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Original Article

Using Two-Dimensional Speckle Tracking Echocardiography to Predict Coronary Artery Disease Severity in Patients with Chronic Stable Angina

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ABSTRACT

Background: In patients with stable angina pectoris [SAP], conventional echocardiography at rest gives minimal information regarding coronary artery disease [CAD]. Even in patients with severe CAD, left ventricle [LV] wall motion at rest may be normal. As a result, it would be beneficial if another resting parameter could aid to distinguish patients with severe CAD from those with milder or no CAD. 2D strain echocardiography can anticipate the degree of coronary lesions.

Aim of the work: The goal of this study was to study the relationship between LV systolic deformation and the severity of CAD in individuals with SAP using 2D STE.

Patients and Methods: This study included [120] SAP patients, who were divided into three groups according to coronary angiography: Group [A] consists of [12] patients whose coronary angiography is normal Group [B]: [40] patients with low SS < 22. Group [C]: [48] patients with SS ≥ 22. All patients were undergoing Echocardiography [conventional and STE for assessment of global and circumferential strain.

Results: There is a statistically significant correlation between the number of vessels affected and GLS and GCS. There is a significant correlation between SS and GLS [P=0.001] which is weak significant in group B and lost in group C. GLS can predict high SS with a cut-off value of ≤-15, with a sensitivity of 85% and specificity of 87.5%, also GCS can predict high SS with a cut-off value ≤-18, with a sensitivity of 75% and specificity of 83.3%.

Conclusion: 2D STE using GLS can diagnose ischemia with a cut-off value of ≤-19 and predict lesion severity with a cut-off value of ≤-15; also, GCS can diagnose ischemia with a cut-off value ≤ -23 and predict lesion severity with cut-off value ≤-18.

Keywords: Stable angina pectoris, SYNTAX score, 2D STE, GLS, GCS

INTRODUCTION

Echocardiography is considered the most common cardiac imaging device in patients suspected of having a cardiac disease. However, at rest, this conventional echocardiography gives us little information about the state of the coronary artery in patients suspected of having stable angina pectoris [1].

Parameters of conventional echocardiography are usually used for LV function assessment. However, these parameters have multiple drawbacks, such as their angular dependency, low spatial resolution, and one-dimensional deformation analysis [2]. Even in patients with severe CAD, the resting wall motion of the left ventricle may be normal. Hence, it would be advantageous if another resting characteristic could help discriminate between patients with severe CAD and those with less severe or no CAD [3].

Two-dimensional strain echocardiography can detect early changes in the heart function that result from ischemia and predict the coronary disease severity as SYNTAX score [SS], which is a score used to evaluate the severity of coronary artery disease [CAD] in patients undergoing coronary angiography [4].

The left ventricular [LV] myocardium deforms in complex three-dimensional ways throughout the cardiac cycle. Myocardial deformation in echocardiography can be defined in several ways, but for simplicity, the three principal strains are the longitudinal strain, the radial strain, and the circumferential strain [5, 6].

Because longitudinally oriented myocardial fibers are localized sub-endocardial, and it is the most vulnerable area to ischemia, measurements of the longitudinal motion and deformation using two-dimensional strain echocardiography [2D STE] may be the most sensitive markers of CAD [7].

Patients who are suspected of having coronary artery disease should routinely be evaluated with strain echocardiography because it is a cheap and risk-free diagnostic tool. To improve the selection of patients who are referred for coronary angiography we need to detect the link between SYNTAX score as an index of severity of CAD and left ventricular systolic deformation, Patients undergoing coronary angiography must have a high SS predicted.

PATIENTS AND METHODS

Our observational study included 120 patients who sought medical attention for chest pain and were suspected to have stable angina pectoris at Sayed-Galal Hospital [Al-Azhar University] between April 2021 to February 2022. Twenty patients were excluded due to fulfilling the exclusion criteria.

Our study followed the Helsinki declaration principles. We got ethical approval from the Cairo faculty of medicine [Al-Azhar University]. Written informed consent was obtained from each patient.

We grouped the included patients according to their coronary angiography results into Group [A]: 12 patients with normal coronary angiography, and Group [B]: 40 patients with SS<22. Group [C]: 48 patients with SS≥22. We defined stable coronary artery disease as a non-acute condition due to atherosclerosis of epicardial coronary arteries and/or micro-circulation and is diagnosed following a diagnostic ischemia test or an acute coronary syndrome [8]. The exclusion criteria were: 1] Conduction abnormalities on ECG [LBBB, RBBB], 2] Ejection fraction <50%, 3] Evidence of cardiomyopathy, 4] Patient with left ventricular hypertrophy, 5] Patients with more than mild valvular disease, 6] Patients with previous CABG and poor image quality

Data collection: Careful history was taken from all patients for assessment of chest pain, other cardiac symptoms, and previous diagnostic tests for ischemia. General examination and cardiac examination were done for each patient

Conventional 2D Transthoracic Echocardiography

All the patients were examined in the lateral decubitus posture on the left side. It was performed on a "Philips iE33 X Matrix" ultrasound machine equipped with STE technology and "S5-1" & "X5-1" matrix array transducers [Philips Medical Systems, Andover, USA] [1 - 5 MHz]. ECG-gated examinations are typically applied to aid us in picture acquisition and processing.

The following information has been gathered: The M-mode modality was utilized to evaluate the parasternal long axis view linear internal LV dimension. At the level of the mitral valve leaflet tips, it is measured perpendicular to the left ventricular long axis. Apical 2-chamber and 4-chamber views were used to estimate EDV and ESV, respectively, which were then used to derive ejection fraction [EF]. The Simpson-modified formula for EF is: EF = [EDV - ESV] / EDV [9].

2-D Study of speckle tracking echocardiography:

For further study, we captured the apical 4-chamber view, apical 2-chamber view, and apical long-axis view. The operator visually evaluated the tracking quality, made adjustments as necessary, and finally gave his approval. The longitudinal strain of the LV was automatically measured across 17 segments, with the mean value of each strain used to represent the strain over the entire LV [LVGLS].

Aortic valve closure in the apical long-axis view was used as the automated threshold for identifying peak systole. By marking the level and apex of the mitral annulus on each digital loop, the endocardial borders were mechanically delineated. If the automatic delineation of the area of interest was subpar, it was refined by hand. Because there is no way to quantify LS. Poorly acquired or artifactual images were not included [9]. In addition, the following points of view were recorded for future analysis: basal short-axis view at the tip of mitral valve leaflets, mid-short-axis view at the level of papillary muscles, and apical short-axis view at the level of apex distal to papillary muscle level just proximal to the level at which LV cavity end-systolic obliteration occurs [10].

The operator examined the tracking quality visually, made any necessary changes, and accepted it. By marking the endocardial and epicardial borders, the automated delineation of endocardial borders was obtained. The operator assessed the LV strain values automatically in 16 segments, then manually averaged them as the mean value of each strain and displayed them as global circumferential strain [LVGCS]. If the automated delineation was not optimal, the area of interest was manually adjusted. Because of the inability to measure CS, segments with poor image acquisition or artifacts were excluded.

Coronary angiography: It was done using the usual [Judkins] method, and digital imaging was used to get and store the images. All of the analyses on cine loops from different angles were done after the fact by a single skilled invasive cardiologist who didn't know what the results of the echocardiographic studies were**.** Stenosis was reported as either left anterior descending artery [LAD] stenosis, right coronary artery [RCA] stenosis or left circumflex artery [LCX] stenosis. [RCA]. More than 70% of the blockage was considered to be a significant stenosis [11]. Interventional cardiologists evaluated each patient's coronary angiography data and provided the SS using www.syntaxscore.com.

Statistical analysis: All statistical analysis was done using the SPSS version 25 [IBM Corp., Armonk.,NY.,USA]. Categorical variables were described as numbers and percentages and were compared using the Chi-square test. The Kolmogorov-Smirnov test was initially used to check the normality of continuous data. All continuous data were presented as mean and SD and were compared using the wat ANOVA test. Pearson's correlation was done to test for linear relations between variables. ROC curve was made to determine the sensitivity, specificity, and cut-off value of GLS and GCS for discrimination of normal coronary angiography from CAD. A p-value of <0.05 was considered statistically significant.

RESULTS

Our study included 120 patients suspected to have stable angina pectoris. The patients were divided into three groups based on the coronary angiography results. All three groups were matched for the demographics and baseline characteristics [age, gender, hypertension, diabetes, and smoking] with no statistically significant difference between them [P value < 0.05] [table 1].

In terms of systolic function, the difference between the three groups was not significant statistically [P value =0.062]. According to the Number of affected vessels, we found a significant difference between groups B and C [p-value=0.001] as shown in table [2]. Also, the number of affected vessels was significantly correlated with the GLS and GCS. The greater the number of vessels affected the more reduced strain [p-value 0.001 for both, r= -0.6, and - 0.58 respectively] as shown in table [3].

As regards the global longitudinal strain, it was significantly higher in group A than in groups B and C [p-value ≤0.001] [table 4]. Also, we found significant statistical correlation exists between SYNTAX score and GLS in all patients [r = -0.7, P value = 0.001], However, it was weak significant in group B [r=-0.3, p = 0.03] and lost in group C [r=-0.19, p = 0.1] [table 5].

As regards the Global Circumferential strain, it was significantly higher in group A than in groups B and C [p-value ≤0.001] [table 4]. Also, we found a very strong statistical correlation exists between SYNTAX score and GCS in all patients [r = -0.67, P value = 0.001], However, it was weak significant in group B [r=-0.3, p = 0.01] and lost in group C [r=-0.22, p = 0.1] [table 5].

ROC curve acted as a discriminatory_tool between the patient with normal coronary angiography from a patient with CAD by Global Longitudinal Strain that can predict obstructive CAD with a cut of value ≤-19, sensitivity of 85%, specificity of 81%, positive predictive value of 83%, negative predictive value of 52% and diagnostic accuracy of 84.3% [figure 1, table 6].

ROC CURVE was used to discriminate the patient with a Low SYNTAX score from the patient with a high SYNTAX score by Global Longitudinal Strain that can predict a high SYNTAX score with a cut of value ≤-15, with a sensitivity of 85% specificity of 87.5%, positive predictive value of 85%, negative predictive value of 87.5% and diagnostic accuracy of 88.4% [figure 2, table 6].

ROC curve was used to discriminate the patient with normal coronary angiography from the patient with CAD by Global Circumferential strain that can predict obstructive CAD with the cut of value ≤-23, sensitivity of 77.3%, specificity of 83.3%, positive predictive value of 97.1%, negative Predictive value of 33.3% and diagnostic accuracy of 86.7% [figure 3, table 6].

ROC curve was used to discriminate the patient with a Low SYNTAX score from the patient with a high SYNTAX score by Global Circumferential strain that can predict a high SYNTAX score with cut-off value ≤-18, with a sensitivity of 75% specificity of 83.3% positive predictive value of 78.9%, negative predictive value of 80% and diagnostic accuracy of 81.8% [figure 4, table 6].

Table [1]: Comparison between three groups as regard demographic data

		Group A [n=12]	Group B [n=48]	Group C [n=40]	P-value
Gender [n, %]	Males Females	4 [33%] 8 [67%]	28 [58%] 20 [42%]	16 [40%] 24 [60%]	0.128
Diabetes mellitus [n, %]	Yes No	8 [67%] 4 [33%]	35 [73%] 13 [27%]	27 [67.5%] 13 [32.5%]	0.828
Hypertension	Yes No	9 [75%] 3 [25%]	24 [50%] 24 [50%]	23 [57.5%] 17 [42.5%]	0.287
Smoking	Yes No	8 [67%] 4 [33%]	22 [46%] 26 [54%]	28 [70%] 12 [30%]	0.143
Age	Mean ± SD	60	56.71	56.5	0.586

Table [2]: Comparison between the groups [B, C] as regard number of vessels affected

	Number of affected vessels			Chi-square test	P-value
	Single vessel	Two vessels	Three vessels		
Group B [N=48]	20 [90.9%]	24 [57.1%]	4 [16.7%]	64.623	<0.001
Group C [N=40]	2 [9.1%]	18 [42.9%]	20 [83.3%]		

Table [3]: Correlation between number of vessels and GLS

	Number of vessels	
	r	**p-value**
GLS	-0.600	<0.001*
GCS	- 0.58	<0.001*

Table [4]: Comparison between three groups as regard GCS and GLS

		Group A [n=12]	Group B [n=48]	Group C [n=40]	ANOVA	P
GCS	Mean ± SD Range	-27.33± 3.67 21-36	-24.88±3.62 20-36	-20.90±3.84 16-28	16.062	**<0.001**
GLS	Mean ± SD Range	-20.67±2.42 18-24	-17.46±1.74 14-21	-13.75±2.38 10-19	31.381	**<0.001**

Table [5]: Correlation between SYNTAX score and global longitudinal Strain and global circumferential strain

	SYNTAX score	
	Pearson correlation	Sig. [2-tailed]
GLS for all study	-0.787	<0.001
GLS for group B	-0.360	0.035
GLS for group C	-0.118	0.199
GCS for all study	-0.678	<0.001
GCS for group B	-0.381	0.013
GCS for group C	-0.255	0.111

Table [6]: Validity of obstructive CAD and severity of CAD detection by using GCS and GLS

	Cut-Off	sensitivity	specificity	PPV	NPV	Accuracy
Validity of obstructive CAD detection						
GCS	≤-23	77.3%	83.3%	97.1%	33.3%	86.7%
GLS	≤-19	85%	81%	83%	52%	84.3%
Validity of detection of severity of CAD						
GCS	≤-18	75%	83.3%	78.9%	80%	81.8%
GLS	≤-15	85%	87.5%	85%	87.5%	88.4%

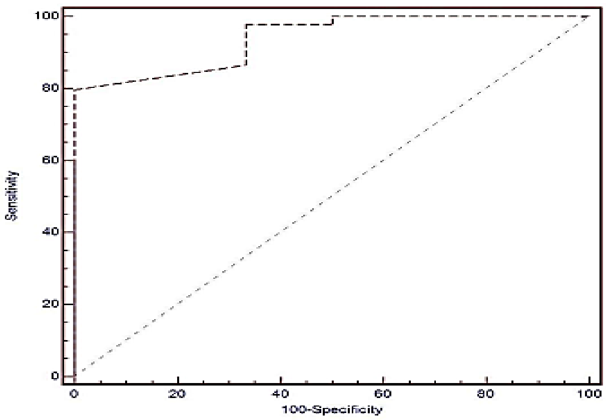

Figure [1]: ROC curve of predictive accuracy of GLS for discrimination of normal coronary angiography from CAD

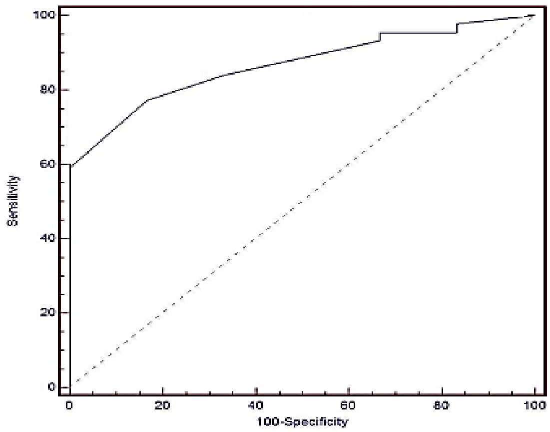

Figure [2]: ROC curve of the predictive accuracy of GCS for discrimination of normal coronary angiography from CAD

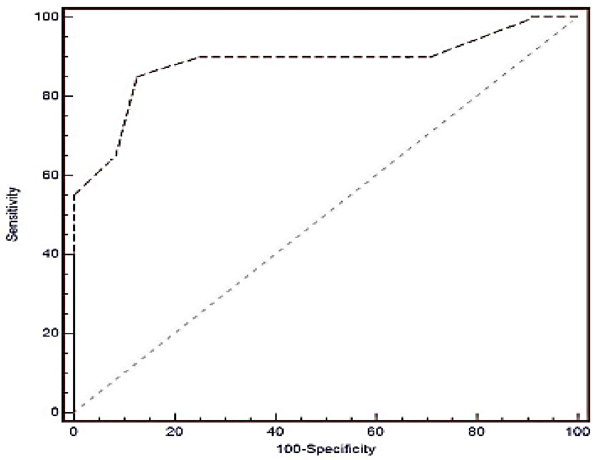

Figure [3]: ROC curve for the predictive accuracy of GLS for discrimination of the LOW syntax score from HIGH syntax score

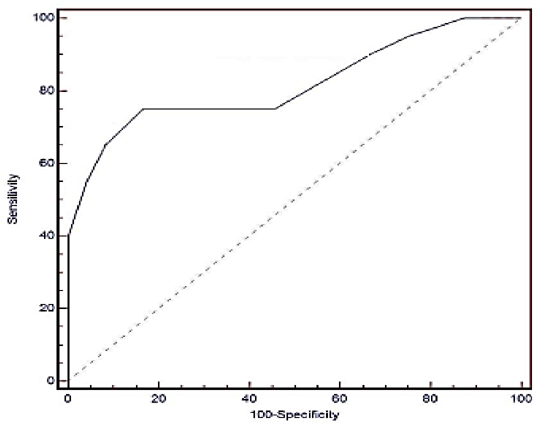

Figure [4]: ROC curve of the predictive accuracy of GCS for discrimination of the LOW syntax score from HIGH syntax score**.**

DISCUSSION

Our study showed no significant differences between the three study groups in terms of age and gender, which was consistent with the findings of **Nucifora *et al.*** [15] and **Biering-Sørensen *et al.*** [16]. We detected no significant difference in EF across the three groups in this investigation, which agrees with **Shimoni *et al.*** [7] and **Mustafa *et al.*** [17]. This is also consistent with the findings of **Choi *et al.*** [18] who investigated whether global and segmental longitudinal plain systolic strain [LPSS] measured 2D STE could be useful for diagnosing severe CAD and discovered that the GLS was lower in the high-risk group.

In this study, we discovered a significant negative correlation between the SYNTAX score and GLS. On a resting echocardiogram, all patients showed normal global and/or regional wall motion, and a lack of correlation with the high-risk group was discovered, which agreed with **Sarvari *et al.*** [19] who examined 77 patients with NSTE-ACS and discovered a substantial inverse relationship between SYNTAX score and GLS20.

In this study, we found a significant inverse correlation between syntax score and GCS. This is in line with **Sarvari *et al.*** [19]. We discovered that resting GLPSS and GCSS could be used in the discrimination of patients with normal CAG and patients with CAD by a cut of value =-19, sensitivity 85% and specificity 81% for longitudinal strain and cut of value -23, sensitivity 77.3 and specificity 83.3 for circumferential strain. This is in agreement with **Sarvari *et al.*** [19] that studied 77 patients with NSTE-ACS for discrimination of non-obstructed CAD from significant CAD by cut-off value -15.9 for GLPSS and cut-off value -17.5 for GCS.

Additionally, this is in agreement with **Norum *et al.*** [20] who evaluated 781 patients with suspected cardiac ischemic chest pain, the mean GLS was -17.2% in CAD-positive patients versus 19.2% in CAD-negative patients. Also, it is consistent with **Biering-Srensen *et al.*** [16], who investigated 293 patients with GLPSS cut-off value - of 18.4% with a sensitivity of 74% and specificity of 58%, and **Smedsrud *et al.*** [21] who researched 109 patients with GLPSS cut off value -17.4% with sensitivity 51% and specificity 81%. This also is consistent with other studies [3, 7, 15]. **Nucifora *et al.*** [15] examined 182 patients who had been sent for MSCT coronary angiography due to an elevated risk profile or stable chest discomfort. They discovered that the GLPSS cut-off value was -17.4 with 83% sensitivity and 77% specificity. Also, **Anwar *et al.*** [22] used left ventricular 17-segment models to compare the accuracy of global and segmental longitudinal strain [LS] for the detection of CAD to visual assessment of WMA using coronary angiography as a gold standard in 25 patients referred to coronary angiography with clinical suspicion of CAD. Also, in agreement with **Mustafa *et al.*** [17] they studied 200 patients with chronic stable angina with GLPSS cut off value-19.5. Also consistent with **Radwan *et al.*** [23], where the GLPSS cut-off value was -18.65, and **Bakhoum *et al.*** [24], where the GLPSS cut-off value was -21.1.

In our study, we noticed that resting GLPSS and GCS were found to be useful in distinguishing patients with severe CAD from those with less severe CAD by a cut of value-15, sensitivity 85%, and specificity 87.5% for longitudinal strain and cut of value-18, sensitivity 75% and specificity 83.3% for circumferential strain. This was consistent with **Sarvari *et al.*** [19], who examined 77 patients with NSTE-ACS to distinguish between significant CAD [defined as a vessel diameter reduction of at least 50% in at least one major coronary artery] and occluded CAD [defined as a TIMI flow grade of 0 or 1] by cut off values of -12.4 for GLPSS and -14.2 for GCS [20]. Also in agreement with **Sarvari *et al.*** [19], study who found that the GLPSS cut-off value of the high risk group was −13.95% with good sensitivity and specificity, therefore, Reduced GLPSS can help identify patients who are more likely to have complex CAD on angiograms and for whom coronary artery bypass surgery may be the best treatment option by increasing the pretest likelihood for the existence of severe CAD. And also, in agreement with **Mustafa et at.** [18], that studied 200 patients with chronic stable angina and found that the GLPSS cut-off value of the high-risk group was-13.5. Also, according to **Eek *et al.*** [25] who assessed 61 NSTEMI patients using 2D STE for the correlation between GLPSS and the infarcted size of the myocardium revealed by CMR, the cut-off value for GLPSS in the high-risk group was -13.8, with a sensitivity of 85% and a specificity of 96%. The SS calculation considers morphological parameters such as tortuosity and calcification in addition to the number of coronary lesions. As a result, a greater SS may not always indicate an increase in the amount of myocardial ischemia, which may explain the loss of correlation in the high-SS group. Our findings back up previous studies that looked into the use of speckle-tracking echocardiography in the diagnosis of CAD. Strain echocardiography is a simple, low-cost, risk-free diagnostic procedure that should be utilized routinely in individuals suspected of having CAD.

Conclusion: contrary to traditional echocardiography, 2D speckle tracking echocardiography [GLS and GCS variables] provides better tools for predication of coronary artery disease severity. This supports its application in excluding substantial coronary artery stenosis in individuals with suspected SAP and in identifying and risk-stratifying atherosclerotic CAD.

Conflict of Interest and Financial Disclosure: None.

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