ASSESSMENT OF LEFT VENTRICULAR SYSTOLIC FUNCTION IN PATIENTS WITH MITRAL AND AORTIC VALVE DISEASE USING GLOBAL LONGITUDINAL STRAIN ECHOCARDIOGRAPHY

Dr. Anudeep Aveleli[1], Dr Ashok G[2], Sandhiya T[3], Dr Gnanaguru Durairaj[4]
[1]*Postgraduate, Department of Cardiology) Chettinad hospital and research institute*
[2]*(Professor,Department of Cardiology) Chettinad hospital and research institute*
[3]*(lecturer, Department of Cardiology,SRM medical college hospital and research centre)*
[4]*(Assistant Professor, Department of Cardiology) Chettinad hospital and research institute)*

KEYWORDS
MS MR AS AR EF GLS RHD

ABSTRACT:
Introduction:Left ventricular global longitudinal strain is widely recognized as a more sensitive measure of LV systolic function compared with LV ejection fraction (LVEF). In addition, the measurement of LVGLS is more reproducible than two-dimensional LVEF. Current guidelines for diagnosis and treatment of valvular heart disease include LVEF as one of the parameters to take into consideration in the clinical decision-making.
Assessment of left ventricular systolic function in patients with aortic and mitral valve heart disease is often reliant on quantification of LV ejection fraction to determine the optimal timing for surgery, evaluate operative risk, and prognostic outcome.
Aim and Objectives:A prospective observational study, to calculate Left Ventricular Global Longitudinal Strain using strain echocardiography to assess LV systolic function in patients with aortic and mitral valve disease
Materialsand Methods:A total of 350 patients with moderate and severe aortic and mitral valve disease(MS,MR,AS,AR) are considered in this study. All 350 patients were found to have preserved Ejection fraction while assessing by 2-dimensional echocardiography using SIMPSON'Smethod.
All standard apical 4 chamber, 2 chamber and 3 chamber were recorded for the 350 patients to measure the global longitudinal strain, in order to detect Subclinical Myocardial dysfunction.
Results:
Out of 350 patients, 258 patients had rheumatic heart disease(MS,MR,AS,AR) , 92 patients had degenerative heart disease. 177(68.6%) out of 258 patients with Rheumatic Heart disease had reduced GLS. 61(66%) out of 92 patients with Degenerative Heart Disease had reduced GLS.
Conclusion:
Left Ventricular Global Longitudinal Strain shows a modest correlation with valvulo - arterial impedance. LVGLS is increasingly used to identify subclinical myocardial dysfunction in patients with valvular heart disease and optimal timing for surgery and prognosticate outcomes after surgery.

INTRODUCTION

GLS is a basic parameter that expresses longitudinal shortening as a percentage (change in length relative to baseline length). GLS is obtained by speckle tracking and assessed through post-processing of apicalpictures of the LV.

Different software from different manufacturers derives GLS in different ways. Common features include view selection, defining end-systole, tracing the myocardium, evaluating tracking quality, and integration.

Strain can manifest itself in a variety of ways. Multiple cardiac segments' contraction delay and temporal dispersion can be shown using waveforms. Spatial dispersion during the cardiac cycle can be depicted using parametric displays.

Determining aberrant GLS is challenging since it typically changes with age, sex, and LV loading conditions. Adults, on the other hand, have normal GLS >18% (sic), aberrant GLS <16% (sic), and borderline GLS 16% to 18%. (Note from the editor: GLS is a negative number.)

Errors in triggering and defining the region of interest (i.e., precisely tracking the LV myocardium during systole) are frequent mistakes in the evaluation of GLS.

ASSESSMENT OF LV FUNCTION:

Assessment of Left ventricular systolic function with echocardiography by Ejection fraction (EF) using Simpsons method as routine conventional method to assess lv function.

SIMPSONS RULE / RULE OF DISK METHOD:

It is a volumetric method.

GLOBAL LONGITUDINAL STRAIN

➢ Myocardial deformation, or strain, imaging is a relatively novel yet promising method for assessment of cardiac function. Strain refers to the percent deformation between two regions and reflects shortening in myocardial muscle.

➢ Myocardial strain can be assessed by Doppler methods in which myocardial tissue velocities in multiple regions are integrated to obtain change in distance.

➢ Doppler-based assessments of myocardial strain are relatively noisy and require dedicated acquisition during scanning, thus limiting their usefulness. In addition, Doppler-derived strain information is angle dependent.

➢ In contrast, strain imaging based on speckle-tracking techniques has proved to be much more robust and reliable, although it has poorer temporal resolution than Doppler-based techniques do, thus limiting its use at high heart rates.

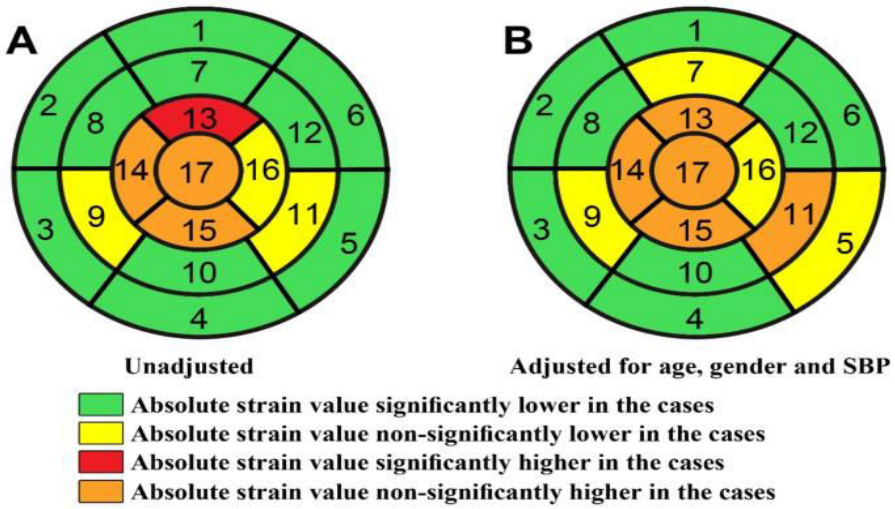
➢ Nevertheless, 2D methods have virtually replaced Doppler-based strain assessments for most applications. These techniques take advantage of the coherent speckle within the myocardialtissue signature to determine regions that are contracting versus those that are moving passively.

➢ Myocardial strain measures have been validated with Sono micrometry, and strain can be estimated in the longitudinal, circumferential, and radial directions by using the appropriate imaging plane. Speckle methods can also be used to assess ventricular twist and torsion or the wringing motion of the heart during contraction and relaxation.

Longitudinal strain can be assessed with the A4C view, and global longitudinal strain has emerged as an important measure of cardiac performance that has been shown to add incremental value to standard measures such as the ejection fraction.

Current equipment both assesses regional strain and calculates global longitudinal strain either by averaging regional strain or by determining the percent difference in the endocardial perimeter between systole and diastole. Longitudinal deformation reflects function of the subendocardial myocardial fiber bands.

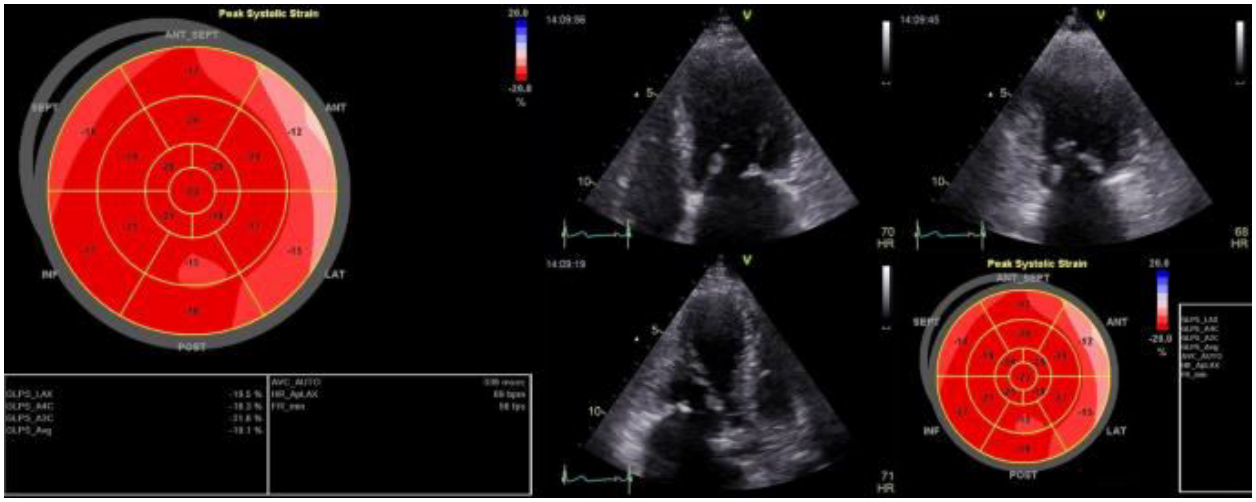
LONGITUDINAL STRAIN:



➢ Deformation analysis
➢ Strain defined as the normalized change in length between 2 points
➢ Strain is unit less and is expressed in

$$\varepsilon = \frac{L1 - Lo}{Lo} = \frac{\Delta L}{Lo}$$

L1 - End systolic fibre length (Final length)
Lo - End Diastolic fibre length (Original length)
➢ Negative strain implies shortening and thinning of segments
➢ Positive strain implies lengthening and thickening of segments
Global longitudinal strain of the Left ventricle varies from (-16% to -20%)



Quantification of the left ventricular ejection fraction (LVEF) is frequently used to assess left ventricular (LV) systolic function in patients with aortic or mitral valve disease in order to prognosticate result, assess operational risk, and choose the best time for surgery.
Nonetheless, it is now generally acknowledged that LV global longitudinal strain (GLS), a measure of myocardial deformation imaging, is a better diagnostic and prognostic indicator than LVEF. It frequently identifies early subclinical myocardial dysfunction before overt LVEF deterioration happens(1). As a result, the American Society of Echocardiography (ASE) and the European Association of Cardiovascular Imaging (EACVI) recently released guidelines on cardiac chamber quantification that recognized the superiority of LV GLS over conventional LVEF measurements and suggested its clinical application in patients. (2)

Poor clinical outcomes are independently linked to subclinical LV dysfunction, which is characterized by inadequate LVGLS, in patients receiving TAVI who have significant aortic stenosis and intact LVEF. Beyond the defined clinical and echocardiographic characteristics, LVGLS assessment has additional prognostic value(3)

Subclinical myocardial dysfunction, defined by impaired LV GLS, is common in patients with asymptomatic severe AS and maintained LVEF. Left ventricular global longitudinal strain deteriorates

over time, and poor LV GLS at baseline is associated with an increased likelihood of progressing to the symptomatic stage and requiring aortic valve intervention.(4)

GLS shows sensitivity in predicting long-term postoperative outcomes. Further analysis is required to determine preoperative GLS threshold to identify asymptomatic patients at the optimal time for mitral valve surgery.(5)

Adverse ventricular remodeling is an inflexion point of disease progression in aortic stenosis (AS) and a significant prognostic factor. Intervention before to irreparable cardiac injury is critical for maintaining positive post-operative results. Current guidelines advocate using the left ventricular ejection fraction (LVEF) to define the intervention threshold in AS. However, LVEF has significant limitations: it only represents volumetric changes in the left ventricular chamber and is ineffective for detecting minor symptoms of myocardial injury. Strain has emerged as a modern imaging biomarker for intramyocardial contractile force, providing information on subclinical myocardial failure due to fibrosis. A considerable body of evidence supports its utility in determining the transition from adaptive to maladaptive cardiac alterations in AS, as well as refining therapeutic thresholds.(6,14,15)

The superiority of global longitudinal strain over left ventricular ejection fraction is based on a system in which other stresses compensate for the degeneration of longitudinal strain, which is more susceptible to damage, hence preserving cardiac function. As a result, longitudinal strain evaluation would provide physicians with early warning symptoms of heart function deterioration, allowing for quick therapy.(7,13)

In asymptomatic patients with severe aortic stenosis the degree of global afterload and its consequences on longitudinal function might play a role in clinical practice.(8,12)

3DGLS is the most robust index for predicting future adverse cardiac events in asymptomatic severe AS patients with preserved LVEF.(9,11)
Lot of studies have been done for pateints with aortic stenosis and requiring TAVI , but in these study we included mitral valve disease and degenerative heart disease to predict the outcomes .

METHODS

A prospective observational study, to calculate left ventricular global longitudinal strain using strain echocardiography to assess LV systolic function in patients with aortic and mitral valve disease. After obtaining ethical clearance, 350 patients with mitral and aortic valve disease were evaluated. We have included patients having Moderate to Severe Rheumatic Mitral and Aortic heart diseases and moderate to severe degenerative heart diseases. We have excluded patients having Mild Rheumatic and Degenerative heart disease, congenital valvular heart disease,Mixed valvular heart disease, patients with significant arrhythmia, dynamic LVOT obstruction and pregnant patients.
In 350 consecutive patients with valvular heart disease, 2 Dimensional Transthoracic echocardiogram is done using Vivid S5 GE machine/Philips machine performed at Chettinad super specialty Hospital, Chennai. The valvular lesion severity is assessed (mild, moderate and severe). Left ventricular systolic function is assessed using conventional echocardiographic parameters. Left ventricular global longitudinal strain is performed to obtain Global longitudinal strain.Using Conventional 2D echo, M-mode, colour flow imaging, Pulse wave doppler, Continuous wave doppler, Tissue doppler imaging and global longitudinal strain will be performed using Vivid S5 GE machine/Philips machine in department of cardiology. The standard parasternal long axis, parasternal short axis at basal, mid and apical level, Apical four chamber, Apical three chamber & Apical two chamber view will be recorded to assess the lv

systolic function. Severity of valvular heart disease which includes Mitral and Aortic valve lesions is assessed using 2D echo to define valve morphology and colour flow imaging is done for the assessment of flow across the valve and doppler quantification is obtained for the quantitative assessment of severity of either of the following valvular disease Aortic regurgitation, Aortic stenosis, Mitral regurgitation, Mitral stenosis. The apical four chamber view and two chamber view is used to obtain severity of mitral valve disease using Doppler quantifications and apical five chamber and three chamber for aortic valve disease respectively. After assessing the valvular parameters, left ventricular systolic function is assessed using conventional Simpson's method. Then global longitudinal strain echocardiography is performed using apical four chamber view, two chamber view and three chamber view to obtain Left Ventricular Global Longitudinal Strain value.

RESULTS

Table 1: patient demography

Demographic data		Subjects	percent
Gender	Male Female	178 172	50.8% 49.2%
Age	<30 y 30-40 y 41-50 y 51-60y >60 y	30 45 70 112 93	8.67% 12.83% 20% 32% 26.5

Table 2 :GLS values in Rheumatic heart disease group

Rheumatic Disorder	MITRAL(190)				AORTIC(68)			
	Moderate MS	Moderate MR	Severe MS	Severe MR	Moderate AS	Moderate AR	Severe AS	Severe AR
MALE(128) GLS Normal-41 Reduced-87	Total-26 Normal-10 Reduced-16	Total-15 Normal-5 Reduced-10	Total-40 Normal-10 Reduced-30	Total-11 Normal-3 Reduced-8	Total-13 Normal-4 Reduced-9	Total-6 Normal-2 Reduced-4	Total-13 Normal-5 Reduced-8	Total-4 Normal-2 Reduced-2
FEMALE(130) GLS NORMAL-40 REDUCED-90	Total-25 Normal-5 Reduced-20	Total-15 Normal-5 Reduced-10	Total-48 Normal-14 Reduced-34	Total-10 Normal-4 Reduced-6	Total-14 Normal-4 Reduced-10	Total-4 Normal-2 Reduced-2	Total-10 Normal-4 Reduced-6	Total-4 Normal-2 Reduced-2

TABLE 3 : GLS values in Degenerative heart disease group

Degenerative Disorder	MITRAL(29)				AORTIC(63)			
	Moderate MS	Moderate MR	Severe MS	Severe MR	Moderate AS	Moderate AR	Severe AS	Severe AR
MALE(50) Normal GLS -19 Reduced GLS - 31	Total-4 Normal-1 Reduced-3	Total-7 Normal-2 Reduced-5	Total-2 Normal-1 Reduced-1	Total-4 Normal-1 Reduced-3	Total-13 Normal-8 Reduced-5	Total-9 Normal-3 Reduced-6	Total-6 Normal-2 Reduced-4	Total-5 Normal-1 Reduced-4
FEMALE(42) Normal GLS- 14 Reduced GLS -28	Total-2 Normal-1 Reduced-1	Total-4 Normal-1 Reduced-3	Total-2 Normal-1 Reduced-1	Total-4 Normal-1 Reduced-3	Total-17 Normal-6 Reduced-11	Total-3 Normal-1 Reduced-2	Total-8 Normal-2 Reduced-6	Total-2 Normal-1 Reduced-1

DISCUSSION

In the present study 350 subjects were included, among them 178(50.8%) were males and 172(49.1%) females. 112 subjects(32%) were between age group 51-60 years and 93 subjects(26.5%) were above 60 years of age, 145 subjects under 50 years of age, depicted in Table 1.

Among 178 males, 33.7%(60 subjects) have Normal GLS and 66.29% (118 subjects) have reduced GLS. Among 172 females, 31.3%(54 subjects) have normal GLS and 68.6%(118 subjects) have reduced GLS.

Out of 350 subjects, 258 (73.7%) have Rheumatic valvular disease and 92(26.2%) have degenerative cardiac disease.

Among 258 subjects with Rheumatic heart diasease, 45.7%(118) have Moderate valvular heart disease, 81 subjects have moderate Mitral valvular disease and 37 subjects have moderate aortic valvular disease, 54.26%(140) have severe Valvular heart disease, 109 subjects and 31 subjects have severe mitral and aortic valvular disease respectively.

Out of 118 Rheumatic Moderate valvular heart disease patients, 37(31.3%) have Normal GLS and 81(68.6%) have reduced GLS, which is significant in our study andoutof 140 subjects with Severe Rheumatic Valvular disease, 44(31.4%) have Normal GLS and 96(68.5%) have reduced GLS, which is also statistically significant.

Out of 92 subjects with degenerative heart disease, 59(64.1%) subjects have moderate valvular disease, 17 subjects with Moderate Mitral and 42 subjects with Moderate aortic valvular disease and (35.9%) subjects have severe valvular disease, 12 subjects and 21 subjects have Severe Mitral and Aortic valvular diseases respectively.

Out of 59 Moderate degenerative Valvular heart disease patients, 21(25.59%) have Normal GLS and 38(64.46%) subjects have reduced GLSAnd Out of 33 Severe Degenerative Valvular heart diseases, 10(30.3%) subjects have Normal GLS and 23(69.69%) subjects have reduced GLS.

In our study we found out that, all 350 subjects have Normal Ejection Fraction calculated by Simpson's method using 2D Echocardiography, but majority of the patient were found to have significantly Reduced GLS while assessing Left Ventricular Global Longitudinal Strain Value.
Out of 350 subjects, 238 subjects (68%) with **Normal EF measured by Simpson's method** using 2D Echo, had **reduced GLS**, which is statistically significant and suggest Subclinical Myocardial Dysfunction in these patients.

CONCLUSION:

Left Ventricular (LV) Global Longitudinal Strain (GLS) has emerged as a crucial tool for assessing LV systolic function, offering superior diagnostic and prognostic value compared to Left Ventricular Ejection Fraction (LVEF). Left Ventricular Global Longitudinal Strain shows a modest correlation with valvulo - arterial impedance. LVGLS is increasingly used to identify subclinical myocardial dysfunction in patients with valvular heart disease and optimal timing for surgery and prognosticate outcomes after surgery.

LIMITATIONS:

1. LV GLS is currently used to evaluate patients with aortic stenosis, further research to establish the diagnostic and prognostic value of LV GLS in aortic regurgitation and mitral regurgitation.
2. Standardization of measurement definitions, including indexation to end-diastolic volume or diameter.
3. This is a Single centre conducted Study with limited subjects.

REFERENCES

1. Ng AC, Delgado V, Bax JJ. Application of left ventricular strain in patients with aortic and mitral valve disease. Current Opinion in Cardiology. 2018 Sep;33(5):470-8.
2. Kong WKF, Vollema EM, Prevedello F, Perry R, Ng ACT, Poh KK, et al. Prognostic implications of left ventricular global longitudinal strain in patients with bicuspid aortic valve disease and preserved left ventricular ejection fraction. European Heart Journal - Cardiovascular Imaging. 2020 Jul 1;21(7):759-67.
3. Lee S, Oh JK, Lee S, Kang D, Lee S, Kim HJ, et al. Incremental Prognostic Value of Left Ventricular Global Longitudinal Strain in Patients with Preserved Ejection Fraction Undergoing Transcatheter Aortic Valve Implantation. Journal of the American Society of Echocardiography. 2022 Sep;35(9):947-955.e7.
4. Vollema EM, Sugimoto T, Shen M, Tastet L, Ng ACT, Abou R, et al. Association of Left Ventricular Global Longitudinal Strain With Asymptomatic Severe Aortic Stenosis. JAMA Cardiol. 2018 Sep 1;3(9):839.
5. Modaragamage Dona AC, Afoke J, Punjabi PP, Kanaganayagam GS. Global longitudinal strain to determine optimal timing for surgery in primary mitral regurgitation: A systematic review. Journal of Cardiac Surgery. 2021 Jul;36(7):2458-66.
6. Anastasiou V, Daios S, Bazmpani M, Moysidis D, Zegkos T, Karamitsos T, et al. Shifting from Left Ventricular Ejection Fraction to Strain Imaging in Aortic Stenosis. Diagnostics. 2023 May 16;13(10):1756.
7. Purwowiyoto SL, Halomoan R. Highlighting the role of global longitudinal strain assessment in valvular heart disease. Egypt Heart J. 2022 Dec;74(1)
8. Liao H, Yang S, Yu S, Hu X, Meng X, Wu K. Prognostic Value of Left Ventricular Global Longitudinal Strain for Major Adverse Cardiovascular Events in Patients with Aortic Valve Disease: A Meta-Analysis. Cardiology. 2024;149(3):277-85.

9. Zito C, Salvia J, Cusmà-Piccione M, Antonini-Canterin F, Lentini S, Oreto G, et al. Prognostic Significance of Valvuloarterial Impedance and Left Ventricular Longitudinal Function in Asymptomatic Severe Aortic Stenosis Involving Three-Cuspid Valves. The American Journal of Cardiology. 2011 Nov;108(10):1463-9.
10. Nagata Y, Takeuchi M, Wu VC, Izumo M, Suzuki K, Sato K, et al. Prognostic Value of LV Deformation Parameters Using 2D and 3D Speckle-Tracking Echocardiography in Asymptomatic Patients With Severe Aortic Stenosis and Preserved LV Ejection Fraction. JACC: Cardiovascular Imaging. 2015 Mar;8(3):235-45.
11. Dahl JS, Videbæk L, Poulsen MK, Rudbæk TR, Pellikka PA, Møller JE. Global Strain in Severe Aortic Valve Stenosis. Circ: Cardiovascular Imaging. 2012 Sep;5(5):613-20.
12. Kearney LG, Lu K, Ord M, Patel SK, Profitis K, Matalanis G, et al. Global longitudinal strain is a strong independent predictor of all-cause mortality in patients with aortic stenosis. European Heart Journal - Cardiovascular Imaging. 2012 Oct 1;13(10):827-33.
13. Carstensen HG, Larsen LH, Hassager C, Kofoed KF, Jensen JS, Mogelvang R. Basal longitudinal strain predicts future aortic valve replacement in asymptomatic patients with aortic stenosis. Eur Heart J Cardiovasc Imaging. 2016 Mar;17(3):283-92.
14. Stassen J, Pio SM, Ewe SH, Singh GK, Hirasawa K, Butcher SC, et al. Left Ventricular Global Longitudinal Strain in Patients with Moderate Aortic Stenosis. Journal of the American Society of Echocardiography. 2022 Aug;35(8):791-800.e4.
15. Fries B, Liu D, Gaudron P, Hu K, Nordbeck P, Ertl G, et al. Role of Global Longitudinal Strain in the Prediction of Outcome in Patients With Severe Aortic Valve Stenosis. The American Journal of Cardiology. 2017 Aug;120(4):640-7.