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Role of Speckle Tracking Echocardiography in Differentiating between Ischemic and Non-ischemic Cardiomyopathy

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Abstract

Background and Aim: Cardiovascular imaging plays an essential role in the early detection of cardiac injury and left ventricular (LV) function subclinical alterations. Non-invasively, speckle-tracking imaging provides objective and quantitative assessment of global and regional cardiac function. We investigated whether speckle tracking echocardiography (STE) can be used to distinguish between ischemic cardiomyopathy (ICM) and non-ischemic dilated cardiomyopathy (NICM) based on the pattern of cardiac deformation.

Materials and Methods: This research involved cases of dilated cardiomyopathy during the period from January 2022 to December 2022 in 100 patients separated into two groups. Baseline clinical data were evaluated. Conventional and STE were done. The cases were separated into two groups: Group A involved 50 cases with a history of ischemia confirmed by coronary angiography and group B involved 50 cases with NICM who had normal coronary angiography.

Results: Patients with NICM had significantly greater LV volumes, lower LV systolic function, and lower global longitudinal and circumferential strain. Basal longitudinal strain over the sum of mid and apical longitudinal strain was significantly lower in NICM (0.42 ± 0.03 vs. 0.49 ± 0.03, $P < 0.001$). Moreover, regional longitudinal strain decreased from apical to basal in NICM and was homogeneous throughout all segments in ICM.

Conclusion: Two-dimensional-STE can help differentiate ICM from NICM. Patients with NICM had a specific strain pattern as basal worsening of LV systolic strain with relative apical sparing.

Keywords: Speckle tracking echocardiography, ischemic, non-ischemic cardiomyopathy

INTRODUCTION

Left ventricular (LV) dilatation with reduced systolic performance characterizes dilated cardiomyopathy (DCM), a condition of the cardiac muscle that is considered a common characteristic of ischemic and non-ischemic heart disorders. Different approaches are taken for treating and prognosing ischemic cardiomyopathy (ICM) and non-ischemic cardiomyopathy (NICM) because they are distinct disorders. Cases diagnosed with ICM survived worse in the long term than those diagnosed with NICM.[1]

Advances in management, earlier diagnosis, and careful follow-up significantly enhanced the prognosis of patients with DCM. In the past few years, DCM prognosis and survival have significantly improved, with decreased need for cardiac transplantation.[2]

Coronary angiography is the most reliable method for identifying ischemic etiology and is recommended by heart failure (HF) guidelines to exclude ischemic etiology.[3] NICM can be diagnosed if there is no evidence of coronary artery disease (CAD) or if the myocardial impairment does not explain

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the degree of ischemic involvement. However, the diagnostic benefits of coronary angiography should be weighed against the risk and cost. According to a previous study, ICM caused newly diagnosed HF in 15% of patients only,[4] and the use of coronary angiography in this setting was unnecessary. Thus, non-invasive methods could be of value in the diagnosis of ICM and should be thoroughly investigated.[5]

Two-dimensional speckle tracking echocardiography (2D-STE) plays a crucial and useful role in the estimation of global and regional myocardial function and can aid in the diagnosis of ischemic etiology.[6] Our research assessed the role of the myocardial deformation pattern evaluated by STE in the differentiation between ICM and NICM.

MATERIALS AND METHODS

Cases with DCM admitted to the cardiology department, Benha University Hospital, Egypt between January 2022 and December 2022 were evaluated. DCM was defined as LV dilatation (LV end-diastolic dimension >57 mm) and decreased LV systolic function [ejection fraction (EF) <45%].[6] Exclusion criteria were the existence of valvular heart disease, atrial fibrillation, permanent pacemaker use, the presence of chronic kidney disease, and poor echo window. The study cases were separated into two groups: Group A, 50 cases with a history of ischemia confirmed with coronary angiography and Group B, 50 cases with NICM who had normal coronary angiography. All patients were of matched age, gender, and risk factors (diabetes mellitus, hypertension). Informed written permission was obtained, and the research was approved by Benha University Faculty of Medicine Research Ethics Committee (study no: 29.9.2020).

Conventional transthoracic echocardiography

A 1.7-4 MHz transducer (Philips IE33 Ultrasound Machine) was used to acquire echocardiographic images while electrocardiogram signals were captured concurrently. The left lateral position of the patient was used for all examinations. During a breath hold, a series of 2D pictures were taken and preserved in cine-loop format for three consecutive heartbeats. The frame rate ranged from 40 to 60s. The apical four- and two-chamber views were used to evaluate LV systolic function using a modified Simpson's approach.[7]

2D speckle tracking echocardiography

We recorded three consecutive cardiac cycles in each apical view and stored the data as grayscale harmonic images in digital format for further analysis. Among forty and sixty frames per second were shown. Apical images were taken near the end of systole, and three sites were marked off: Two on either side of the mitral annulus and one at the apex of the left ventricle. Each of the 17 LV segments from American Heart Association's 17-segment LV model had its peak systolic longitudinal strain values automatically calculated by the algorithm. Global longitudinal strain (GLS) was estimated by averaging the strain measurements taken at each of the 17 segmental strain values. Strain values were measured at levels of strain in each of the six segments [five segments for the apical regional longitudinal strains (RLS)], and the mean of those values was used to determine RLS, including basal, mid, and apical RLS (Figure 1).[8]

The end-systolic period was used to manually establish sample sites together with the endocardial layers to determine the global circumferential strain (GCS) using parasternal short-axis views at the mitral, mid, and apical levels. The software then detected tissue speckles and followed their motion during the cardiac cycle frame by frame.[9]

Coronary angiogram

All patients underwent coronary angiography, and ICM was considered if luminal diameter stenosis ≥50% of the left main (LM) artery or ≥75% of the epicardial coronary artery. Conversely, NICM was considered when the luminal stenosis <50 percent of LM artery or <75 percent of epicardial coronary artery.[10]

Statistical analysis

Statistical analysis was performed with the assistance of the IBM SPSS 19.0 software package. Quantitative data are given as the mean ± standard deviation. An analysis of variance with a totally randomized design was used to conduct a comparative analysis of the variables of the two groups. A post hoc analysis was performed on the findings, and the findings that showed significant differences among the groups were compared. The receiver operator characteristic (ROC) was used to determine the degree to which the echocardiographic data accurately differentiated ICM from NICM. Contrasting the respective diagnostic accuracies required estimation of the area under the curve (AUC). Every statistical test consisted of two parts. *P*-value greater than 0.05 was statistically insignificant.

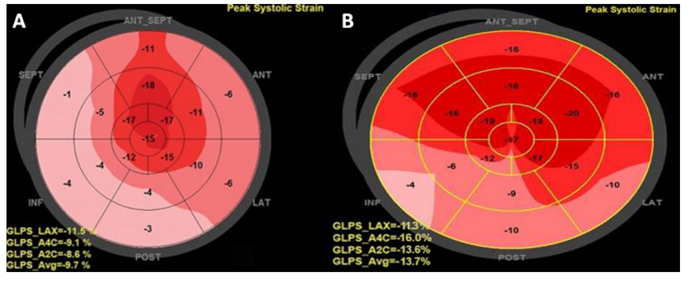

Figure 1: Bull's eye view of LV longitudinal strain of a patient with (A) NICM and (B) ICM

LV: Left ventricular, NICM: Non-ischemic cardiomyopathy, ICM: Ischemic cardiomyopathy

RESULTS

A total of 208 patients with DCM admitted to our cardiology department were evaluated. One hundred and eight patients were excluded because of the presence of valvular heart disease (*n* = 25), atrial fibrillation (*n* = 39), poor echo window (*n* = 24), and 20 patients were not matched. Finally, this study included 100 patients who were divided into two groups. The baseline characteristics of the research groups are provided in Table 1. Cases in the ICM group had more complaints of chest pain (41 patients 82% vs. 31 patient 62%, $P = 0.026$). However, there were no significant statistical variances between the two groups concerning the New York Heart Association functional classification, heart rate, and systolic and diastolic blood pressure (Table 1).

Both LV end-diastolic and end-systolic volumes were significantly greater in NICM patients. However, LVEF was significantly lower in NICM ($P < 0.001$).

The mean GLS and circumferential strains were significantly lower in NICM (-10.34 ± 0.97 vs. -11.83 ± 0.84 % and -7.55 ± 1.33 vs. -11.52 ± 1.61% respectively, $P < 0.001$). Regarding the regional strain, the average basal longitudinal strain (BLS) was significantly lower in NICM (-9.14 ± 1.21 vs. -11.60 ± 1.03%, $P < 0.001$). Moreover, it was significantly lower in NICM in anterior, inferior, anteroseptal, inferoseptal, inferolateral, and anterolateral segments ($P < 0.001$). In addition, the average mid and apical segmental longitudinal strain was significantly lower in NICM. Moreover, the mid and apical longitudinal stain of each segment was significantly lower in NICM (Table 2).

The mean BLS over the sum of the mean mid and apical longitudinal strain was significantly lower in NICM (0.42 ± 0.03 vs. 0.49 ± 0.03, $P < 0.001$). Moreover, the RLS decreased from apical to basal in NICM and was homogeneous throughout all segments in ICM.

ROC curve

The ROC curve was used to test the diagnostic value of the mean GLS, mean GCS, LVEF, and basal over sum of mid and apical longitudinal strain to differentiate between NICM and ICM. The mean GLS cut off value ≤-11 was revealed to have acceptable diagnostic accuracy (sensitivity =86%; specificity =70%) in differentiation between NICM and ICM. Also, the average basal over sum of mid and apical longitudinal strain cut-off value >0.449 was found to have acceptable diagnostic accuracy (sensitivity =90%; specificity =86%) in differentiation between NICM and ICM with higher AUC compared with mean GLS, mean GCS, and LVEF (0.937 vs. 0.894, 0.680, and 0.638) (Figure 2).

Table 1: Baseline clinical and conventional echocardiographic data

	Group A (ICM) (n = 50)	Group B (NICM) (n = 50)	*P*-value
Age, years	51.74±5.98	50.10±6.42	0.189
Gender			
Male, *n* (%)	29 (58)	25 (50)	0.422
Female, *n* (%)	21 (42)	25 (50)	
HTN, *n* (%)	31 (62)	29 (58)	0.683
DM, *n* (%)	39 (78)	29 (58)	0.32
Smoking, *n* (%)	23 (46)	23 (46)	1.0
NYHA functional class			
NYHA I, *n* (%)	12 (24)	15 (30)	0.545
NYHA II, *n* (%)	22 (44)	20 (40)	
NYHA III, *n* (%)	16 (32)	13 (26)	
NYHA IV, *n* (%)	0 (0)	2 (4)	
Heart rate (bpm)	94.92±11.16	97.32±10.03	0.261
SBP (mmHg)	125.7±22.6	127.5±20.5	0.501
DBP (mmHg)	70.9±11.5	72.6±10.9	0.561
Conventional echocardiography			
LVEDV (mL)	225.94±29.27	271.72±43.84	<0.001
LVESV (mL)	134.9±23.91	173.6±37.97	0.005
LVEF (%)	40.22±2.99	35.36±3.94	<0.001

ICM: Ischemic cardiomyopathy, NICM: Non-ischemic cardiomyopathy, HTN: Hypertension, DM: Diabetes mellitus, NYHA: New York Heart Association, SBP: Systolic blood pressure, DBP: Diastolic blood pressure, LVEDV: Left ventricular end diastolic volume, LVESV: Left ventricular end systolic volume, LVEF: Left ventricular ejection fraction

Table 2: Speckle tracking echocardiographic data

	Group A (ICM) (n = 50)	Group B (NICM) (n = 50)	*P*-value
GLS	-11.83±0.84	-10.34±0.97	<0.001
GCS	-11.52±1.61	-7.55±1.33	<0.002
Basal/(mid + apical) GLS	0.49±0.03	0.42±0.03	<0.001
BLS			
Average BLS, %	-11.6±1.03	-9.14±1.21	<0.001
Anterior, %	-11.39±1.44	-8.86±1.18	<0.001
Inferior, %	-11.78±1.79	-9.0±1.46	<0.001
Anteroseptal, %	-12.0±1.52	-8.94±1.67	<0.001
Anterolateral, %	-11.59±1.65	-9.46±1.54	<0.001
Inferoseptal, %	-11.37±1.6	-9.04±1.85	<0.001
Inferolateral, %	-11.49±1.36	-9.52±1.58	<0.001
MLS			
Average MLS, %	-11.79±0.83	-10.71±1.08	<0.001
Anterior, %	-11.81±1.3	-10.56±1.42	<0.001
Inferior, %	-11.94±1.27	-10.66±1.24	<0.001
Anteroseptal, %	-11.72±1.44	-10.92±1.37	0.006
Anterolateral, %	-11.70±1.29	-10.74±1.66	0.002
Inferoseptal, %	-11.52±1.66	-10.6±1.71	0.008
Inferolateral, %	-12.01±1.5	-10.74±1.72	<0.001
ALS			
Average ALS, %	-12.11±1	-11.19±0.93	<0.001
Anterior, %	-12.25±1.27	-11.46±1.07	<0.001
Inferior, %	-12.51±1.37	-11.22±1.15	<0.001
Lateral, %	-12.15±1.48	-11.20±1.55	0.002
Septal, %	-11.53±1.57	-10.84±1.45	0.024
Apex, %	-12.08±1.58	-11.22±1.62	0.009

ICM: Ischemic cardiomyopathy, NICM: Non-ischemic cardiomyopathy, GLS: Global longitudinal strain, GCS: Global circumferential strain, BLS: Basal longitudinal strain, MLS: Mid longitudinal strain, ALS: Apical longitudinal strain

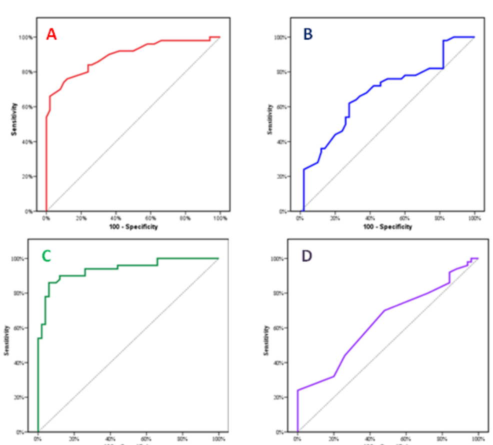

Figure 2: ROC curve for differentiating NICM from ICM using (A) mean GLS; (B) mean GCS; (C) basal over summation of mid and apical longitudinal strain; (D) LVEF

NICM: Non-ischemic cardiomyopathy, ICM: Ischemic cardiomyopathy, GLS: Global longitudinal strain, GCS: Global circumferential strain, LVEF: Left ventricular ejection fraction, ROC: Receiver operator characteristic

Univariate and multivariate regression analyses

Univariate and multivariate regression analyses were used to detect the predictors of ICM (Table 3). Multivariate analysis identified the average basal over sum of mid- and apical longitudinal strain as the only independent predictor of ICM (OR: 184.214, 95% CI: 10.311-3291.173, $P < 0.001$).

DISCUSSION

The most reliable method for diagnosing CAD is invasive coronary angiography. Therefore, it is used in patients with DCM to detect the ischemic etiology of lower LV systolic function. This research aimed to determine whether we can depend on non-invasive measures as STE to differentiate ICM from NICM.

This study showed that we can use echocardiography, especially STE, to differentiate between ICM and NICM. Conventional echocardiographic parameters showed that both LV end-diastolic and end-systolic volumes were significantly greater in NICM patients with significantly lower LVEF. These findings were similar to prior researches by Tymińska et al.[11] and Melichova et al.[12], who revealed that LV volumes and dimensions were significantly higher in NICM patients along with lower LVEF.

Moreover, STE revealed that the mean global LV longitudinal and circumferential strains were significantly lower in NICM ($P < 0.001$). In addition, segmental strain was significantly lower in NICM with a lower mean BLS over the sum of the mean mid- and apical longitudinal strains ($P < 0.001$). The RLS for each individual wall decreased from apical to basal segments in NICM (basal worsening) and was homogeneous throughout all affected segments in the distribution of the diseased vessel in patients with ICM.

Similarly, Abdelkarim et al.,[13] revealed that the global LV longitudinal strain was significantly lower in NICM (-10.29 ± 1.46 vs. -12.40 ± 1.35, $P < 0.001$). Zuo et al.[10] showed that both GCS and global radial strain were significantly lower in NICM than in ICM (-5.4 ± 2.6% vs. -7.0 ± 2.5%, $P = 0.006$; and 7.5 ± 4.5% vs. 10.7 ± 4.7%, $P = 0.019$), respectively.

In addition, Ilov et al.,[14] revealed that in cases with ICM, the worst features were discovered in the apical segments of the LV ($P = 0.008$), whereas in cases with NICM, the worst characteristics were discovered in the basal segments of the LV ($P = 0.046$). The LV peak systolic longitudinal strain was used to make this determination.

In the present study, we used the ROC curve to test the diagnostic value of the mean GLS, mean GCS, LVEF, and basal over sum of mid and apical longitudinal strain to differentiate between NICM and ICM. The cutoff value was ≤-11% for the mean GLS and >0.449 for the ratio between average basal over sum of mid and apical longitudinal strain with higher AUC compared to mean GLS, mean GCS, and LVEF.

Zuo et al.[10] showed that according to ROC analysis, the ratio of BLS to the total of apical and mid-level strains could accurately predict NICM with a sensitivity of 63.4% and a specificity of 88.4% (the cut-off value was 0.47, and the AUC was 0.792). GCS at cut-off >-6.67% was revealed to have acceptable diagnostic accuracy (sensitivity= 65%; specificity= 68%) in the differentiation between NICM and ICM. However, GLS and LVEF were not reliable in differentiating NICM from ICM.

Study limitations

There are some drawbacks to this research. First, there was a relatively small sample size and it was a single-center research. Moreover, the cases included in the study were referred for coronary angiography; therefore, we cannot exclude selection bias. Intraobserver and interobserver variability could not be excluded. Finally, patients with single-vessel disease (SVD) in an artery other than the LM or proximal left anterior descending artery (LAD) were judged to have NICM and were thus excluded from the study. As a result, the impact of SVD with 75% stenosis in an artery other than the LM or proximal LAD on myocardial

Table 3: Univariate and multivariate logistic regression analyses for predicting ICM

	Univariate		#Multivariate	
	P-value	OR (LL - UL 95% CI)	*P*-value	OR (LL - UL 95% CI)
LVESV	0.007	0.921 (0.868-0.978)	0.545	0.875 (0.568-1.348)
LVEDV	<0.001	0.964 (0.949-0.979)	0.193	1.172 (0.923-1.487)
Mean MLS	<0.001	0.275 (0.152-0.499)	0.832	0.833 (0.154-4.516)
Mean GLS	<0.001	0.140 (0.064-0.308)	0.059	0.127 (0.015-1.078)
Mean GCS	0.009	0.724 (0.568-0.923)	0.727	1.097 (0.653-1.841)
Basal / (mid + apical) GLS	<0.001	731.266 (61.79-8655.0)	<0.001	184.214 (10.311-3291.173)

#All variables with p<0.05 was included in the multivariate

ICM: Ischemic cardiomyopathy, LVESV: Left ventricular end systolic volume, LVEDV: Left ventricular end diastolic volume, MLS: Mid longitudinal strain, GLS: Global longitudinal strain, GCS: Global circumferential strain, CI: Confidence interval, UL: Upper limb, LL: Lower limb, OR: Odds ratio dysfunction could not be determined. Intraobserver and interobserver variability could not be excluded.

CONCLUSION

2D-STE can help differentiate between ICM and NICM. Cases with NICM have strain patterns that include relative apical sparing and basal worsening of LV longitudinal strain. In addition, the mean GLS cutoff value ≤-11 and was shown to have acceptable diagnostic accuracy with average sensitivity and specificity. Moreover, the ratio between the basal over sum of the mid and apical longitudinal strains is more specific.

Ethics

Ethics Committee Approval: The research was approved by Benha University Faculty of Medicine Research Ethics Committee (study no: 29.9.2020).

Informed Consent: Informed consent was obtained from the participants.

Authorship Contributions

Surgical and Medical Practices: M.A.M., A.M.S., Concept: M.A.M., A.A.M., M.A.H., A.M.S., Design: M.A.M., A.A.M., M.A.H., A.M.S., Data Collection or Processing: M.A.M., A.M.S., Analysis or Interpretation: M.A.M., A.A.M., M.A.H., A.M.S., Literature Search: M.A.M., A.M.S., Writing: M.A.M., A.A.M., M.A.H., A.M.S.

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