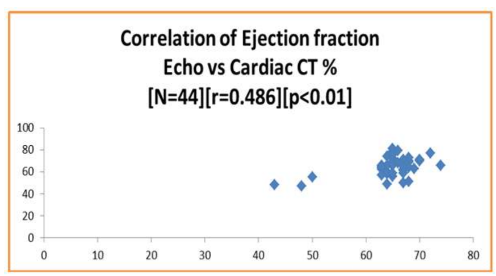

Fig. 5. Correlation of ejection fraction

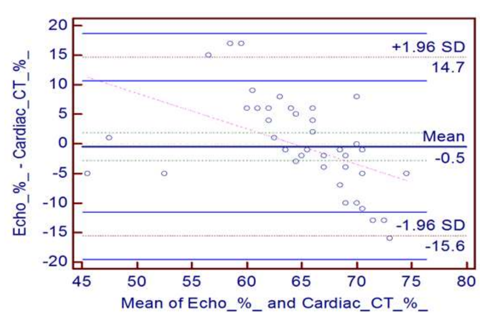

Fig. 6. Bland Altman plot - echo fraction (%) & cardiac CT ejection (%)

Table 2. Mean ejection rate

Group		N	Mean	SD	95% CI for mean		Minimum	Maximum	p value
					Lower bound	Upper bound			
Ejection	Echo	44	64.73	5.48	63.06	66.39	43	74	0.770
	CT	44	65.18	8.70	62.54	67.83	47	81	
	Total	88	64.95	7.23	63.42	66.49	43	81	

3. RESULTS AND DISCUSSION

This study shows cardiac function evaluation using 128 slices MDCT is, as good as the 2D-echocardiography.

Thus MDCT can be a useful alternate tool for functional cardiac evaluation in patients with limited visibility on echocardiography (e.g. in obese & patients with emphysematous lungs) or with contraindications for MRI (e.g. cardiac pacemaker).

In cases which are referred for coronary CT angiography, simultaneous functional evaluation can be done with good accuracy as seen in this study and thus the functional data in conjunction with the anatomical data of the coronary vessels gives broader view of the cardiac status and thus may help in better management, risk assessment, prognostication of the cardiac patients.

In few of the patients, the LVEF values showed significant individual difference. This may be attributed to the differences in normal left ventricular shapes. In such situations MDCT may provide a more robust functional data compared to 2D echo as 2D echo is based on the assumption that all the hearts are of same shape and thus uses the same formula for all the patients, whereas MDCT functional cardiac evaluation is a 3D evaluation of heart and takes in account the actual geometry/shape (and hence accurate volume assessment) of the individual hearts which vary from person to person. However further studies needs to done for the same.

MDCT gives an overview of wide range of non-coronary causes of patient's symptoms (Example: pulmonary embolism, pneumothorax, pneumonia, atelectasis, aortic dissection/aneurysmal rupture and esophageal causes). However these causes were not included in this study.

3.1 Limitations of Cardiac CT Study

The temporal resolution of 128 slice cardiac CT is approximately 150ms whereas echo gives a real time image. Since heart is a continuously moving structure, real time acquisition of images gives a more accurate end systolic and end diastolic volumes.

Use of beta blocker (metoprolol) and vasodilator (isosorbide dinitrate) just before the acquisition of cardiac CT images may cause changes in the functional ability of heart thus confounding the results. However this needs to be validated with further studies.

Use of contrast material (approximately 70cc, at the rate of 6-7cc per second) may cause alteration in the cardiac function as we know that the viscosity of contrast is more compared to blood or normal saline and also the pain/discomfort/anxiety associated with contrast injection may alter cardiac function.

Availability of 128 slice CT is much sparser as compared to echocardiography which is widely available.

Availability of trained cardiac radiologist/technologist is less as compared to cardiologist/echo-technician.

Cost of cardiac CT evaluation is multiple times that of echocardiography. However it may be feasible when functional cardiac CT is combined with the coronary artery imaging.

Patient has to hold the breath for about at 7 to 12secs for CT image acquisition, which may not be possible in many cases where patient is dyspnoeic or may compromise to the quality of the images acquired.

4. CONCLUSION

This study shows the cardiac function evaluation using 128 slices MDCT is as good as the 2D-echocardiography.

Thus MDCT can be a useful tool for functional cardiac evaluation in patients with limited visibility on echocardiography (e.g. in obese & emphysematous patients) or with contraindications for MRI (e.g. cardiac pacemaker).

CONSENT

All authors declare that 'written informed consent was obtained from the patient (or other approved parties) for publication of this paper and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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