SIGNIFICANCE OF LONGITUDINAL SPECKLE STRAIN AND ITS CORELATIONS WITH CORONARY ANGIOGRAPHY IN CORONARY ARTERY DISEASE

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ABSTRCT

Background: Significant coronary artery stenosis might cause persistently impaired longitudinal left ventricle function at rest. LV global longitudinal strain (GLS) can be accurately assessed by 2D speckle-tracking strain echocardiography (2D-STE) in correlation with coronary angiogram (CAG).

Objective: We aimed to evaluate the diagnostic accuracy of LV global longitudinal strain obtained by 2D-STE in the prediction of the severity of coronary artery disease (CAD) in acute coronary syndrome.

Methods: 100 patients with the acute coronary syndrome were included. They underwent transthoracic echocardiography (TTE) to measure GLS and they also underwent coronary angiography (CA). Images were obtained in the apical long-axis, four-chamber, and two chamber views. The regional longitudinal systolic strain was measured in 17 myocardial segments and averaged to provide global longitudinal strain (GLS). This GLS was co-related to the severity of coronary artery disease. Results: There was a significant decrease in GLS in patients with the significant coronary artery disease as compared to a patient with non-significant coronary artery disease. The GLS in patient with non-significant coronary artery disease was -22.34±0.32. The value of GLS in single-vessel CAD, double vessel CAD and triple vessel CAD being -18.88±1.07, -17.33±0.8, -15.33±0.45 respectively. The GLS cut off valve was found to be -18.46+3.18 (p=<0.001).The sensitivity of GLS in SVD, DVD, TVD was 96.88%, 85% and 88.46% respectively and specificity was 81.29%,70.1% and 69.81% respectively. There was a significant positive correlation between GLS and the severity of coronary artery disease which was seen as incremental significant decrease in GLS with an increasing number of coronary vessels involved.

Conclusion: Measurement of global longitudinal strain using 2D speckle tracking echocardiography is a sensitive and accurate tool in the prediction of severity CAD in acute coronary syndromes.

Keywords: Cad-Coronary Artery Disease, 2decho -2d Speckle Tracking Echocardiography, Gls-Global Longitudinal Strain, Cag-Coronary Angiography.

INTRODUCTION

Non-invasive identification of patients with significant coronary artery disease (CAD) in acute coronary syndrome remains a clinical challenge despite the widespread use of imaging and provocative testing. More than 50% of patients currently referred to coronary angiography show normal or non-obstructive CAD. Exercise testing is widely used for selecting a patient for coronary angiography but it has its clear limitations as emphasized in the guidelines for stable CAD.

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Severe CAD is known to cause LV dysfunction. However, the LV ejection fraction is usually normal at a relatively early stage. Therefore establishing a more sensitive index for the detection of early-stage LV dysfunction is of great importance. The longitudinally arranged subendocardial fibers are most vulnerable to ischemic effect due to their direct exposure to the intraventricular blood pressure and the anatomy of the coronary circulation. As a result, the longitudinal function is impaired first in CAD. Measurements of longitudinal motion and deformation are, therefore, the most sensitive markers of coronary artery disease especially in patients with severe coronary stenosis, where intermittent ischemia may result in subtle forms of stunning that may be detectable with strain measurements. Global longitudinal strain (GLS) can be detected by two-dimensional speckle tracking echocardiography (2D-STE). The aim of this study was to evaluate the value of global longitudinal strain (GLS) at rest to predict the presence of significant CAD and to determine the severity of CAD in patients with the acute coronary syndrome

METHODOLOGY

- A total of 100 patients diagnosed with acute coronary syndrome presenting to department of cardiology, Manipal Hospital, Bangalore were included in the study after taking informed written consent.
- A baseline demographic data was collected at the time of recruitment and patients were evaluated by taking history, clinical examination, ECG, cardiac markers and ECHO to determine eligibility for enrolment in the study.
- Study population were then subjected to 2D-speckled tracking echo (2D-STE) done by using GE vivid - E9.2D Greyscale echo image from 3 standard planes 4c,2c,3c were acquired. Post-processing software automatically divides the ventricle into six equally distributed segments. A 2D data set is produced. Mathematical algorithms are applied to generate values of GLS.
- Following which study population was subject to coronary angiogram using standard protocol and severity of CAD was determined in terms of single vessel, double vessel and triple vessel disease. Vessels with >50% were considered as obstructed CAD. Vessels with >70% stenosis were considered as severe CAD.
- Statistical analysis was done and co-relation between the GLS values and severity of CAD was determined

RESULTS

The mean age for study subjects was 59.21±5.42yrs and the range of 42-70yrs. Maximum subjects in this study belonged to the age group of 51-60 years comprising a total of 48% of the study population which was followed by the subjects belonging to the age group 61-70 years which was 44%. Only 8% of subjects were below 50 years of age.

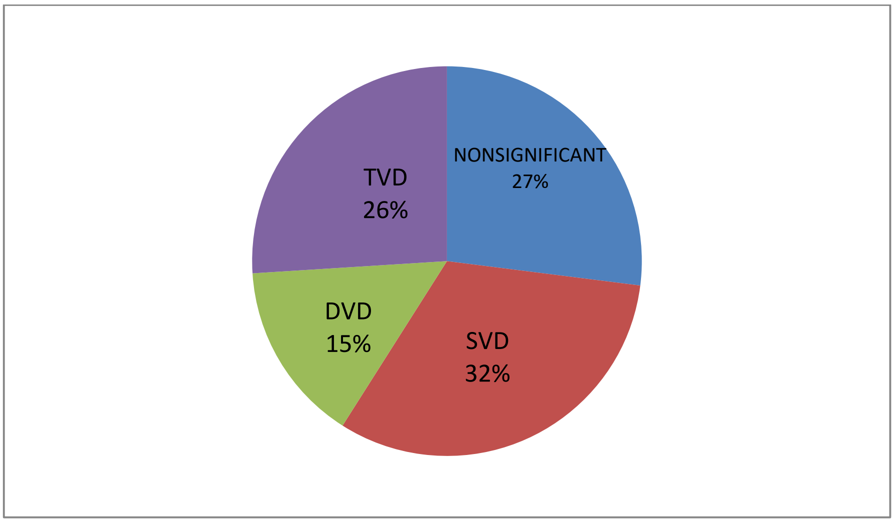
Males accounted for a total of 64% of the study population, whereas females comprised 36% of the study population. Male: Female ratio was 1.8:1 in the study.

The most commonly observed risk factors were hypertension & diabetes followed by smoking and positive family history. However, it was seen that most of the study subjects had more than one risk factor.

The most common diagnosis among study subjects was anterior wall MI followed by inferior wall MI. Least commonly observed diagnosis being inferio-posterior wall MI.

Diagnosis	Frequency	Percent
Anterior wall MI	60	60.0
Inferior wall MI	23	23.0
Inferio-posterior wall MI	4	4.0
NSTEMI	13	13.0
Total	100	100.0

Out of 100 subjects, 27 had non-significant CAD, 32% had single vessel disease, 26% had triple vessel disease and 15% had double vessel disease diagnosed using angiography.



The most common vessel affected among the single vessel disease was LAD, least common being LCX. LAD and LCX was the most common combination of vessels to be affected among the double vessel diseases. Triple vessel disease was seen among 26% of study subjects. Whereas non significant CAD was seen in 27% subjects.

Significant vessel affected	**Frequency**	**Percent**
LAD	19	19.0
RCA	8	9.0
LCX	5	7.0
LAD+LCX	12	12.0
LAD+RCA	2	2.0
LCX+RCA	1	1.0
LAD+LCX+RCA	26	26.0
Non-significant CAD	27	24.0
Total	100	100.0

Vessel strain	Mean±Sd	Median	IQR
RCA AVG Strain value	-12.53±6.832	-13	-30 to -2
LCX AVG Strain value	-13.60±7.015	-15	-34 to -1
LAD AVG Strain value	-15.52±7.057	-17	-32 to -1

Table depicting average strain value in the RCA, LCX and LAD territories among the study subjects irrespective of the severity of CAD.

There is a significant decrease in average strain value in RCA among study subjects with significant stenosis which is defined as stenosis > 50%. This difference in mean value was statistically significant with p<0.001 at a 95% confidence interval.

Table : RCA Average Strain value.

RCA AVG Strain value	**RCA Stenosis**		**P value**
	<50% (n=66)	**>50% (n=34)**	
RCA AVG Strain value	-13.88+7.76	-9.91+3.26	0.001

LAD AVG Strain value	**LAD Stenosis**		**P value**
	<50% (n=45)	**>50% (n=55)**	
LAD AVG Strain value	-19.44+5.07	-12.31+6.858	0.001

The table shows there is a difference in LAD average strain value for LAD Stenosis >50% & <50%. This difference in mean value was statistically significant with p<0.001 at a 95% confidence interval. The average strain value is less in patients with significant stenosis.

LCX AVG Strain value	**LCX Stenosis**		**P value**
	<50% (n=56)	**>50% (n=44)**	
LCX AVG Strain value	-18.04+4.92	-7.95+4.90	0.001

Table showing a significant decrease in average strain value among study subjects with significant stenosis. This difference in mean value was statistically significant with p<0.001 at a 95% confidence interval.

Table 11: Average strain value for vessels in single vessel diseased subjects

SVD	LAD (n=19)	LCX(n=6)	RCA(n=7)	TOTAL (n=32)
NO OF PATIENT WITH > 50% STENOSIS	16*(84.21%)	6(100%)	7(100%)	29(60.06%)
CORRESPONDING AVERAGE STRAIN IN RESPECTIVE VESSEL	-11.21±5.96	-8.39±4.35	-8.05±5.71	

The above table depicts the average strain value in study subjects with single vessel disease in their respective territory of affection viz., LAD, LCX, RCA. Out of 29 patients with the single-vessel disease most common to be affected was the left anterior descending artery.

*16 subjects were found to have LAD stenosis above 50% remaining 3 had 50% stenosis, hence the total number of subjects with LAD involvement has been taken to be 19

Table 12: Average strain value for vessels in double vessel disease subjects

DVD	LAD +LCX(n=12)	LAD+RCA(n=2)	RCA+LCX(n=1)	TOTAL (n=15)
NO OF PATIENT WITH > 50% STENOSIS	11+11	2+1	1	14
CORRESPONDING AVERAGE STRAIN IN RESPECTIVE VESSEL	-16.42;-8.3	-3;-1.6	-14.3;-13.5	

The above table depicts the average strain value of individual vessels for double vessel disease subjects. The average strain value has been calculated for the 3 different combinations of vessels involved, LAD+LCX being the most among the subjects with double vessel disease.

Table 13: Average strain value for vessels in triple vessel diseased subjects

TVD	RCA+LCX+LAD	TOAL(26)
NO OF PATIENT WITH > 50% STENOSIS	26	26
CORRESPONDING AVERAGE STRAIN IN RESPECTIVE VESSEL	-10.56;-8.27;-13.09	

Above table depicting the average strain of individual vessels in subjects with triple vessel disease.

Table : Mean GLSS value and severity of coronary artery disease.

Severity of CAD	Mean GLSS value
Non-significant CAD (stenosis <50%)	-22.34±0.32
SVD	-18.44±1.07
DVD	-17.33±0.8
TVD	-15.33±0.45

Above table depicting the mean GLSS value and the corresponding severity of coronary artery disease. There was a significant decrease in the GLSS value as the severity of coronary artery disease increased.

Table : Sensitivity and specificity of GLS value in significant single vessel disease.

GLSS Value*	SVD		Total	Sensitivity	Specificity
	Yes	No			
>-18.44	31(53.5%)	27(46.5%)	58	96.88%	60.29%
<-18.44	1(2.4%)	41(97.6%)	42		
Total	32	68	100		

Optimal cut off value of GLS for significant single vessel disease was -18.44±1.07 and sensitivity was 96.88% and specificity was 60.29%.

Table : Sensitivity and specificity of GLS value in significant double vessel disease.

GLSS Value	**DVD**		**Total**	**Sensitivity**	**Specificity**
	Yes	No			
>-17.3	17(37.7%)	28(62.3%)	45	85.00%	65.00%
<-17.3	3(5.5%)	52(94.5%)	55		
Total	20	80	100		

The optimal cutoff value of GLS for significant double vessel disease was -17.3±0.8 and sensitivity was 85% and specificity was 65%.

Table Sensitivity and specificity of GLS value in significant triple vessel disease.

GLSS Value	**TVD**		**Total**	**Sensitivity**	**Specificity**
	Yes	No			
>-15.3	23(44.2%)	29(55.8%)	52	88.46%	60.81%
<-15.3	3(6.2%)	45(93.8%)	48		
Total	26	74	100		

The optimal cutoff value of GLS for significant triple vessel disease was -15.3±0.45 and sensitivity was 88.46% and specificity was 60.81%.

DISCUSSION

Demographic characteristics

Age

In the present study, a maximum number acute coronary syndromes belonged to the age group of 51-60 years comprising a total of 48% of the study population which was followed by the subjects belonging to the age group 61-70 years which was 44%.In H. Radwan, E. Hussein[30] et al study, mean age was 51.3 ±8.8 years whereas in our study mean age was 59.21+5.42yrs while in Nicola Gaibazzi, and Pigazzani et al study mean age was 64.9+11 years (p=0.34). [31]

Gender

In the present study males accounted for a total of 64% of the study population, whereas females comprised 36% of the study population. Male: Female ratio was 1.8:1 in our study. In H. Radwan, E. Hussein et al out of 58 patients, 38 (65.5%) were males and 20 (34.5%) were females,with male: female ratio being 1.9:1 [30] . In study by Sørensen et al, males comprised 35% and females 65% of the study population. Whereas in Nicola Gaibazzi et al study, males were 39% and females 61% of the study population.

Risk Factors

Out of 100 patients in the present study, observed risk factors were as follows, hypertension in 39(39%), smoking in 36(36%), diabetes in 38(38%) and positive family history in 36(36%) and dyslipidemia was seen in 20(20%). However, it was seen that most of the study subjects had more than one risk factor. In H. Radwan, E. Hussein et al[30] smoking was the commonest risk factor seen in 72.4%(42) of study population followed by hypertension 34(58.6%), DM 28(48.3%), dyslipidemia 32(52.2%), and positive family history 2(3.4%) while in Nicola Gaibazzi, and Pigazzani et al study hypertension was the most common risk factor seen among 18(54%) of study population, followed by DM 7(21%), and dyslipidemia seen in 16(48%)[31].

Diagnosis in Acute coronary artery disease.

In the present study 60 (60%) had Anterior wall MI which was the commonest ACS presentation among 100 study subjects followed by inferior wall MI 23(23%), inferio-posterior wall MI was seen in 4(4%) of study population whereas NSTEMI was seen in 13(13%). In their study, Amira M. Ismail et al (2015) found that 18 patients (60%) had anterior wall myocardial infarction as the commonest presentation, followed by inferior wall myocardial infarction seen in 6(20%) , and a total of six patients (20%) with infarctions in other sites (inferolateral and posterolateral MI) and one patient had RV myocardial infarction. [35]

Coronary Artery Disease Burden

In our present study out 100 subjects, 32(32%) had single vessel disease while patients with double disease involvement were 15(15%) and TVD were 26 (26%). And subjects with non-significant coronary artery involvement were 27(27%). In H. Radwan, E. Hussein[30] et al study SVD was seen among 20(34.4%), DVD 14(24.1%), TVD 24(41.3%) of the study population respectively while patient with non-significant coronary artery disease were 22(27.5%). And in the study conducted by Nicola Gaibazzi, and Pigazzani et al patients with single-vessel disease were 20(34.4%), DVD12(24%), TVD 21(43%) respectively whereas patients with non-significant coronary artery disease was 33(33%). [31]

Significant Vessel Distribution

In our present study, on coronary angiography, commonest vessel found to have >50% stenosis which is considered as significant stenosis was LAD 59(59%) followed by LCX and RCA which were 43(52%) and 36(48%) respectively. In H. Radwan, E. Hussein et al study commonest vessel to have significant stenosis was >50% LAD 58 %(100%), followed by LCX 36(62%), and RCA32 (55.1%). [30]

In study by Smedsrud et al, LAD was the commonest vessel to have significant stenosis ie, 65%, followed by RCA 58% and LCX 48% respectively. Similarly in Gaibazzi et al study LAD was the commonest vessel to have significant stenosis followed by RCA and LCX respectively.

Average Longitudinal Strain in Significant Coronary Artery Stenosis. (Stenosis >50%)

In our study average LAD strain value in patient with significant coronary artery stenosis was -12.31+6.858 (p<0.001at 95% confidence interval) while in LCX was -7.95+4.90 (p<0.001at 95% confidence interval) and in RCA was -9.92+3.26 (p<0.001at 95% confidence interval) respectively.

	S.Maustfa et all (2018)[36]	Nicola Gaibazzie et al[31]	Present study	P valve
AVERAGE LAD STRAIN IN SIGNIFICANT STENOSIS (>50%)	**-18.300**	**-19.2+3.9**	**12.31+6.856**	**(p=<0.001)**
AVERAGE LCX STRAIN IN SIGNIFICANT STENOSIS (>50%)	**-19.313**	**-13.9+4.3**	**-7.95+4.90**	**(p=<0.001)**
AVERAGE RCA STRAIN IN SIGNIFICANT STENOSIS (>50%)	**-18.0850**	**-15.8+5.0**	**-9.91+3.26**	**(p=<0.001)**

Table 18: Comparison of average longitudinal strain in LAD, RCA and LCX with other studies.

Cut-Off Gls Values in Significant Coronary Artery Disease

In our present study which includes 100 patients with acute coronary syndrome without regional wall motion abnormality, patients were subjected to 2D-STE GLS and coronary angiography. Among those patients having significant stenosis (>50%) on coronary angiography it was revealed that GLS value was significantly lower than those with non-significant CAD (<50% stenosis) with mean values of GLS were -22.34±0.32 (non significant CAD) vs. -18.46±3.18 (significant CAD) with p < 0.001.

Previous studies evaluated patients with suspected CAD, to assess rest GLS to predict obstructive CAD following invasive angiography and they found a significant decrease in GLS in patients with significant CAD compared to non-significant CAD. This finding was similar to our results.

Biering-Sørensen et al. enrolled 296 patients with suspected acute coronary syndrome found that GLS was significantly lower among patients with significant CAD than those with non-significant CAD with mean values of (GLS) were-17.1± 2.5 vs. -18.8 ±2.6, (p <0.000).[32]

Gaibazzi et al found that GLS using vendor-independent software has similar accuracy compared with stress-echo wall motion analysis for the prediction of significant CAD. Patients with CAD group had significantly reduced rest GLS -19+2.4 vs. -22.7 +2.4, (P =0.001) compared with patients with non-significant CAD. [31]

Hanan Radwan, Ekhlas Hussein et al stated that GLS declined incrementally with an increasing number of stenotic coronary arteries GLS -18.65 ± 0.79 as compared to patients with non-significant stenosis (p<0.000)[30]

GLS cut off for significant stenosis	Biering-Soerensen et al [32]	Gaibazzi et al[31]	Hanan Radwan, Ekhlas Hussein et al[30]	Montgomery et al[33]	Smedsrud et al[34]	Present Study
GLS	-17.0±2.5	-19.0±2.4	-18.65±0.79	−16.8 ± 3.2	−17.7± 3.0	-18.46±3.18
Sensitivity	51%to 81%	81.6%	93.1%	66 %	51 %	78.8%
Specificity	58%to 81%	84.9%	81.8%	76 %	81 %	72.1%
P valve	<0.001	0.003	0.001	0.0002	0.003	<0.001

Table 19: Comparison of cut-off GLS values in significant coronary artery disease with other studies.

The optimal GLS diagnostic cutoff value varies significantly among previous studies. This could be explained by the fact that GLS may depend on the clinical characteristics of patients, the effect of vendor-dependent 2D-STE software and operator skills may lead to variation.

Other data have indicated that GLS is more dependent on the 2D-STE software used, rather than ultrasound equipment used to acquire images, which makes the use of vendor-independent software particularly attractive to standardize GLS for widespread use.

Gls Value Co-Relation in Single Vessel, Double Vessel and Triple Vessel Disease

In the present study, we found that GLS declined incrementally with increasing severity of CAD defined by an increasing number of stenotic coronary vessels. Patients with single vessel disease had GLS value of -18.88±1.07 while double vessel disease and triple vessel disease had GLS values of -17.33±0.8, -15.33±0.45 respectively. (p=0.004). The risk of having multi-vessels disease increases with decreasing GLS value.

GLS	SVD	DVD	TVD	P VALVE
Hanan Radwan, Ekhlas Hussein et al [30]	-15.13± 0.68	-12.25±0.9	-9.1±1.94	0.000
Biering-Sorensen et al [32]	−18.0±2.4	−16.7±2.7	−16.3±2.3,	<0.001;
Nicola Gaibazzi et al [31]	-19.662±.66	-19.201±.67	-18.08 ±2.5	<0.002
In this study	-18.88±1.07	-17.33±0.8	-15.33±0.45	<0.004

Table 21: Comparison of GLS value and its co-relation with severity of CAD among different studies.

Hanan Radwan Ekhlas [30] et al found that GLS value decreases incrementally with the involvement of significant coronary artery disease in SVD, DVD and TVD with GLS of -15.13± 0.68,-12.25±0.9,-9.1±1.94 respectively. (P=0.000). [30]

Biering-Sorensen et al also found that that GLS value decrease incrementally with the involvement of significant coronary artery disease in SVD, DVD and TVD with GLS of−18.0±2.4,−16.7±2.7,−16.3±2.3respectively(p=< 0.001).[32]

Nicola Gaibazzi et al found that that GLS decrease incrementally with the involvement of significant coronary artery disease in SVD DVD and TVD with GLS of -19.662±0.66,-19.201±0.67,-18.08±2.5 respectively. (p=0.002).[31]

In our study we found that GLS value decreased incrementally with the increasing severity of significant coronary artery disease. With value of GLS being -18.88+1.07,-17.33+0.8,-15.33+0.45 in SVD, DVD and TVD respectively. (p=0.004).

Comparison of Sensitivity and Specificity of Gls Values among Different Studies

STUDY	Gaibazzi et al	Biering-Soerensen et al	Smedsrud et al	Montgomery et al	Shimoni et a	Nucifora et al	Present study
SENSITIVITY	81.6%	74%	51%	66%	81%	83%	90.11%
SPECIFICITY	84.9%	58%	81%	76%	67%	77%	62.03%

Table no 21: Comparison of sensitivity and specificity of GLS values among different studies.

Gaibazzi et al, found that GLS using vendor-independent software has similar accuracy compared with stress-echo wall motion analysis for the prediction of significant CAD. Patients with CAD group had significantly reduced rest GLS (-19+ 2.4 vs - 22.7 + 2.4, P = 0.001) compared with patients with non-significant CAD. They showed that GLS </> -20.7 may predict significant obstruction (>50%) of CAD, with sensitivity 81.6% and specificity 84.9%.

Biering-Soerensen et al. enrolled 296 patients with suspected stable angina pectoris found that GLS was significantly lower among patients with significant CAD than those with non-significant CAD with mean values of (GLS) were (-17.1 ± 2.5 vs -18.8 ± 2.6, p < 0.000). They showed that GLS >/< -18.4% may predict significant obstruction (>70%) of CAD, with sensitivity 74% and specificity 58%.

Smedsrud et al. included 86 patients with stable chest pain.They found GLS value was (-17.9 ± 3.5) in patients with CAD+ and (-20.1 ± 2.9) in patients with CAD -. The cutoff value of GLS for prediction significant CAD (>50%) was -17.4% with sensitivity (51%) and specificity (81%).

Montgomery et al. found that GLS was significantly lower among patients with significant CAD than those with non-significant CAD with mean values of (GLS) were (-16.8 ± 3.2 vs -19.1 ± 3.4, $p < 0.000$). They showed thatGLS >/< -17.8 may predict significant obstruction (>50%) of CAD, with sensitivity 66% and specificity 76%.
Shimoni et al. included 97 patients with suspected CAD. They found that GLS was significantly lower among patients with significant CAD than those with non-significant CAD with mean values of (GLS) were (-17.3 ± 2.4 vs -20.8± 2.3 $p < 0.000$). Also they showed that GLS >/< -19.7 may predict significant obstruction (>50%) of CAD with sensitivity 81% and specificity 67%.
Nucifora et al, included 182 patients without known CAD, and they showed GLS >/< -17.4 may predict significant obstruction (>50%) of CAD by multislice computed tomography (MSCT) coronary angiography, with sensitivity 83% and specificity 77%.
In our present study, including 100 patients with CAD, it was seen that among those patients having significant stenosis (>50%) on coronary angiography it was revealed that GLS value was significantly lower than those with non-significant CAD (<50% stenosis) with mean values of GLS were -22.34±0.32 (non significant CAD) vs. -18.46±3.18 (significant CAD) with $p < 0.001$.Also GLS value >/< -18.44 may predict significant obstruction of CAD with sensitivity of 90.11% and specificity of 62.03%.

CONCLUSION

- Global longitudinal strain (GLS) assessed by 2D-STE at rest is a sensitive predictor of significant CAD.
- GLS has high sensitivity 90% for early detection of significant CAD.
- Measurement of global longitudinal strain using 2D speckle tracking echocardiography is a sensitive and accurate tool in the prediction of severity of CAD.
- 2D-STE has the potential to improve the value of echocardiography in the detection of CAD by identifying high-risk patients and to provide more information for the treating physician.

Limitations

- Small sample size and single center study.
- The study was observational in design, the clinical endpoints were not followed, so prognostic value of GLS could not determined.
- Segmental RLS was not assessed because there were different methods used for obtaining regional strain. As a 16-segment or a 17-segment anatomical model for LV the results represent a problem as this anatomical model does not necessarily reflect the individual coronary artery distribution because there is individual variability in the coronary blood supply to myocardial segment, and also we need for proper standardization of how to uniformly obtain regional longitudinal strain (RLS) data.

BIBLIOGRAPHY

1. Sharma M, Ganguly N. Premature Coronary Artery Disease in Indians and it's Associated Risk Factors, Vasc Health Risk Manag.Sep 2005;1(3): 217–225.
2. Wong, ND (May 2014)."Epidemiological studies of CHD and the evolution of preventive cardiology. Nature reviews. Cardiology.11 (5): 276–89. doi:10.1038/nrcardio.2014.26.
3. GBD 2013 Mortality and Causes of Death, Collaborators (17 December 2014)."Global regional and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013."Lancet.385: 117–171. Doi10.1016/S0140-6736(14)61682-2.
4. What Are the Signs and Symptoms of Coronary Heart Diseases.www.nhlbi.nih.gov.September 29 2014. Retrieved 23 February 2015.
5. Hong Burden of cardiovascular Disease in Asia: Big Challenges and Ample Opportunities for Action and Making a Difference. Clin Chem.2009 July;55(8)1450-2 DOI 1.1373/Clinchem.2009.125369.
6. Enas EA, Senthilkumar A.Coronary artery disease in Asian Indians: an update and review Internet J Cardiol.2001:1.
7. Enas EA, Dhawan J, Petkar S.Coronary artery disease in Asian Indians: lessons learned and the role of lipoprotein (a). Indian Heart J. 1997 Jan-Feb; 49(1):25-34.
8. SCHLESINGER, M. J., ZOLL, P. M., AND WESSLER, S.The conus artery a third coronary artery. Am. Heart J. 38: 823, 1949.
9. 9. Falk E, Nakano M, Benton JF, et al: Update on acute coronary syndromes: The pathologists view. Ear Heart J 34:719, 2013.
10. Libby P: Inflammation in atherosclerosis. Arteriosclerosis Thrombus Vacs Biol 32:2045, 2012.
11. Crea F, Liuzzo G: Pathogenesis of acute coronary syndromes. J Am Coll Cardio 61:1, 2013.
12. Bruschke AV, Sheldon WC, Shirey EK, et al: A half century of selective coronary arteriography. J Am Coll Cardio 54:2139, 2009.
13. Patel MR, Dehmer GJ, Hirshfeld JW, et al: ACCF/SCAI/ STS/AATS/AHA/ASNC/HFSA/SCCT 2012 Appropriate use criteria for coronary revascularization focused update: A report of the American College of Cardiology Foundation Appropriate Use Criteria Task

Force, Society for Cardiovascular Angiography and Interventions, Society of Thoracic Surgeons, American Association for Thoracic Surgery, American Heart Association, American Society of Nuclear Cardiology, and the Society of Cardiovascular Computed Tomography. J AmColl Cardio 59:857, 2012. Patel MR, Bailey SR, Bonow RO, et al: ACCF/SCAI/AATS/

14. AHA/ASE/ASNC/HFSA/HRS/ SCCM/SCCT/SCMR/STS 2012 appropriate use criteria for diagnostic catheterization. J Thoracic Cardiovascular Surge 59:1995, 2012.
15. Bashore TM, Balter S, Barac A, et al: 2012 American College of Cardiology Foundation/Society for Cardiovascular Angiography and Interventions expert consensus document on cardiac catheterization laboratory standards update: A report of the American College of Cardiology Foundation Task Force on Expert Consensus documents developed in collaboration with the Society of Thoracic Surgeons and Society for Vascular Medicine. J AmColl Cardio 59:2221, 2012.
16. Fihn SD, Gardin JM, Abrams J, et al: 2012 ACCF/AHA/ ACP/AATS/PCNA/SCAI/STS Guideline for the diagnosis and management of patients with stable ischemic heart disease: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines, and the American College of Physicians, American Association for Thoracic Surgery, Preventive Cardiovascular Nurses Association, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. J Am Coll Cardio 60:e44, 2012.
17. Kushner FG, Hand M, Smith SC, Jr, et al: 2009 focused updates: ACC/AHA Guidelines for the Management of Patients with ST-Elevation Myocardial Infarction (updating the 2004 Guideline and 2007 Focused Update) and ACC/AHA/SCAI Guidelines on Percutaneous Coronary Intervention (updating the 2005 Guideline and 2007 Focused Update): A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. Circulation 120:2271, 2009.
18. Bulum J, Strozzi M, Smalcelj A: Spontaneous and catheter-induced secondary coronary artery dissection: A single-center experience. Acta Cardio 63:203, 2008.
19. West R, Ellis G, Brooks N: Complications of diagnostic cardiac catheterization: Results from a confidential inquiry into cardiac catheter complications. Heart 92:810, 2006.
20. Chambers CE, Fatherly KA, Holzer R, et al: Radiation safety program for the cardiac catheterization laboratory. Catheter Cardiovascular Interv 77:546, 2011.
21. Alvarez-Tostada JA, Moose MA, Bean JF, et al: The brachial artery: A critical access for endovascular procedures. J Vasc Surg 49:378, 2009
22. Bertrand OF, Rao SV, Pancholy Septal: Transracial approach for coronary angiography and interventions: Results of the first international transracial practice survey. J Am Coll Cardio Intv 3:1022, 2010.
23. Rao SV, Cohen MG, Kandzari DE, et al: The Trans-radial approach to percutaneous coronary intervention: Historical perspective, current concepts, and future directions. J Am Coll Cardio 55:2187, 2010.
24. Pearlman AS, Ryan T, Picard MH, et al: Evolving trends in the use of echocardiography: A study of Medicare beneficiaries. J Am Coll Cardio 49:2283, 2007.
25. Douglas PS, Wolk MJ, Brindis R, et al: Appropriateness criteria: Breaking new ground. J Am Coll Cardio 46:2143, 2005.
26. Patel MR, Spertus JA, Brindis RG, et al: ACCF proposed method for evaluating the appropriateness of cardiovascular imaging. J Am Coll Cardio 46:1606, 2005.
27. Brindis RG, Douglas PS, Hendel RC, et al: ACCF/ASNC appropriateness criteria for single photon emission computed tomography myocardial perfusion imaging (SPECT MPI). A report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group and the American Society of Nuclear Cardiology Endorsed by the American Heart Association. J Am Coll Cardio 46:1587, 2005.
28. Carr JJ, Hendel RC, White RD, et al: 2013 appropriate utilization of cardiovascular imaging: A methodology for the development of joint criteria for the appropriate utilization of cardiovascular imaging by the American College of Cardiology Foundation and American College of Radiology. J Am Coll Cardio 61:2199, 2013.
29. Wolk MJ, Bailey SR, Doherty JU, et al: ACCF/AHA/ASE/ASNC/HFSA/HRS/SCAI/S CCT/SCMR/ STS 2013 multimodality appropriate use criteria for the detection and risk assessment of stable ischemic heart disease: A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, American Heart Association, American Society of Echocardiography, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for

Cardiovascular Magnetic Resonance and Society of Thoracic Surgeons. J Am Coll Cardio 63:380, 2014.

30. Hanan Radwan, Ekhlas Hussein et al 2016 Value of global longitudinal strain by two-dimensional speckle tracking echocardiography in predicting coronary artery disease severity The Egyptian Heart Journal-Department of Cardiology, Faculty of Medicine, Zagazig University, Zagazig City, Sharkia Governorate, Egypt 2016.

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