Assessment of L.V. Function by Multislice Cardiac Ct As Compared to 2d_Echocardiography

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ABSTRACT:

BACKGROUND:
Assessment of left ventricular function and volumes provides valuable information in patients with heart disease. It is also considered a prognostic marker in coronary artery disease. Two- dimensional transthoracic echocardiography is the most widely used method for Left Ventricular function assessment, but this modality is operator dependent and can be impaired by a poor acoustic window.

OBJECTIVE:
To validate a single tertiary center experience in Multi Detector Computed Tomography for the evaluation of cardiac function in patients undergoing coronary CT angiography.

PATIENTS AND METHODS:
A cross sectional study, conducted at Ibn Albitar center from September 2012 till May 2013. Patients included are those who already underwent 64-slice CT coronary angiography to evaluate known or suspected coronary artery disease, CT coronary angiography is performed using a 64- slice Multi Detector CT-scanner. Transthoracic Echocardiography was done by a single operator served as the reference standard.

RESULTS:
Eighty patients (66.3% male) were included in the study, the mean age was 53.19 ± 10.6 years. The mean Left ventricular End Diastolic Volume by Cardiac CT and Echocardiography were 125.31 ± 41.92, 126.75 ± 41.894 ml respectively, with excellent correlation ($r = 0.912$; $P < 0.001$). Average Left ventricular End Systolic Volume (LVESV) by Cardiac CT and Echocardiography were 58.08 ± 34.18, 53.74 ± 33.15 mL respectively^ With Excellent correlation coefficient ($r = 0.971$; P0.001), with trends towards CT showing slightly higher values than that of Echocardiography.
Average Left ventricular Ejection Fraction was 55.40 ± 14.57% as determined by Cardiac CT, compared to 59.26 ± 9.8% by Echocardiography, with good correlation between the two methods ($r = 0.734$; $P=0.01$), although LVEF was slightly underestimated by Cardiac CT (3.86 ± 9.9%; P0.001).

CONCLUSION:
The current study showed that (our experience in the) assessment of cardiac function by CT is comparable to the commonly used 2D Echocardiography method. And can be used in patients already performing coronary CT angiography, (potentially for those in whom the images from TTE are inadequate. ^w j.

KEY WORDS: cardiac function, cardiac CT, echocardiography.

INTRODUCTION:

Assessment of left ventricular (LV) function and volumes provides valuable information in patients with ischemic heart disease. Furthermore, LV ejection fraction (LVEF) is an important prognostic marker in coronary artery disease (CAD). Two-dimensional transthoracic echocardiography is the most widely used method for LV function assessment, but the modality is operator dependent and can be impaired by a poor acoustic window.

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Cardiac MRI has been considered the clinical "gold standard" for LV function assessment,[1] but it is unavailable in our country and cannot be performed in patients with implanted devices. Multidetector CT of the heart is increasingly used in our country to evaluate the coronary arteries. Currently, Multidetector CT is being considered as a potential tool for the combined assessment of the coronary anatomy and LV function.[2]
The recently introduced 64-slice systems have high temporal and spatial resolution and allow the acquisition of high-resolution 3-dimensional images of the entire heart in few seconds. The assessment of LV function and LV volumes with

MDCT, in addition to noninvasive evaluation of the coronary arteries in patients with known or suspected CAD, will optimize the evaluation of patients with CAD.[(2)] .

AIM OF THE STUDY:

The purpose of this study is to validate our experience in MDCT for the evaluation of LV volumes, function, and mass in patients undergoing coronary CT angiography, in comparison to our commonly used 2D-TTE methods.

PATIENTS AND METHODS:

1) Patients and Study Protocol

Data collection was started from September 2012 till May 2013, 80 non-selected patients who already underwent 64-slice MDCT coronary angiography in Ibn Albitar Center for Cardiac Surgery, Baghdad, Iraq, for the evaluation of suspected coronary heart disease or of previous revascularization.

Patients were instructed to take high doses of beta blockers the day before the examination to maintain heart rate below 60 beats per minute.

The weight and height of the patients were obtained, and Body Surface Area (BSA) were calculated by the DuBois and DuBois formula:[(3)]

Two dimensional echocardiography and MDCT were performed within a maximum of one week from each other, and preferably at the same day.

Patients who have a contraindication from coronary CT angiography were excluded from the study, as were patients with poor acoustic window by 2D-TTE.

As patients were already performing MDCT for evaluation of coronary artery disease, informed consent was not required.

2) Multi-detector computed tomography

Data acquisition.

MDCT examinations were performed with a 64-channel scanner; Philips, Cleveland, OH. Collimation was 64x0.625 mm and rotation time was 400ms.

Tube voltage was 120 kV. The total amount of contrast (Omnipaque (IOHEXOL) 350) was 100 mL, followed by a saline flush of 50 mL at a rate of 5ml/sec. Automated detection of peak enhancement in the aortic root was used to time the scan. Patients were instructed about the procedure of the exam and the breath holding technique, and a pretest scan was performed. ECG was connected to the patients for retrospective analysis,

To assess LV function and LV volumes, data reconstruction was done in 10 time frames at 10% steps of cardiac cycle, starting at early systole (0% of cardiac cycle) to end-diastole (90% of cardiac cycle). Consequently, images were transferred to a remote workstation with dedicated cardiac function analysis software (Philips, Cardiac, Extended BrillianceTM workspace. V 4.5.2.40007, 2-May-2010, The Netherlands). ***Data analysis.***

Data were uploaded to the workstation, and automatic segmentation of cardiac chambers was done. An independent observer examined the multiple cardiac phases and the End Diastolic and End Systolic phases were identified. Cardiac axes were reviewed and corrected in multiple planes, if necessary, as were the endocardial contours, and the papillary muscles were regarded as part of the LV cavity. The LV end-diastolic (LVEDV) and LV end-systolic (LVESV) volumes were calculated (by disc summation method) and the LVEF was derived by subtracting the end- systolic volume from the end-diastolic volume and dividing the result by the end-diastolic volume.

3) Echocardiography

For comparison of LVEF and LV volumes, harmonic 2D echocardiography was performed by single operator with "at least one week from the MDCT exam. Echocardiographic examinations were performed on an IE33 (Phillips medical system). Images were obtained using a 3.5 MHz transducer, and images were acquired in standard apical two- and four-chamber views, from which the LV volumes were derived and LVEF was derived using the biplane Simpson's rule. With parasternal long axis view septal wall thickness, posterior wall thickness, LV end diastolic dimension, and LV end systolic dimension were measured and LV mass was calculated using Devereux method [(4)]

$LVmass= 0.8\ (1.04\ ([LVIDD + PWTD + IVSTDJ^{3}- [LVIDDJ^{S}))+ 0.6g.$

Where LVIDD is LV dimension in diastole (cm), PWTD is posterior wall thickness in diastole (cm), IVSTD is interventricular septum thickness in diastole (cm).

4) Statistical analysis

Continuous data are expressed as mean ± standard deviation (SD). Agreement for LV volumes and global LV function by MDCT and echocardiography was determined by Pearson's correlation coefficient (r), linear regression analysis, and the Bland-Altman analysis. [(5>] The 95% limits of agreement were defined as the range of values ± 2 SDs from the mean value of differences.

The statistical significance of the mean difference between the different modalities was tested by use of the Student's t-test. A p-value < 0.05 was considered to be statistically significant. For statistical analysis, commercially available

Windows-based software was used (PASW Statistics 18.0.0, 2009;SPSS, Chicago, IL).

RESULTS:

The study population consisted of 80 patients, 53 men and 27 women, with a mean age of 53 ±10 years.

MDCT was performed without complications in each of the 80 patients. The average Heart Rate during MDCT was 66 ± 11 bpm. All MDCT examinations were suitable for analysis. Patients characteristics are summarized in the (table 1) below.

DISCUSSION:

The assessment of global and regional LV function and LV volumes is essential in the evaluation of patients with CAD. These parameters provide important information for clinical diagnosis, risk stratification, therapeutic strategy, and prognosis, as has been shown previously in numerous scintigraphic studies.(6)

Our results show excellent correlations between MDCT and 2D-TTE for LVEDV, LVESV, (r = 0.912, and r = 0.971 respectively), and good correlation with LVEF (r = 0.734). There was mild overestimation of LVESV by MDCT and consequently, LVEF measured by MDCT yielded a slight underestimation of 3.9% compared with 2D-TTE.

Multiple studies have been published regarding the assessment of LVEF using 4-, 8-, 16- and 64- slice and dual-source MDCT. LVEF as determined by the use of MDCT showed good or excellent agreement with the respective measurements from cineventriculography, 2D- echocardiography, MRI and SPECT. (2>7„12)

The results of this study are in line with a previous study conducted by Cury et al(10), where a good agreement was demonstrated for LVEF, as determined by 64-row MDCT and 2D-TTE (r = .68). Similar to our study, a slight underestimation of 2% using MDCT was shown. Global LV function was investigated by Wu et al (11) using 64-row MDCT and 2D-TTE. The investigators showed a good correlation between the two imaging modalities for the assessment of LVEF (r = 0.87, P< 0.001). However, also with 64-row MDCT, systematic underestimation of LVEF has been reported. Palazzuoli et al (12>, in a study conducted using 64-slice MDCT with 20 phases of cardiac cycles, shows good correlation (r = 0.84) with 2D-TTE, with minor underestimation (0.8% ± 6.5).

A temporal resolution of 30-50 ms per image is necessary for the exact measurement of LVEF, especially in patients with higher HRs.<13)

The temporal resolution of MDCT is still inferior to that of echocardiography. Generally, end- systole is always overestimated owing to the limited temporal resolution of MDCT and, subsequently, LVEF is then underestimated. The temporal resolution of MDCT is associated with gantry rotation time, the use of an image reconstruction algorithm and HR<1j). Although we used a 64-slice MDCT scanner with a 400 ms rotation time and multisegmental image reconstruction, our temporal resolution was limited by the use of 10 cardiac phases (0-90%) sampled during each cardiac cycle in order to detect the ES and ED periods.

In the current study, a slight overestimation of LV volumes by MDCT was observed as compared with 2D-TTE. A factor that might contribute to the overestimation in LV volumes by 64-row MDCT is the use of dose modulation. While this feature has become available as a means to reduce radiation exposure to the patient as compared to full-dose scanning, it is associated with a slight decrease in image quality in images acquired during decreased tube current. However, it is unlikely that this minor decrease in image quality would have affected global LV volume measurements.

Second, discrepancies may be explained by differences in the definition of the upper limits of the ventricle, which can be set at different levels depending on the technique used. Currently, there are no clear guidelines on the systematic analysis of MDCT data for the purpose of cardiac function assessment. Finally, the minor overestimation of LV volumes by MDCT as compared to 2D-TTE may be explained by the different approach of LV volume calculation between the two techniques. While 2D-TTE is most routinely used to measure cardiac function in daily clinical practice, its main limitation remains that measurements are based on a geometric assumption of 2D images. As a result, inaccuracies in volumetric calculations may occur. In contrast, MDCT allows endocardial border definition with high-resolution using true 3D reconstructions. Yamamuro et al recently showed that measurements between MDCT and MRI, the current gold standard for LV function assessment, were more closely related as compared to measurements between 2D-TTE and MRI.(14) MDCT may therefore be a more accurate tool for LV function analysis than 2D-TTE, and this may explain the small differences in LV volumes between the two techniques, nevertheless general disadvantages of MDCT include the use of potentially nephrotoxic contrast and the relatively high radiation dose. The ongoing development of

MDCT to improve spatial and temporal resolution may lead to an increased radiation burden^t^fcO

Limitation of the study:

Some limitations of the current study should be addressed. First, MDCT (a 3-dimensional technique) was compared with 2D echocardiography, and a comparison between MDCT and CMR (both 3-dimensional techniques) would have been more appropriate. Nevertheless, the agreement between MDCT and 2D-TTE was good for the assessment of the different LV parameters.

Another limitation to the current study was the use of 10 phases of cardiac cycles for the evaluation of the end systolic and end diastolic times, several studies showed that data reconstruction of 20 or more phases would reduce some source of errors for the evaluation of LV function [15]

MDCT and 2D-TTE were performed within 7 days of each other, (in about 40% of the sample). Premedication with b-blockers was used for MDCT but not for 2D-TTE. The delay time between CT and echocardiography and pre-medication with b-blockers could have changed myocardial contraction and LV volumes as measured with the two methods.

It should be noted that LVEF was well preserved in the majority of our study population, and limited wall motion abnormalities were present. This could reduce the correlation between the two techniques in general practice.

Finally, the current study involved the assessment of global LV function by MDCT, further studies to detect regional wall motion using multiple cross sectional views during reconstruction of MDCT images using multiple phases of cardiac cycle are recommended.

Table 1: Patients Characteristics.

ECHO Characteristics	Mean ± standard deviation
Septal wall thickncss(cm)	1.01 ±0.266
Posterior wall thickness(cm)	1.005 ±0.259
LV diastolic dimension(cm)	5.1 +0.686
LV systolic dimension(cm)	3.47 ± 0.793
LV diastolic volume(ml)	126.75 ±41.894
LV systolic volume(ml)	53.74 ±33.149
Ejection Fraction %	59.26 ± 9.798
LV mass(gm)	193.67 ±72.35

Characteristics		Mean ± Standard deviation(SD) or Frequency (80)	Range
Age (yr) (Mean ± SD)		53.19 ± 10.603	(29-76)
Sex (male)		66.3 %	
Height(cm) (Mean ± SD)	Male	172.23 ±5.056	(164-184)
	Female	160.96 ±4.653	(151-173)
Weight(kg) (Mean ± SD)	Male	83.02 ± 13.825	(54-110)
	Female	72.63 ± 10.856	(53-98)
BSA (m^2) (Mean ± SD)	Male	2.00 ±0.189	(1.59-2.39)

	Female	1.82 ± 0.15	(1.5-2.1)
Hypertension		61.3 %	
DM		36.3 %	
IHD		25%	

Table 2: Analysis of Echocardiographic data.

By 2D-TTE the septal and posterior wall thickness, LV Dimensions, volumes, and EF by modified Simpson's method are shown in the Table (2).

The LV volumes, ejection fractions, and LV mass obtained by the MDCT are shown in the table (3), along with the correlation of these data with that obtained by 2D-TTE.

Table 3: Analysis of MDCT data, and its correlation with 2D-TTE data

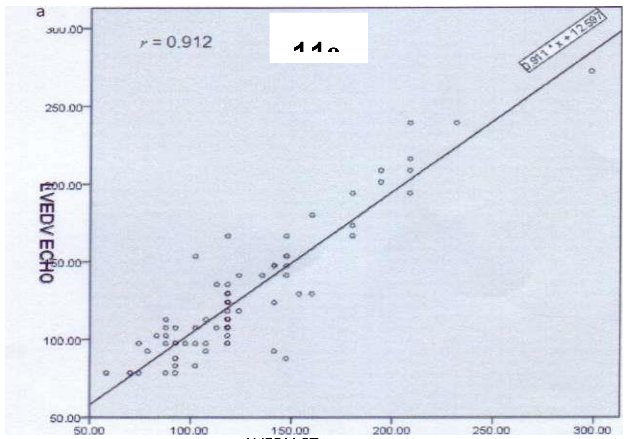
Characteristics	Mean ± SD* (MDCT)	Mean ± SD (2D- TTE)		p-value
End systolic volume(ml)	58.08 ±34.18	53.74 ±33.15	0.971	<0.001
End Diastolic volume(ml)	125.31 ±41.92	126.75 ±41.9	0.912	<0.001
Ejection Fraction%	55.40 ± 14.57	59.26 ±9.8	0.734	0.01
Myocardial Mass(gm)	190.87 ±68.98	193.67 ±72.35	0.793	0.005

* SD = Standard deviation
** r= Pearson's correlation coefficient

Table 4: The mean of differences of LV volumes, Ejection fraction, and LV mass, of that measured by 2D-TTE and MDCT, with its significance (by independent t-test), and confidence interval assessed by Bland-Altman analysis.

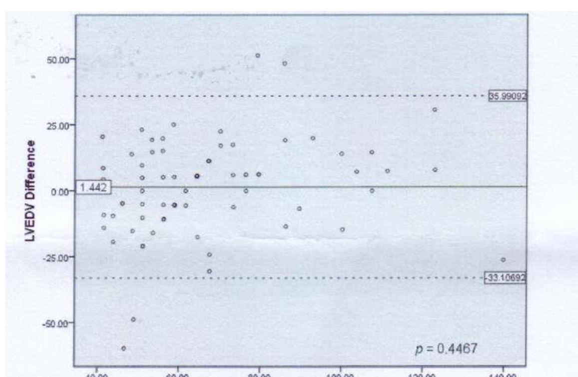
	2D-TTE	MDCT	Mean of difference ±SD	p-value	(95%)('onfidcnce Interval
LVESV Mean (ml)	53.74	58.08	-4.34 ±8.19	<0.001	-20.4-11.71
LVEDV Mean (ml)	126.75	125.31	1.44 ± 17.6	0.446	-33-35.93
EVEF Mean %	59.26	55.40	3.86 ±9.9	<0.001	-15.54-23.26
LV Mass Mean (gin)	193.67	190.87	2.8 ± 16.31	0.94	-29.17-34.77

The mean of difference between the variables measured by 2D-TTE and by MDCT as calculated by Bland Altman analysis, along with its 95% confidence interval is summarized in the (table 4) below.



LVEDV CT

LV End Diastolic Volume (LVEDV):
The mean LVEDV was 125.31 ± 41.92 ml (range 58.13 - 298.30 ml), by MDCT, as compared with 126.75 ± 41.894 ml (range 78.58 - 272.16 ml) by 2D-TTE. Linear regression analysis showed an excellent correlation between MDCT and 2D-TTE for the assessment of LVEDV (r =0.912; P< 0.001). At Bland- Altman analysis, there was no significant difference observed in LVEDV measurement between MDCT and 2d-TTE (mean difference = 1.44± 17.6; p = 0.446).



LVEDV Mean

Figure 1 . a. Linear regression analysis showed an excellent correlation between MDCT and 2D-TTE for the assessment of LVEDV (r =0.912; P< 0.001) b. At Bland- Altman analysis, there was no significant difference observed in LVEDV

LV End Systolic Volume (LVESV):

On MDCT, average LVESV was 58.08 ± 34.18 mL (range 22.3 -180 mL), as compared with 53.74 ± 33.15 mL (range 20.16 - 186.93 mL) on 2D-TTE.
The correlation coefficient between the two modalities for the assessment of LVESV was excellent (r = 0.971; P0.001).

Bland-Altman analysis showed a trends towards MDCT showing slightly higher values than that of 2D-TTE, mean value of difference (±SD) of -4.34 ± 8.19 mL (P0.001). The 95% limits of agreement ranged from -20.4 to 11.7.

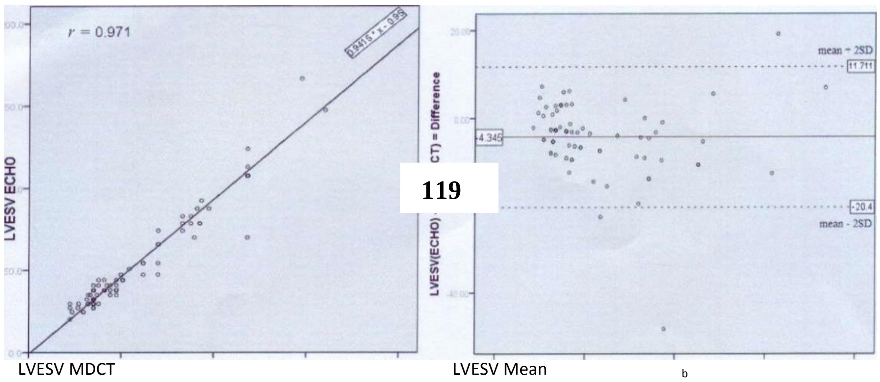


Figure 2: a. Linear regression analysis showed an excellent correlation between MDCT and 2D-TTE for the assessment of LVESV (r = 0.971; P<0.001).b. Bland-Altman analysis showed a trends towards MDCT.

LV Ejection Fraction (LVEF):

Average LVEF was 55.40 ± 14.57% (range 18.33-81.23%) as determined on MDCT, compared with 59.26 ± 9.8% (range 30.2-71.5%) on 2D-echocardiography. Evaluation of LVEF by linear regression analysis demonstrated a good correlation between MDCT and 2D-echocardiography (r = 0.734; P=0.01). At Bland-Altman analysis, LVEF was slightly underestimated by MDCT as compared to 2d-TTE. (3.86 ±9.9%; P<0.001).

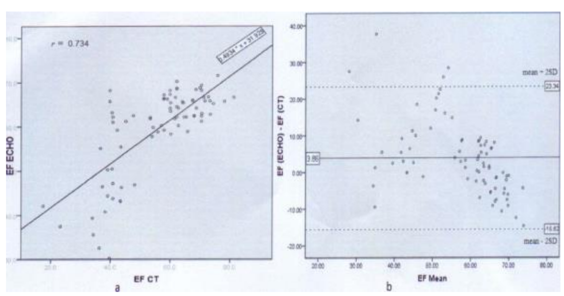


**Figure 3. a. Linear regression analysis demonstrated a good correlation between MDCT and 2D-echocardiography in the evaluation of EF (r = 0.734; P=0.01). b. At Bland-Altman analysis, LVEF was slightly underestimated by MDCT (3.86 ±
9.9%; PO.OOl).**

LV mass:

Average LV mass was 190.87± 68.98 gm (range 51.28-336.44 gm) as determined on MDCT, compared with 193.67 ± 72.35 gm (range 56.34-369.3 gm) on 2D- echocardiography. Evaluation of

LV mass by linear regression analysis demonstrated a good correlation between MDCT and 2D-echocardiography (r = 0.793; **P**=0.005). At Bland-Altman analysis, there was no significant difference between the two variables (2.8 ± 16.31, p = 0.12).

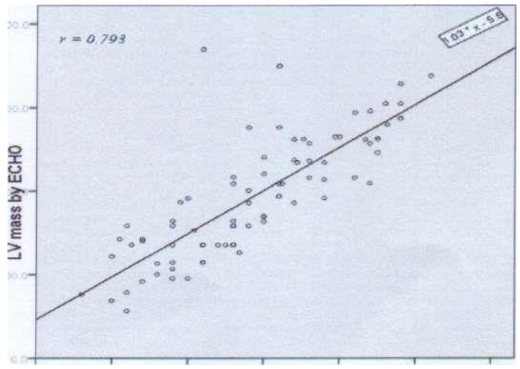


Figure 4. Evaluation of LV mass by linear regression analysis demonstrated an excellent correlation between MDCT and 2D-TTE (r = 0.793; P=0.005).

CONCLUSION:

We concluded from our study thatthe assessment of cardiac function by MDCT is comparable to the commonly used 2D-TTE Simpson's method^. And can be used in patients already performing coronary CT angiography, potentially for those in whom the images from TTE are inadequate.

RECOMMENDATION:

2) Cardiacfunctional analysis is recommended to be performed in all patients undergoing coronary CT angiography, whenever it is feasible, as it provides us with additional valuable information without significant side effects.
3) We also recommend to continue this study and to extend it to further involve regional wall motion assessment.

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