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Correlation study of Myocardial strain imaging with angiographic findings in patients with chronic stable angina

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***Abstract*---**Background: Global Longitudinal Strain (GLS) measured by 2D speckle-tracking strain echocardiography (2D-STE) can detect impaired longitudinal left ventricle (LV) function at rest which is associated with significant coronary artery stenosis. Objective: Global longitudinal strain (GLS) may be used to predict the presence, extent and severity of CAD according to coronary angiographic findings in patients with chronic stable angina. Methods: 2D-STE and coronary angiography were performed on 100 individuals with suspected stable angina pectoris who had normal resting conventional echocardiography. Global longitudinal strain were assessed and were correlated with coronary angiography for each patient. Results: Statistically significant difference was found when comparing the mean GLS among patients with normal coronaries and different degrees of coronary artery disease (CAD).Mean GLS was – 20.76±1.39, -17.66±0.65, - 16.05±0.58 and -14.22±0.65 for normal/minor, single vessel, two vessels and three vessels respectively(p<0.001). Patients with significant left main (LM) stenosis had GLS of 14.41±1.27 compared with GLS of 17.1±1.91in patients without LM stenosis (p=<0.001). In our study cutoff value for detection of single vessel disease was -18.300 with good sensitivity and specificity (100% and 96.6%, respectively) with AUC (Area Under the Curve) 0.996 and p

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value< 0.001. With a sensitivity and specificity of 96% and 94%, an AUC of 0.989 and a p-value of <0.001, the cut-off value for identifying two vessels disease was set at -16.850. The three-vessel disease was detected with a sensitivity and specificity of 95% and 100%, respectively, with an AUC of 0.994 and a p-value of <0.001 when the cut-off value was 15.200. GLS and the syntax score had a significant negative correlation (p-value <0.001). Conclusion: The presence, extent, and severity of CAD may be predicted with high sensitivity and specificity using GLS evaluated by 2D-STE at rest.

***Keywords*---**coronary artery disease, global longitudinal strain, echocardiography, left ventricle.

Introduction

Coronary artery disease is one of the major causes of mortality and morbidity. In the diagnosis and risk stratification of patients with suspected stable angina pectoris(SAP) noninvasive imaging methods (NIIT) should be used [1]. In assessing individuals with stable CAD, resting transthoracic echocardiography is one of the most often performed techniques. In the absence of structural heart disease and prior myocardial infarction, many patients with critical CAD do not show wall motion abnormalities on resting conventional echocardiography. ECG, myocardial perfusion scintigraphy (MPS), stress echocardiography, and ECG are all often used in addition to TTE (Transthoracic Echocardiography). Exercise ECG is the most widely available technique but has the lowest sensitivity and specificity. Although nuclear imaging tests have great diagnostic accuracy, they are limited by radiation dose and lack availability [2]. It is also possible to do dobutamine stress echocardiography without exposing yourself to radiation, and it has excellent sensitivity and specificity comparable to nuclear perfusion scintigraphy. However, this method requires a high level of competence, limiting its use[3]. To better select patients for coronary angiography, we need an easy, noninvasive way to identify early signs of LV(Left ventricular) dysfunction. It's important to note that although the LVEF may be a good indicator of LV function, it does not take into account ultra-structural alterations in the myocardium that might affect LV systolic function. Myocardial strain imaging, a relatively new medical innovation, has the potential to help us better understand and treat CAD. In chronic stable angina, a conventional echocardiogram at rest does not reveal much about the presence of CAD. LV dysfunction may result from severe CAD.

In the early stages, the ejection fraction of the left ventricle is generally normal, however.[4] As a result of their direct exposure to intraventricular blood pressure and the structure of the coronary circulation, the longitudinally arranged subendocardial fibres are more susceptible[5-7]. As a consequence, the longitudinal function is initially affected in CAD patients. However, individuals with severe coronary stenosis may have subtle forms of stunning that may be detected by strain measurements, making studies of longitudinal motion and deformation the most sensitive indicators of coronary artery disease in such patients. 2D-STE can detect GLPSS or global longitudinal peak systolic strain[5-7].

SYNTAX score (SS) is an angiographic technique used to estimate the severity of CAD in patients undergoing coronary angiography. Early alterations in heart function induced by ischaemia detected by using two-dimensional strain echocardiography able to predict extent the of coronary lesions in the shape of SS [8]. GLPSS at rest may predict the presence,extent, and severity of CAD in individuals with chronic stable angina.

Methodology

Study design

It was Institution-based, cross-sectional, observational study. The study was conducted on 100 Chronic stable angina patients admitted to the cardiology ward, Medical College & Hospital, Kolkata, during a 1year study period from the day of ethical clearance. After taking informed consent from each patient, the research could proceed. Relevant history, clinical examination, imaging parameters of strain imaging, and conventional echocardiography were assessed and compared with coronary artery involvement by angiography. Adults (age ≥18 years) with chronic stable angina, refractory to medical therapy, high-risk feature on noninvasive testing, history of ventricular arrhythmia were included.

List of exclusions were patients with a very poor echo window, patients unwilling to give consent, patients with LVEF<50% by 2D-Echo, patients with RWMA(Regional wall motion abnormality) and patients who had previously had PCI (Percutaneous coronary intervention) or CABG (Coronary artery bypass grafting), Acute coronary syndrome proven by the presence of cardiac enzymes in the patients (serum Troponin), more than trivial valvular heart disease, congenital heart disease, congestive heart failure, intra-ventricular conduction disturbances, pathological Q waves on a resting electrocardiogram, atrial fibrillation, patients who declined coronary angiography , failure to assess all segments by speckle tracking.

Baseline evaluation

On admission to the hospital, all patients had their medical histories reviewed. This included information on their age, gender, BMI, and any known risk factors for coronary atherosclerosis (such as tobacco use, diabetes mellitus, high blood pressure, dyslipidemia, and a family history of coronary artery disease). After that, a thorough physical examination, including a cardiological examination was performed. The Indian Consensus Group used modified criteria for Asian Indians to classify BMI of ≥23 kg/m2 and ≥25 kg/m2 as overweight and obese, respectively (for Asian Indians residing in India). 12 leads surface electrocardiography was performed on each patient to rule out any arrhythmias or alterations in ST-T wave patterns at rest. Routine laboratory testing included a complete blood count (CBC), liver and kidney function, and cardiac biomarkers (troponin I and CK-MB) to rule out an acute event.

2D speckle tracking with strain imaging was done in Philips EPIQ 7C (Ultrasound system for Cardiology) with Automated Cardiac Motion Quantification (aCMQ) software loaded. 2D, M-Mode, and Doppler echocardiography were used to measure the thickness of the left ventricular wall, internal dimensions, abnormalities in wall motion, and systolic and diastolic function.

Three consecutive end-expiratory cardiac cycles were captured at a high frame rate (80–100 frames/s), and harmonic imaging was acquired in the apical four, two-chamber, and long-axis views to measure peak systolic strain using automated function imaging speckle tracking analysis. The GLS for the whole LV was computed using an average of the LV longitudinal peak strain of each image and the mean of the three views, which was then shown in 17 segment model in a "bull's eye" plot. This strain's normal value was -20 [9]. Strain defines the deformation of the myocardium from unwound to a tense or contracted condition which may be described mathematically using the following formula.[10,11,12]

$\varepsilon = (L-L_0)/L_0$

ε is strain, L_0 is the baseline length and L is the length in systole

Longitudinal strain is the deformation of the left ventricle from the base or annular ring to the apex (the z-direction) that generally results in a negative strain because the length of the left ventricular chamber (L) in the systole is shorter than the length (L0) at baseline in the normal heart[11,12].To represent the result as a percentage, multiply it by 100.

Coronary angiography

Angiography of the coronary arteries was performed on all patients within two weeks following echocardiography. Selective angiography of the left and right coronaries in numerous views to avoid side branch overlaps and shortening of the relevant coronary stenosis. Significant reduction in artery lumen area was defined as a decrease of at least 70%, and for left main stenosis, a decrease of at least 50%. Coronary artery disease (CAD) may be classified into normal/minor CAD, SVCAD (Single vessel Coronary artery disease),DVCAD (Double vessels coronary artery disease), TVCAD(Triple vessels Coronary artery disease) depending on the findings of coronary angiograms, which were used to categorize the patients.

To calculate the SYNTAX I score, all images were analyzed, and the total of the individual scores for each lesion defined as a luminal blockage of ≥50% in vessels 1.5 mm was added together. We used specialized software to generate SYNTAX scores (http://www.syntaxscore.com/calc/start.htm). Patients were then classified into three groups depending on the presence and or severity of coronary artery disease (CAD): no CAD on angiography, low SS (SS≤ 22), and high SS (SS > 22), respectively.

Global Longitudinal Strain (GLS)

Global longitudinal strain is the average individual strain value of 17 segments. It is calculated from 3 views: Apical 4 chambered, Apical 3 chambered, and Apical 2 chambered.

Ethical Clearance

Before inclusion in the study, informed consent was taken from the patients and caregivers. After clearance was received from the Institutional Ethics Committees of Medical College & Hospital, Kolkata, the study was carried out.

Statistical Analysis

The SPSS version 20 statistical software was utilized in the study.
A Pearson's chi-square test for independence of attributes or Fisher's Exact Test compares the number of patients and the percentage of patients in each group. To compare the mean, median, and standard deviation of continuous variables across groups, Mann-Whitney U/Kruskal Wallis tests are utilized. The Spearman's Rank Correlation Coefficient measures the strength of relationships between two continuous variables.

Analysis of non-parametric receiver operating characteristic (ROC) curves were performed, and ROC curves were used to assess the accuracy of GLS to various events, as shown by AUC and the 95 percent Confidence Interval (CI) for each event (CI).It was determined that the "optimum cutoff point" was the cutoff point with the maximum [(sensitivity + specificity)/2] ratio, at which there was a maximally accurate categorization of the events. It has been decided to use an alpha level of 5%, which means that any value of p that is less than 0.05 is deemed significant.

Results

Study population

A total of 100 patients who met the inclusion and exclusion criteria were included in this research. In addition to standard echocardiograms and speckle tracking 2D strain imaging, all patients were evaluated for clinical and laboratory data.The parameters were finally correlated with angiographic findings. The mean age was 55.67±6.66, and the mean BMI (Body mass index) was 23.64±3.42. Of the study subjects, 32% were female, and 68% were male. Among the cardiovascular risk factors in the study population, diabetes mellitus was present in 56%, hypertension in 60%, and dyslipidemia in 49% of patients. Out of 100 patients, 47% were smokers. 11% of the study population had a family history of CAD. (Table1)

Table 1 : Baseline characteristics of studied patients

Mean age	55.67±6.66
Mean BMI	23.64±3.42
Gender (male)	68%
Gender(female)	32%
Diabetes mellitus	56%
Hypertension	60%
Dyslipidemia	49%
Smoking	47%
Family history of CAD	11%

Coronary angiography results

Out of total 100 chronic stable angina patients, 89% patients had substantial coronary artery disease, whereas only eleven percent had normal or mild CAD in

their CAG. 39 (39%)of the people with CAD had a single vessel disease, whereas thirty patients (30%) had the two-vessel disease, and twenty (20%) had three vessel disease.
Out of 89 CAD patients, 54patients(60.67%) had LAD disease as part of SVCAD/DVCAD or TVCAD. 38 patients (42.69%) had LCX disease as part of SVCAD/DVCAD or TVCAD.36 patients(40.44%) had RCA disease as part of SVCAD/DVCAD or TVCAD.
10 patients(10%) had left main involvement among the total study subjects. According to the syntax score, 5 patients had no CAD (syntax score = 0), 68 patients had low syntax (syntax score<= 22), and 27 patients had intermediate and high syntax (syntax scores > 22).

Demographic data of the studied patients & extent of CAD

BMI differed significantly (p = 0.009) from one group to another. There was no statistically significant difference in age (p value =0.072) (Table 2).

Table 2 - Comparison of age & BMI among study population

		Normal or minor CAD	SVCAD	DVCAD	TVCAD	P value
Age	Mean±SD	52.82±6.15	54.51±5.94	56.40±6.72	58.40±7.46	0.072
BMI	Mean±SD	22.54±3.45	22.59±3.26	24.38±3.25	25.16±3.33	0.009

BMI – Body mass index

When considering risk factors variables including hypertension, smoking, dyslipidemia, and family history of coronary artery disease there were no significant difference (p value >0.05) but significant difference in case of diabetes mellitus and extent of CAD.(Table – 3 and 4)

Table 3 - Risk factors of the studied patients as regard to extent of CAD

		CAD				Total		
		NORMAL/ MINOR CAD	SVCAD	DVCAD	TVCAD		p Value	Significance
DM	No	5(45.45)	25(64.1)	8(26.67)	6(30)	44(44)	0.009	Significant
	Yes	6(54.55)	14(35.9)	22(73.33)	14(70)	56(56)		
Total		11(100)	39(100)	30(100)	20(100)	100(100)		
Hypertension	No	4(36.36)	17(43.59)	10(33.33)	9(45)	40(40)	0.815	Not Significant
	Yes	7(63.64)	22(56.41)	20(66.67)	11(55)	60(60)		
Total		11(100)	39(100)	30(100)	20(100)	100(100)		
Smoker	No	9(81.82)	17(43.59)	16(53.33)	11(55)	53(53)	0.166	Not Significant
	Yes	2(18.18)	22(56.41)	14(46.67)	9(45)	47(47)		
Total		11(100)	39(100)	30(100)	20(100)	100(100)		
Dyslipidemia	No	8(72.73)	21(53.85)	16(53.33)	6(30)	51(51)	0.129	Not Significant
	Yes	3(27.27)	18(46.15)	14(46.67)	14(70)	49(49)		
Total		11(100)	39(100)	30(100)	20(100)	100(100)		
Family history of CAD	No	10(90.91)	35(89.74)	27(90)	17(85)	89(89)	0.932	Not Significant
	Yes	1(9.09)	4(10.26)	3(10)	3(15)	11(11)		
Total		11(100)	39(100)	30(100)	20(100)	100(100)		

DM: Diabetes mellitus

Table 4 - Comparison of presence of diabetes mellitus among subjects with different severity of coronary artery involvement

		SYNTAX Score			Total		
		NO CAD	<=22	>22		p Value	Significance
DM	No	2(40)	36(52.94)	6(22.22)	44(44)	0.017	Significant
	Yes	3(60)	32(47.06)	21(77.78)	56(56)		
Total		5(100)	68(100)	27(100)	100(100)		

In this study there was presence of more diabetic patients in patients with SYNTAX Score >22 compared to other groups.

Echocardiographic data according to the extent of CAD

In terms of LVEDD (Left ventricular end-diastolic diameter), LVESD (LV end-systolic diameter), and LVEF (LVejection percentage), statistically significant differences between the normal/minor, single vessel, two vessels and three vessels disease groups are evident in Table 5.

Table 5 - Echocardiographic data according to extent of CAD

	CAD							
	Normal/ Minor CAD			Significant				
	Mean	Median	SD	Mean	Median	SD	p Value	Significance
LVEDD	44.00	43.00	2.61	47.98	49.00	3.34	<0.001	Significant
LVESD	26.09	26.00	1.97	30.58	31.00	3.34	<0.001	Significant
LVEF	65.45	65.00	4.01	60.24	60.00	4.37	0.001	Significant

Mean of GLS in the studied population

According to the study, patients with and without severe coronary artery disease (CAD) had significantly different mean GLS values (p < 0.001).(Table 6)

Table 6- Mean of GLS in the studied population

	Significant coronary artery disease							
	Normal/ Minor CAD			Signifiant				
	Mean	Median	SD	Mean	Median	SD	p Value	Significance
GLS	20.76	20.20	1.39	16.34	16.40	1.48	<0.001	Significant

GLS declined incrementally with an increasing number of stenotic coronary arteries (Mean GLS was – 20.76±1.39, -17.66±0.65, -16.05±0.58 and -14.22±0.65 for normal/minor, single vessel, two vessels and three vessels respectively (p<0.001). (Table 7)

Table 7- Mean of GLS in the studied population

	CAD													
	NORMAL/ MINOR CAD			SVCAD			DVCAD			TVCAD				
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	p Value	Significance
GLS	20.76	20.20	1.39	17.66	17.70	0.65	16.05	16.10	0.58	14.22	14.20	0.65	<0.001	Significant

Patients with significant left main (LM) stenosis had GLS of 14.41±1.27 compared with GLS of 17.1±1.91in patients without LM stenosis (p<0.001).

Detection of the number of diseased vessels

In our investigation, the single-vessel disease was detected with good sensitivity and specificity (100% and 96.6%, respectively) with an AUC of 0.996 and a p-value of 0.01, which used a threshold value of -18.300 for detection (Figure 1).

Test Result Variable(s): GLS

Area	p Value	Asymptotic 95% Confidence Interval	
		Lower Bound	Upper Bound
0.996	<0.001	0.987	1.000

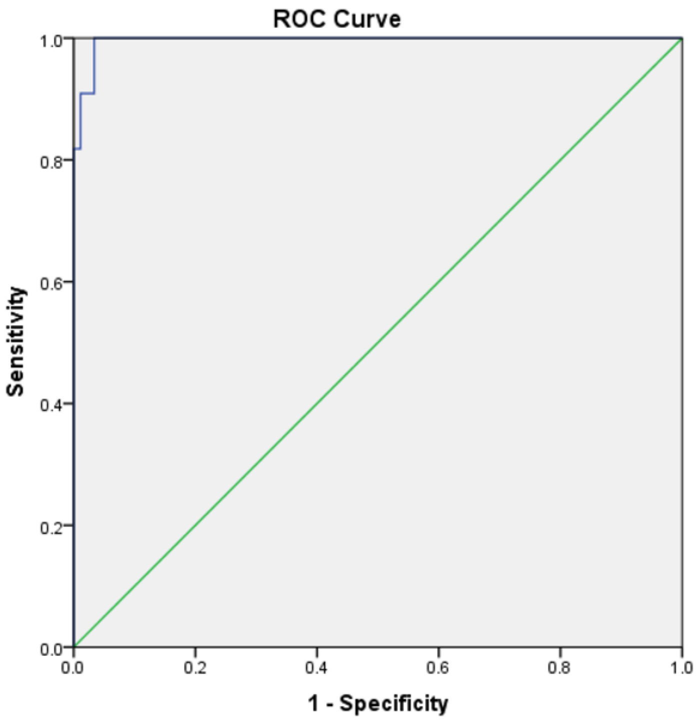


Figure 1: ROC curve analysis to define a cut off value of GLS to predict SVCAD in study subjects. (n=100)

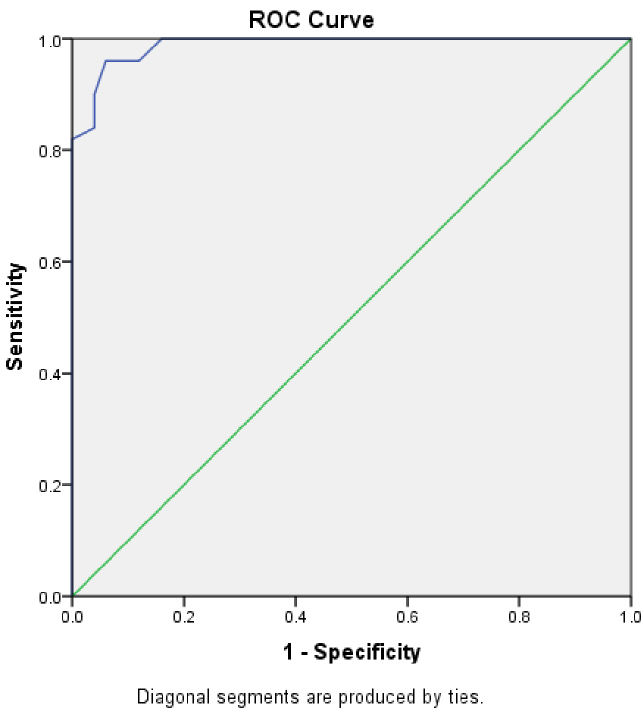
Cut off	Sensitivity	Specificity
18.300	1.000	0.966

Two vessels disease was detected at cut-off value of -16.850 with 96% sensitivities and 94% specificities, with an AUC of 0.989 and a p-value of less than 0.001. (Figure 2).

Area Under the Curve

Test Result Variable(s): GLS

Area	p Value	Asymptotic 95% Confidence Interval	
		Lower Bound	Upper Bound
0.989	<0.001	0.975	1.000



Cut off	Sensitivity	Specificity
16.850	0.960	0.940

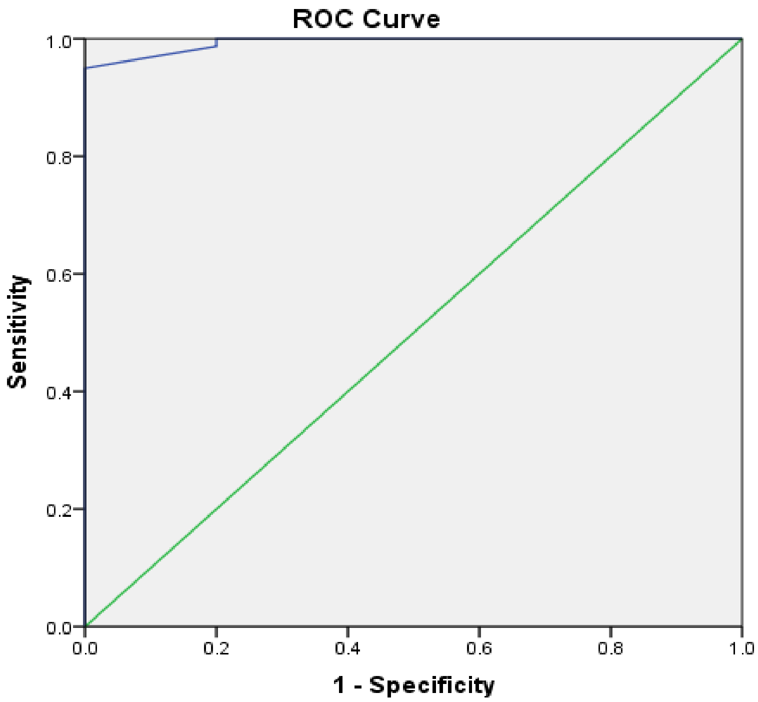
Figure 2: ROC curve analysis to define a cut off value of GLS to predict DVCAD in study subjects. (n=100)

The cutoff value for the detection of three vessels disease was -15.200 with a sensitivity and specificity (95% and 100%, respectively) with AUC 0.994 and p value <0.001(Figure 3).

Area Under the Curve

Test Result Variable(s): GLS

Area	p Value	Asymptotic 95% Confidence Interval	
		Lower Bound	Upper Bound
0.994	<0.001	0.984	1.000



Cut off	**Sensitivity**	**Specificity**
15.200	0.950	1.000

Figure 3 : ROC curve analysis to define a cut off value of GLS to predict TVCAD in study subjects. (n=100)

Correlation between GLS and syntax score

In this study five individuals had no CAD (syntax score=0), 68 had a low syntax score (<=22), and 27 had an intermediate or high syntax score (>=22). We found that the GLS and the syntax score had an extremely strong negative correlation (p-value less than 0.001). According to SYNTAX score mean of GLS in patients with no CAD was 21.64, in patients with syntax score of <=22 &>22 was 17.37 & 14.58 respectively. (Table 8; Figure 4).

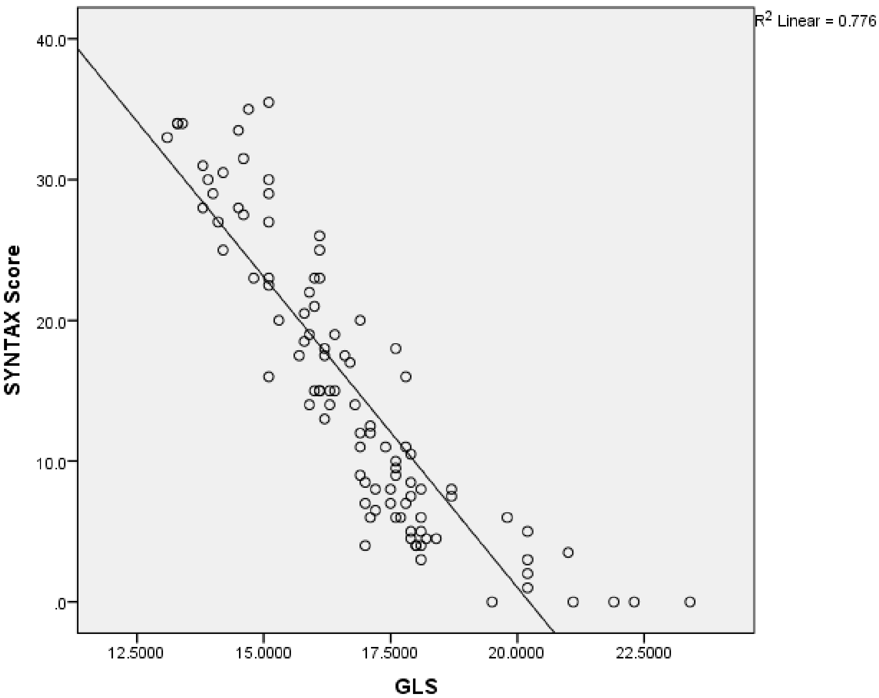


Figure 4 - Scatter diagram to show the negative correlation between GLS and SYNTAX Score.

Table 8 - Correlation between GLS and syntax score

	SYNTAX Score										
	NO CAD			<=22			>22				
	Mean	Median	SD	Mean	Median	SD	Mean	Median	SD	p Value	Significance
GLS	21.64	21.90	1.46	17.37	17.30	1.25	14.58	14.60	0.88	<0.001	Significant

Discussion

There is a need for a simple, noninvasive method to detect CAD in the early stage before developing Left ventricular dysfunction & regional wall motion abnormality. Approach to screening CAD considering appropriateness and cost-effectiveness is also important. Most individuals with presumed stable angina exhibit normal wall motion at rest, as conventional echocardiogram being often the first imaging test used to rule out a heart disease. This is because most of these individuals had no previous MI or cardiac failure. As a result, it would be helpful if another resting module could distinguish between cases with severe and less severe CAD.[8]

The intraventricular blood pressure and the coronary circulation's structure make the longitudinally distributed subendocardial fibres more sensitive.[5-7] A longitudinal function is the first to be impacted when dealing with CAD. Therefore, the most sensitive coronary artery disease indicators are longitudinal motion and deformation measurements. Intermittent ischemia may cause subtle forms of stunning in individuals with severe coronary stenosis, which may be detectable with strain measurements. 2-D speckle-tracking echocardiography (STE) at rest for measuring global longitudinal strain is an excellent method to detect significant CAD[13]. As a result, we examined the predictive value of GLS at rest in patients with stable angina pectoris for the presence, degree, and severity of CAD.

In the present study, 100 patients were included satisfying the inclusion and exclusion criteria. Clinical and laboratory parameters were studied, and every patient was subjected to a conventional echocardiogram and 2D strain imaging by speckle tracking technique. The parameters were finally correlated with angiographic findings. The mean age was 55.67years, and 46% of the study population belonged to the age group 51-60 yrs, 29% in the age group 41-50 yrs, and 25% in the age group 61-70 yrs. Of the study subjects, 32% were female, and 68% were male. 33% of study population were obese(BMI>25kg/m^2), 14% were overweight (BMI 23-25kg/m^2). Among the cardiovascular risk factors in the study population, diabetes mellitus was present in 56%, hypertension in 60%, and dyslipidemia in 49% of patients. Out of 100 patients, 47% were smokers. 11% of the study population had a family history of CAD.

Comparable research[14] found that the average age and BMI of the participants were both 53.86 ± 8.99 and 28.67 ± 6.28, respectively. There were 62.5 percent diabetics, 64% hypertensives, 114 patients(57%) dyslipidemic, 79(39.5%) smokers, and 13.5 percent with a family history of coronary artery disease among the patients evaluated in this study.

There were no significant differences in risk variables except smoking between female and male participants in this study. When compared to females, the male age group was much younger. The BMI of males and females is almost the same.
89 percent patients with chronic stable angina had significant coronary artery disease in CAG, whereas 11 percent had normal or mild coronary artery disease (CAG). A total of 39 (39% of the CAD patients) had a single vessel disease, 30 (30% of the CAD patients) had a two-vessel illness, and 20(20% of the CAD patients) had three-vessel disease.

Out of 89 CAD patients, 54patients(60.67%) had LAD disease as part of SVCAD/DVCAD or TVCAD. 38 patients (42.69) had LCX disease as part of SVCAD/DVCAD or TVCAD. 36 patients (40.44%) had RCA disease as part of SVCAD/DVCAD or TVCAD. Ten percent of the overall research participants had left main involvement. Comparing fundamental characteristics of the research population revealed no significant variation in the age of CAD groups. No significant differences were found across CAD groups concerning hypertension, tobacco use, dyslipidemia and family history of CAD in terms of demographic data except for diabetes mellitus. Research by Hanan Radwan et al. [15]also found that both CAD and non-CAD groups had similar risk factors. In Shaimaa Moustafa et.al [14] study even though the age difference between healthy people and those with coronary artery disease was statistically significant, there was no statistically significant difference in gender ($p<0.094$), BMI ($p<0.508$), or risk factors like diabetes, hypertension, dyslipidemia, smoking, or a family history of coronary artery disease ($p>0.05$) in this study.

According to echocardiographic data, a substantial difference in LV end-diastolic and LV end-systolic diameter, ejection fraction was found between the Normal/minor, single vessel, two-vessel, and three-vessel disease groups. LV end-diastolic, end-systolic, and ejection fractions ($p <0.001$, $p <0.001$, and $p <0.001$, respectively) were found to be significantly different between the normal, single vessel, two-vessel, and three-vessel disease groups, in agreement with Hanan Radwanet al's study [15] which found that EF was lower in the CAD group (59.3 ± 3.2 percent vs 65.7 ± 4.7 percent $p <0.000$). Three separate studies Biering-Sørensen et al.[16], Montgomery et al.[17] and Nicola et al[18] showed no statistically significant difference between the groups of patients with and without CAD when it came to their levels of EF and LV internal diameters. A significant positive association was found between GLS and EF, whereas a significant negative correlation was found between LVEDD and GLS. The Hanan Radwan et al.[15]research found a strong positive correlation between GLS and EF ($p<0.001$). In the present study, patients with normal/Minor CAD group had GLS (-20.76 ± 1.39). Another study [14] showed GLPSS of -20.11±0.8 in normal coronary artery group.. Hanan Radwan et al., [15]where the normal group's GLPSS was 18.65 ± 0.79; Sameh Bakhoum et al., [19]where the normal group's GLPSS was -21.1 ± 1 0.8; and Vrettos et al.[20], where the normal group's GLPSS was -17.39 ± 1.15, and others.

GLS mean demonstrated a statistically significant difference between individuals with no considerable CAD and those with substantial CAD in the study group. More the number of stenotic coronary arteries resulted in lower GLS, with mean GLS was – 20.76±1.39, -17.66±0.65, - 16.05±0.58 and -14.22±0.65 for normal/minor, single vessel, two vessels and three vessels respectively($p<0.001$). GLS was 14.41 ± 1.27 for individuals with significant stenosis of the left main (LM), instead of a GLS of 17.1 ± 1.91 for those without LM stenosis. According to Hanan Radwan, [15]the GLS for individuals without severe coronary artery disease was 18.65 ± 0.79 and 15.13 ± 0.68, -12.25 ± 0.09 , -9.1± 1.94 for SVD, DVD and TVD correspondingly. According to Shaima Moustafa et al., [14]the mean GLPSS was 20.11 ± 0.8 for normal, -18.34 ± 2.25, -16.14 ± 2.85, -14.81 ± 2.12 and -13.01±2.92 for normal, single vessel, two vessels, three vessels and left main disease, respectively.

Single vessel disease was detected with a cutoff value of -18.300 in our research, with good sensitivity and specificity (100% and 96.6%, respectively) with an AUC of 0.99, and p-value of<0.001. The threshold value for two-vessel disease identification was -16.850, with a sensitivity of 96% and a specificity of 94%, with an AUC of 0.989 and a p-value of <0.001. Cutoffs were set at -15.200 with 95% and 100% sensitivities and specificities, respectively, with an AUC of 0.994 and p-value of<0.001 to identify three-vessel disease. Previous studies [9,16-18,21-25] on individuals with suspected CAD indicated that rest GLS decreased significantly in patients with obstructive CAD compared to people with no CAD. This finding matched our study results.

Multislice computed tomography(MSCT)coronary angiography performed on 182 individuals with no prior history of coronary artery disease by Nucifora et al. [23]indicated that GLS ≤17.4 could predict substantial blockage (>50%) of the coronary arteries by this test. Shimoni et al. [22]studied 97 individuals with probable coronary artery disease. Study participants who had substantial coronary artery disease were shown to have considerably lower GLS than those who did not, with mean GLS values being (-17.3 ± 2.4) and (-20.8 ± 2.3), respectively. GLS -19.7 may also indicate substantial blockage (>50 percent) of CAD with a sensitivity of 81 percent and a specificity of 67 percent.

Biering-Soerensen et al. [16]studied 296 patients with assumed stable angina and found that GLS was significantly lower in patients with substantial CAD than in individuals with non-significant CAD in their analysis of 296 patients (GLS was -17.1 ± 2.5 vs -18.8 ±2.6, p <0.000 for patients with significant and non-significant, respectively). In this research, a GLS ≤-18.4 percent may indicate substantial blockage (>70 percent) of CAD with 74% sensitivity and 58% specificity.

Six trials, including 778 individuals with suspected CAD, were utilized by Billehaug Norum et al[25]to determine the diagnostic accuracy of GLS in predicting serious coronary artery disease. Patients with severe CAD had considerably lower GLS, with mean values of GLS being 17.2 ± 2.6 vs. 19.2 ± 2.8, p<0.000. GLS cutoffs for predicting CAD+ ranged from -17.4% to -19.7%, with sensitivity ranging from 51% to 81% and specificity ranging from 58% to 81%. For individuals with chest symptoms, the finding was that the GLS measurement at rest only have modest diagnostic accuracy in predicting coronary artery disease (CAD). Diastolic function and afterload have an impact on GLS, which may explain why the CAD+ and CAD-groups had similar GLS distributions.

For the prediction of major CAD, GLS employing vendor-independent software is as accurate as stress-echo wall motion analysis, as shown in Gaibazzi et al.[18]. People who had substantial coronary artery disease had considerably lower rest GLS (-19 ± 2.4 vs. -22.7 ± 2.4, P =0.001) than those who had no CAD. This research found that a GLS value of≤ 20.7 had a sensitivity of 81.6 percent and a specificity of 84.9 percent for predicting substantial CAD (stenosis >50 percent). If a patient has an increased risk of coronary artery disease, 2-D STE at rest is an excellent predictor. It is considered that longitudinal deformation is the most sensitive marker of CAD because the myocardial fibers that are most vulnerable to ischemia are those that are located subendocardially.[22,23,26]

In Choi et al(26)study that included 108 patients with chest pain without regional wall motion abnormality at rest echocardiogram, patients were grouped according to the coronary angiography findings as follows; high-risk group with left main or three-vessel CAD (n = 38), low-risk group with one- or two-vessel CAD (n = 28), and a control group without CAD (n = 30). GLPSS was significantly reduced, especially in mid- and basal segments, in the high-risk group. Patients with severe CAD were accurately identified by ROC curve analysis using mid- and basal GLPSS (area under the ROC curve = 0.83, 95 percent confidence interval [CI]: 0.75 ± 0.91). A CAD diagnosis was possible, however the research relied on the number of vessels affected rather than the severity of occlusion.

Xie et al [27] compared 45 patients with multivessel CAD with 36 people with minimal risk of CAD using longitudinal, circumferential, and radial systolic function of the left ventricle assessed by STE (global, basal, mid, and apical regions). Both groups' conventional ultrasonic measurement indices were quite close in terms of results and interpretation. In multivessel CAD compared to the control group, although global, basal and mid longtidinal, circumferential and radial strain was statistically reduced ($p < 0.00$). GLS was 14.41 ± 1.27 for individuals with substantial stenosis of the left main (LM), as opposed to a GLS of 17.1 ± 1.91 for those without LM stenosis (p=<0.001). Another research[16] indicated that individuals with LM stenosis had a low GLS and a high ALS pattern, a difficulty in utilizing the apical segments to identify high-risk patients.

Patients with LM stenosis have a particular pattern, which was previously observed in a different research.[26] Patients with CAD were divided into three groups based on their syntax scores: 5 had no CAD (syntax score=0), 68 had low syntax scores (<=22), and 27 had intermediate and high syntax scores (>22). GLS and syntax score had a substantial negative correlation ($p < 0.001$). Mean GLS in individuals with no CAD was - 21.64, whereas patients with syntax score of <=22 & >22 had mean GLS of -17.37 and -14.58, respectively.

For coronary revascularization, a SYNTAX score may assist determine the degree of lesion complexity. Trifurcations, bifurcations, tortuosity, and calcification are all taken into consideration when calculating the SYNTAX score. The amount of myocardial ischemia is also determined by the location and diameter of the lesion. In our investigation, we discovered a strong correlation between anatomy and function. Though previous studies have shown that longitudinal strain correlates well with the presence and severity of CAD but however few investigations have examined the relationship between GLPSS and Syntax scores.

In the 158 individuals who had never had myocardial infarction before, Tanaka and colleagues[28] discovered a moderate association between SYNTAX scores and the degree of stress-induced myocardial ischemia as determined by myocardial SPECT ($r = 0.647$, $p < 0.0001$) in their study. Stress SPECT results show that it correlates strongly with myocardial ischaemia.

Vrettos et al[20]study correlated Syntax score and GLPSS in patients with stable angina with normal global and/or regional wall motion. GLPSS cutoff value of -13.95 percent on vendor non-specific software utilized in this investigation predicted the identification of high SS(SYNTAX score) among patients with suspected CAD with strong sensitivity and specificity, according to the results of this study. SS may be linked to microcirculatory injury, as shown by the association between the GLPSS and SS. GLS decreased with increased CAD severity and extent (measured by the number of stenotic coronary arteries in the coronary angiography) in our research.

Study limitation

This study has some limitations.

1) Relatively small sample size
2) Single centre study
3) Poor echo window may affect image quality and hence strain measurements
4) Different cut off values for GLS in different echo machines
5) The clinical endpoints were not followed so prognostic value of GLS was not determined since the trial was cross-sectional in nature.
6) Due to different techniques for measuring regional longitudinal strain, segmental RLS (regional longitudinal strain) was not evaluated.
7) There were no radial, transverse, circumferential or synchrony analysis in this research. Since a result, measures of longitudinal deformation are regarded to be among the most sensitive indicators of coronary artery disease (CAD), as these fibers are the most vulnerable to ischemia.

Conclusion

Aiming to determine whether GLS at rest may accurately detect CAD in patients with chronic stable angina, we conducted this study. Two-dimensional speckle tracking echocardiography at rest may indicate severe CAD. We found that GLS decreased with increasing CAD severity and extent (measured by the number of stenotic coronary arteries) in the current research. Multivessel disease is more likely when GLS decreases. We found negative correlation between resting GLS and coronary angiography's SYNTAX score. 2D STE had good sensitivity and specificity in predicting the presence, degree, and severity of CAD in individuals with suspected stable angina pectoris. When used in the initial examination of patients with suspected CAD, myocardial strain imaging may enhance the value of strain echocardiography to diagnose CAD earlier, identify individuals at higher risk, and give additional information to clinicians.

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