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Determination of the agreement between Cardiac Magnetic Resonance Imaging and Echocardiogram in the estimation of ejection fraction for patients with coronary artery disease.

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Abstract:
Background*: left ventricular ejection fraction (LVEF) is much important clinical parameter in respect of diagnosis of heart diseases and disease management. Cardiac Magnetic Resonance Imaging (CMR) is a gold standard method in the evaluation of left ventricle function. The accuracy of such imaging method is affected by arrhythmogenic disorder and patient capability of hold breathing. Echocardiography is cheap; portable imaging modality; however, the image quality is reduced by patient motion and subjective variation.*
Objectives: *This study aims to determine the agreement between CMR and Echocardiogram in the estimation of ejection fraction for patients with coronary artery disease.*
Materials and Methods*: In this retrospective comparative study, 90 patients with coronary artery disease were categorized according to the value of (EF) into two groups. Group 1 n=67, patients with ejection fraction < 50%, considering 50% as cut point of abnormal fraction. Group 2 n=23 patients with ejection fraction >50%. Each group had 2D transthoracic echocardiography and (CMR) with maximum intervals ≤ 60 days.*
Results*: 2D Echocardiography was overestimated in both groups(EF<50% or EF>50%), with no significant difference between the two groups (P<0.0001). The agreement limit for the first group is 46.53 %,and -6.38 unit of bias, in the second group, limit of agreement of 51.29 % and a bias of -15.28 %.*
Conclusion: *When assessing left ventricular ejection fraction, the two methods showed good agreement in patients with coronary artery disease.*
Key Word*: left ventricular ejection fraction; cardiac magnetic resonance imaging; echocardiography; coronary artery disease.*

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I. Introduction

Cardiovascular disease is considered as the most causal factor that leads to global mortalities and reduction of life quality [(1)(2),moreover ischemic heart disease (IHD) is the leading cause of death in countries of all income levels(3).On the other hand, the world health organization (WHO) on report published on 2020 about the most causal of disease reported that the ischemic heart disease mortality has been increased from 6 million on 2000 to 8.9 million on 2019 and responsible for 16% of the world's total deaths. Left ventricular ejection fraction (EF) is an important clinical parameter concerning the diagnosis of heart disease(4),many new advanced methods were introduced in the estimation of left ventricle ejection fraction, the accuracy of such modality depend on patient characteristics and disease (5).

Echocardiography is a robust and reproducible method for monitoring non-invasive heart function in clinical and experimental research(6).It provides cheap, safe and real time image by portable instrumentation(7). Cardiac magnetic resonance imaging provides serial image for heart chamber on desired image plane without use of contrast agent or ionizing radiation(8), the efficiency of cardiac MRI degraded by long acquisition time and breathing artifact(9) and contraindications including implanted metal devices inside

the patient body(10),however the accuracy of echocardiography and cardiac magnetic resonance imaging using 2 dimensional and volumetric image acquisition respectively, depend on subjective evaluation of imaginary to extract left ventricular function(11,12) which impaired by reduction of image quality and patient motion(13).Left ventricular quantification is critical in clinical management for ischemic heart disease(4). The resent studies considered EF as gold standard method in assessment of cardiac systolic function(14). The transthoracic 2D echocardiography has significant reduction in accuracy in patient with cardiac chamber enlargement or those which have valvular abnormalities(11), Several studies consider CMR as the gold standard in estimation for left ventricle ejection fraction (LVEF) (15–17)these advances were due to the using volumetric approach which is of value in patients with myocardial wall motion and abnormalities non symmetric ventricle(15).

This study aimed to examine the agreement of the left ventricular ejection fraction; which has been estimated from 2dimensional approach in echocardiography and compared with the volumetric approach of cardiac magnetic resonance in the patients with coronary artery disease.

II. Materials and Methods

This retrospective comparative study was carried out in patients with CAD in the department of cardiac radiology at the Madinah Cardiac Center in king Fahad Hospital, Madinah Saudi Arabia from June 2014 to June 2019. A total of 90 adult subjects (both males and females) aged ≥ 15, years were included in this study.

Sample

The sample size was estimated based on a single proportion design. The target population from which was randomly selected the sample was considered 750. We assumed that a confidence interval of 10% and a confidence level of 95%. The sample size obtained for this study was 90 patients for the two groups.

Patients were selected retrospectively as acute or chronic coronary syndrome who were refereed to cardiac center in king Fahad hospital. Patients were undergone CMR and echocardiography with maximum intervals≤ 60 days, the research conducted from June 2014 to June 2019. Patients were divided into two groups according to the echocardiographic estimation of ejection fraction as follows:

-Group A (N=67 patients) –coronary artery disease group with ejection fraction ≤50% the borderline in abnormal ejection fraction defined by the American society of echocardiography and European Association of Cardiovascular Imaging.

-Group B (N=23 patients) - coronary artery disease group with ejection fraction ≥ 50% the borderline in abnormal ejection fraction defined by the American society of echocardiography and European Association of Cardiovascular Imaging

The excluded patients were those with non-ischemic cardiomyopathy, congenital heart disease, mechanical valve replacement, arrhythmia during acquisition, left ventricular aneurysm, renal insufficiency (serum creatinine of more than 1.5 mg/dl), poor quality CMR, or echocardiographic images, contra-indication to MRI and those patients with a pacemaker or implanted cardioverter defibrillator.

Procedure

The study was performed retrospectively from the hospital information system. After research approval was obtained from the hospital research committee, data sheet was used to collect the data of the recruited patients. The datasheet included socio-demographic characteristics including: age, gender, weight, body surface area, and any history of diabetes and hypertension.

The study population was categorized according to British society of echocardiography guidelines for left ventricular function categorization (‘severely impaired’, left ventricular ejection fraction ≤35%; ‘impaired’, left ventricular ejection fraction 36–49%; ‘borderline low’, left ventricular ejection fraction 50–54%; and ‘normal’, left ventricular ejection fraction ≥55%) (18)

CMR was performed on GE at a field strength of 1.5 T image acquisition during breath-hold were performed using phased array coil. To assess left ventricle function, standard steady-state free precession cine imaging (35 phases per cardiac cycle; repetition time, 3.4 msec; echo time, 1.4 msec; flip angle, 55) was performed. Four-chamber, three-chamber, two-chamber, and short-axis views with a slice thickness of 8 mm were acquired in the basal-apical direction

The heart Evaluations were performed using (GE_cvi42 version 5.3). Delineation of myocardial contour and border tracings were performed semi-automatically by an expert radiologist and the system, with manual correction when needed for each short-axis slice separately at end-diastole and end-systole to derive left

ventricle volume and ejection fraction. Tracings were performed with the papillary muscles and trabeculations allocated to the left ventricle cavity as performed on echocardiographic images.
Transthoracic echocardiography was performed on an Ultrasound system (Hewlett Packard, Mississauga, Canada)) with a 2.5 MHz transducer. Image analysis was performed on workstations (Philips Medical Systems, Best, The Netherlands), left ventricle function obtained using M mode technique

Statistical analysis

Data were analyzed using SPSS version 28 (SPSS Inc., Chicago, IL).data was presented as mean and standard deviation, paired *t*-test was used to determine significance of differences between mean values of two-continuous variable. Bland Altman plot was used to determine the limit agreement between CMR and Echocardiogram in the estimation of ejection fraction. The level $P < 0.05$ was considered as the cutoff value of significance

III. Result

The present study was a retrospective comparative study done in the Radiology Department, at the cardiac center of king Fahad hospital in Al-Madinah Al-Munawara in Saudi Arabia during a period extending from June 2015 to June 2019.

The study was carried out on 90 patients (79 male 87.8% age 54.6±13.7), 36% had hypertension and 40%was diabetic patient (table 1), CMR-EF46.8875±14.07759,EC-EF49.0019±18.64657, while in data sample subgroups CMR-EF< 50%, mean ±SD 28.65±12.073 and EC-EF< 50%, Mean± SD 35.03±10.03, CMR-EF > 50%, mean ±SD 41.56±13.53, and EC-EF > 50%, Mean 56.77±5.39,1). paired sample t test for CMR-EF compared to EC-EF, p value< 0.0001, while in patient subgroups CMR-EF < 50% compared to EC-EF < 50%, p value< 0.0001. CMR-EF> 50% compared to EC-EF > 50%, p value< 0.0001 (table 1).

Bland Altman plot demonstrates the limit of agreement between the two imaging modalities, on the present study limit of agreement in the group of patients with coronary artery disease limit of agreement 49.8, bias -8.63 while in patient subgroups patients with LVEF <50 limit of agreement was 46.53, bias -6.38LVEF >50 limit of agreement was 51.29, bias -15.28.

Table: 1 general characteristics of study participant

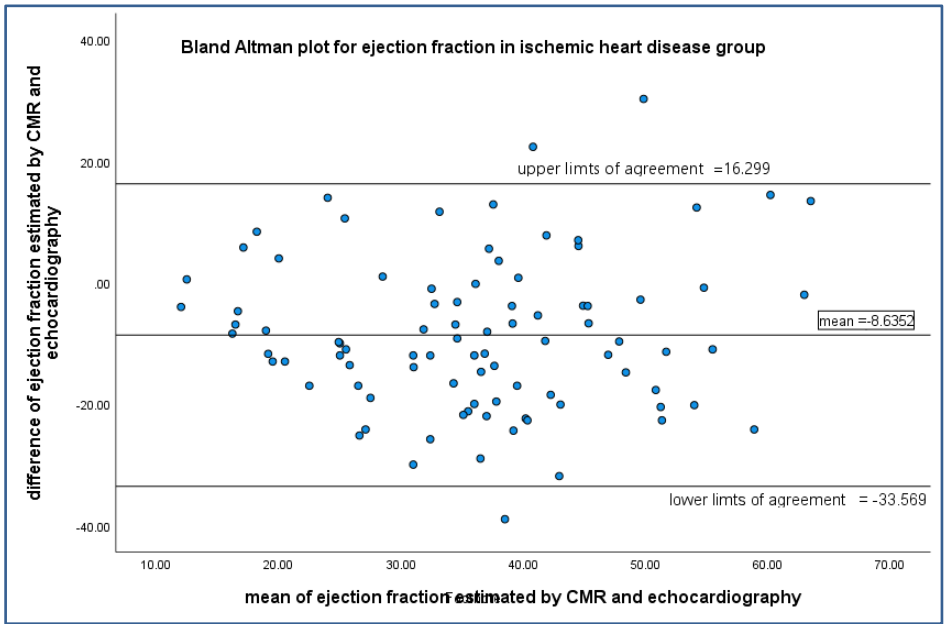
Variable	Study participant No (90)	
Gender	Male	%87.8
	Female	12%
Age	Mean± SD	54.6±13.7
Weight	Mean± SD	71.4±14.2
Diabetes	Percentage	40%
Hypertension	Percentage	36,6%

Abbreviation No=number, SD standard deviation

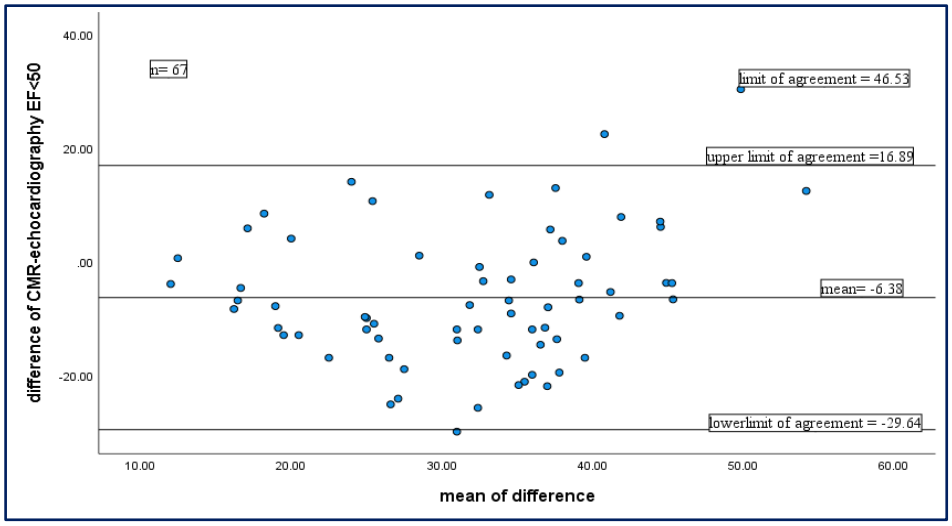
Table:2 Clinical Parameters, Ejection fraction measured by MRI and ejection fraction measured by echocardiography for the two groups

Ejection Fraction	mean± SD	P-value*
Ejection Fraction measured by Echocardiography - Ejection Fraction measured by CMR	49.0019±18.64657	<0.0001
	46.8875±14.07759	
Ejection Fraction estimated from CMR less than 50%	28.65±12.07	< 0.0001
Ejection Fraction estimated from echocardiogram less than 50%	35.03±10.025	
Ejection Fraction estimated from CMR more than 50%	41.56±13.53	< 0.0001
Ejection Fraction estimated from echocardiogram more than50%	56.77±5.39	

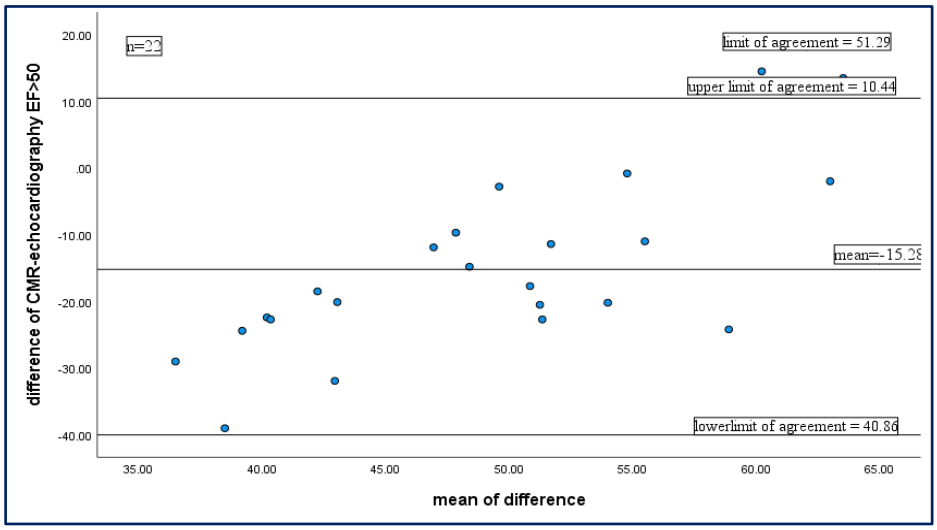
Note: P-value* paired sample t-test <.05 is considered as statically significant
Abbreviation: CMR cardiac magnetic resonance imaging SD standard deviation



(A)



(B)



(c)

Figure (1) A, B and C Bland Altman plot for ejection fraction measured by MRI and ejection fraction measured by echocardiography for the data sample and the two subgroups

IV. Discussion

Coronary artery disease (CAD) is the leading cause of death worldwide, as well as the leading cause of heart failure (HF). (1) 2019 old and recent studies were described the alteration in left ventricular volumes and dimensions.(19,20)In the present study, the EC-EF was overestimated when compared to cardiac MRI in coronary artery disease group and both subgroups, the previous literature was reported overestimation of EC compare to CMR. Zhao L Et.al (2020) (21) Rupert Simpson et al (2018) and it differs from Bethell,E Et.al (2014) result that the echo is underestimated when compared to CMR(22).

CMRI may be more trustworthy due to its efficiency and reproducibility, as well as decreased intra- and inter-observer variability.(23)This was compared topoor reproducibility of echocardiography assessment of LV function which was came as reflet of poor image quality.(24)Moreover, thecurrent study was used paired sample t-test to show the pair similarity and difference, patients' main group and subgroups, which was demonstrated there was no significant difference between CMR-EF and EC-EF (P< 0.0001) this finding agreed with literature published by Zhao L Et.al (2020) (21) Moreover Pellikka PA Et.al(2018)(25)

On Bland Altman plot LVEF of coronary artery disease group and subgroups inconsistence with the previous studies, in the main patient group, the limit of agreement 51unit and the bias -6.9. these finding resemble to (Lei Zhao et al 2020) that showed their limit of agreement (39.4), bias 5.6 (21)while the study presented by (Hoffmann et al 2014) their study was performed on open label study their bias 11.0% (limits of agreement, (41.3)(26)and more than which was showed by(Cankaya et al 2021)their finding was showed bias was 2.9 (limits of agreement, 34.6 to -27.9(62.5))(27). The limit of agreement was decreased in the group of patients with EF <50 was 46.53 bias -6., this in the same direction with open-label multicenter study in 2018 reported by Pellikka PA Et.al(2018)(28) when comparing biplane echocardiography with CMR their limit of agreement was 35.31% more over Zhao L Et.al. (2020)(21) on their patient group with ejection fraction < 35 limit of agreement 37.3 and in group 50<EF>35 the limit of agreement 38.5. in the patient group with EF> 50%, the current study reported the limit of agreement 51.29% this far from Zhao L Et.al(2020)(21) findings that indicate good agreement between the imaging modalities limit of agreement 25.6 %. The bias variation may come from LVEF Assessment may be influenced by differences in the study population.(29)furthermore, echocardiographymay have significant interobserver variability and interpreter skill in qualitative assessment of LV size andfunction(30)Transthoracic 2-dimensional echocardiography, measurement accuracy degraded by chamber enlargement and valvular abnormalities. (Gang Huang, and Peng Zhou et al 2019)therefore, to minimize misleading diagnosis special care should performed in Standardization of the methodologyused to left ventricular ejection fractionas the clinical decisions are based on these data.(31)

V. Conclusion

In a term of patients presented with coronary artery disease, 2D echocardiography results were overestimated when compared with CMR with good agreement between the two imaging modalities in the patient group with an abnormal ejection fraction.

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