Predictive Value of Global Longitudinal Strain for Left Ventricular Dysfunction Post Mitral Valve Replacement

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Abstract

Dysfunction of left ventricle occurred even after improved surgical methods together with strict guidelines for the replacing mitral valves were followed. The dysfunction of LV (left ventricle) followed by MVR can be predicted through novelity of echocardiographic indices. It has been suggested that Left Ventricular echocardiographic GLS, which is obtained from strain imaging, is a novel measurement to represent dysfunction of latent LV in a more accurate way. A group of one hundred patients having severe MR (mitral regurgitation) were considered in this study, for mitral valve replacement (MVR). Strain imaging was done both at baseline and also after MVR during follow up. To determine the threshold value of LV- echocardiographic GLS, for prognosis of left ventricle impairment after Mitral valve replacement, the Relative Operating Characteristics Curve had been sketched. For identification of the independent prognosticator of LV impairment persuing MVR, one dimensional and multi dimentional regression investigation were conducted. Following MVR, patients with LVEF <50% exhibited lower LV-GLS from the set of data before any interventions are made (−19.9 vs. −17.7)

compared to those with Left Ventricular Ejection Fraction ≥ 50%. Following three months of monitoring, patients with LVEF <50% exhibited markedly higher initial measurements of Left Ventricular End Systolic Dimension (35.36 mm versus 28.23 mm) and Left Ventricular End Diastolic Dimension (49.33 mm versus 45.10 mm) compared to those with Left Ventricular Ejection Fraction ≥50%. After MVR, patients exhibiting LV impairment were associated with a GLS threshold value of −19%, which had a sensitivity of 80.3% and a specificity of 75.7%. Echocardiographic GLS < -19% (OR = 25.7, CI:5.11-62.1, P=<0.001) was identified as an free prognosticator of Left Ventricular impairment following Mitral Valve Replacement in a multidimensional regression analysis. After MVR, echocardiographic GLS value below −19% was identified as a free prognosticator of impermanent LV impairment; another variable that confirmed the prognostication of Left Ventricular impairment after –Mitral Valve Replacement was an LVESD of ≥40 mm.

KeyWords:
MVR, GLS, LVEF, LVESD

1. Introduction

Valvular heart disease most commonly manifests as mitral valve regurgitation. A notable and contentious issue in giving medical care to patients with moderately severe mitral regurgitation MR is the prolonged onset of left ventricular impairment after replacement of mitral valve., which increases the risk of serious cardiovascular problems. Due to its dynamic nature, etiology, consequences from diversity of causes, and gradual progression, mitral regurgitation has proven to be extremely difficult for clinicians to evaluate and treat in the long run [Hiemstra *et al*., 2020, Crescenzi *et al*., 2015].

In accordance with American and European guidelines, individuals who exhibit symptoms of severe mitral regurgitation (MR)should be advised to have mitral valve surgical procedures [Beyersdorf *et al.,* 2021,Nishimura *et alm,* 2014]. Additionally, the operative indications in patients with no symptoms with primary severe Mitral Regurgitation depends on parameters from a 2-dimensional echocardiogram as well as additional clinical parameters like the presence of high pulmonary pressure and atrial fibrillation (AF)

[Beyersdorf *et al.,* 2021]. Conversely, untreated MR patients may experience persistent overloading of volume, which could lead to impaired left ventricular function and cardiac arrest [Pandis *et al* 2014, Sabbagh *et al.,* 2018]. Therefore, it is crucial to identify declining systolic function as soon as possible in individuals who are asymptomatic, have an isolated case of severe mitral regurgitation, or have an LVEF >60% or LVESD~45 mm. Latent subclinical myocardium injury is difficult to identify using conventional echocardiography measurements due to their limited sensitivity. We must find more indicators that indicate the likelihood of impairment of left ventricle after mitral valve replacement in order to diagnose the condition early and treat it before it progresses. In order to enable early decision making, improvements in cardiac imaging techniques may make it possible to more accurately diagnose myocardial alterations brought on by mitral valve disorders [Dona *et al.,* 2021].

GLS evaluated with STE (SPECKLE TRACKING ECHOCARDIOGRAPHY) Scanning approach that uses the naturally existing speckle pattern in the myocardium to assess the mobility of tissues in the heart. These days, myocardial strain imaging is utilized to precisely assess LV myocardium function and longitudinal contraction. Longitudinal strain measurements may reveal underlie LV dysfunction even when EF is adequate [Kitai *et al.,* 2014,Canessa *et al.,* 2021]. In a number of clinical situations, strain imaging has been demonstrated to be an indicator of earlier diagnosis and prognosis. The purpose of our research was to ascertain the usefulness of GLS in prognosis of left-ventricular dysfunction following MV surgical process.

2. Methods

2.1. Study population and data collection

In a recent prospective observational study, patients who had MVR surgery at the department of echocardiography, National Institute of Cardiovascular Diseases (NICVD), Karachi, Pakistan. The research has given approval from the ethical committee of institution. All participants provided informed consent.

In this prospective observational study, we looked at patients who had surgery

to replace their mitral valve at at the department of echocardiography, (NICVD) for six months period. Before starting the study, we got permission from ethical committee of our hospital, that makes sure research is done ethically. We also made sure all the patients knew about the study and agreed to take part in it.

The study comprised patients who had MVR after presenting with severe organic MR. Exclusions from the study were individuals with LVEF <60%, concomitant tricuspid valve replacement, foregoing myocardial infarction MI, cardiac revascularization, cardiovascular surgery, or related severe valvular illness. In a pre-designed data collecting form, patient data were prospectively gathered. Data about demographics, clinical information, MR etiology, surgical data, echocardiographic data, and speckle tracking data were all included in the data collection form. Every patient underwent an echocardiographic evaluation prior to surgery, and the evaluation was repeated three months following corrected MVR to arbitrate the occurrence of left ventricular LV impairment. Throughout their hospital stay, patients were closely observed in order to record any cardiac events or outcomes at the time of discharge.

2.2. Echocardiographic evaluation

Commercially accessible devices (Vivid 7 and E9, GE) were used to perform transthoracic echocardiography. A 3.5 MHz transducer was used. As stated by ACC-AHA (2014) [Otto *et al.,* 2021] Doppler images attributed to color flow and continous wave which is the multiparametric process used to assess the severity of MR in accordance with the current recommendations. This approach included determining the regurgitant volume,
assessment of the seriousness of the regurgitant condition as effective regurgitant orifice area EROA (through the approach of nearby iso-velocity surface area), and proximal regurgitant jet width (vena contracta). LV dysfunction was defined during follow-up following MVR as LVEF <50%.

2.3. Speckle-tracking strain analysis

The three perspectives (apical four-chamber A4C, apical three-chamber A3C, and apical two-chamber A2C) were taken as window to analyze longitudinal strain, which measured the contraction (negative strain) and relaxation (positive strain) of cardiac's wall. For calculation of strain the LV endocardial border was manually outlined in the end-systolic frame. An automatic strain curve extraction was performed by the software from the grayscale pictures. As variations in the entire myocardium rather than an average of the values of each segmental strain, the longitudinal and circumferential strains were global strains. As the highest negative number on the strain curve during the course of the cardiac cycle, peak strain was identified. By taking the average of the maximum values of three apical window, GLS was computed [Collier *et al.,* 2017, Grigioni et al., 2008].

2.4. Surgical technique

During surgery for each patient, intrusive arterial and pulmonary pressure assessment was mandatory. The procedure employed heart lung machine through aorto-bicaval cannulation, accompanied by moderate hypothermia (approximately 28 °C–32 °C). Followed by antegrade root cardioplegia administered every 20 minutes following aortic cross clamp. Watersons Groove or Trans-Septal were the two ways to approach the left atrium. For the replacement, we employed pledgetted interrupted sutures with the synthetic patches or pledgets placed on the left atrial side, and the LA was subsequently closed when sutures were placed. Warm cardioplegia was given as soon as the heart started to beat and the aortic cross clamp was taken off.

In every subject, complete chordal preservation was achieved.

2.5. Data interpretation:

For every statistical analysis, the Statistical Package for Social Sciences (SPSS v22.0) was employed. . Mean ± standard are the quantitative variables , whereas the qualitative were presented as percentages (%). Utilizing the independent sample t test, parametric values compared between two groups. For comparison of categorical variables the chi-square test was used and were shown in percentages and frequencies.

To forecast the various perils for the existence of malfunctional left ventricle, logistic regression was employed. A two-tailed p value <0.05 was esteemed to specify Nominal p-value.

3. Results

Baseline characteristics of population are shown in Table 1. The ratio of men to women was 1:2.5. The most of patients complained of dyspnea, and the maximum number of patients had mild symptoms (NYHA class II). 62% of patients had rheumatic etiology, 16% had infective endocarditis, and 22% had mitral valve prolapse.

Table 1

Baseline characteristics of population.

Variables	N=45
Age (Years)	38±11.6
Weight (Kg)	68±34
Height (cm)	147±34
Gender	
Male	13 (29%)
Female	32 (71%)
The New York Heart Association(NYHA) functional classification	
The New York Heart Association(NYHA) class I	3 (7%)
The New York Heart Association(NYHA) class II	28 (62%)
The New York Heart Association(NYHA) class III	11 (24%)
The New York Heart Association(NYHA) class IV	03 (7%)
Variables	**N=45**
BASELINE ECG	
AFIB	18
NSR	27
PASP (Pulmonary Artery Systolic Pressure) (mmHg)	39
BLOOD PRESSURE (mmHg)	
Systolic	115
Diastolic	73
HR (Heart Rate) (bpm)	90
(NYHA: The New York Heart Association)	

This table 2 shows lab investigations with baseline data, which is helpful to implicate how these parameters are related with Global Longitudinal Strain (GLS), which may serve as a crucial predictor of left ventricular dysfunction post-surgery.

Table 2

Baseline Lab Investigations

Parameter	Mean	Range	Key Observations
Creatinine (mg/dL)	0.81	0.3 – 1.3	Within normal range
Hemoglobin (Hb) (g/dL)	11.95	0.94 – 102	Slightly low; possible anemia
Platelet Count ($x10^3/\mu L$)	193.64	8 – 425	Normal; low values suggest thrombocytopenia
INR (International Normalized Ratio)	2.06	0.8 – 10.3	Elevated; possible anticoagulant therapy or liver dysfunction
Total Leukocyte Count (TLC) ($x10^3/\mu L$)	28.08	4 – 195	High; indicates infection/inflammation

Clinical Implications

Key Findings	Implications
Renal dysfunction and anemia	Significant association between creatinine and hemoglobin suggests impaired kidney function affecting blood parameters.
Inflammation and coagulation abnormalities	Strong correlation between INR and TLC indicates systemic

Key Findings	Implications
	inflammation affecting coagulation pathways.
Platelet abnormalities and bleeding risk	Moderate negative correlation between platelet count and INR suggests patients with thrombocytopenia may have an increased bleeding risk.
GLS as a predictor	Given these systemic abnormalities, Global Longitudinal Strain (GLS) may serve as a crucial predictor of left ventricular dysfunction post-surgery. Further studies are needed.

This table 3 show key cardiac parameters on differential basis (ie pre and post procedure)

Table 3

Key Cardiac Parameters (Pre- & Post-Procedure)

Parameter	Pre-Procedure Mean ± SD	Post-Procedure Mean ± SD	T-Statistic	P-Value
LVEF (%) (Left Ventricular Ejection Fraction)	**54.89 ± 7.40**	**42.3 ± 12.0**	**10.09**	**< 0.001**
LV-END-DD (mm) (Left Ventricular End-Diastolic Diameter)	**52.1 ± 6.90**	**48.3 ± 6.90**	**1.63**	**0.11**
LV-END-SD (mm) (Left Ventricular End-Systolic Diameter)	**40.1 ± 8.90**	**37.43 ± 7.72**	**-4.03**	**< 0.001**
PASP (mmHg) (Pulmonary Artery Systolic Pressure)	**38.98 ± 13.02**	**30.07 ± 5.25**	**Significant reduction**	**-**
RV Size (mm) (Right Ventricular Size)	**22.62 ± 7.43**	**22.02 ± 6.61**	**0.92**	**0.36**

This indicates that patients undergoing mitral valve replacement (MVR) exhibit significant systolic dysfunction post-procedure, as evidenced by a decline in LVEF, LV-END-DD and LV-END-SD. While left ventricular dimensions and right ventricular size remained stable, the observed reduction in pulmonary artery systolic pressure (PASP) suggests hemodynamic improvement.

Global Longitudinal Strain (GLS) is a more sensitive marker of left ventricular dysfunction compared to LVEF and may provide earlier detection of myocardial impairment post-MVR. Since conventional LVEF measurements often fail to detect subtle myocardial dysfunction, GLS could serve as a crucial predictor of left ventricular dysfunction following valve surgery.

The echocardiographic variables at paradigm and at follow-up are

mentioned in Table 4. In our study population, reduction in LVEF ,LV-END-SD, and LV-END-DD during follow-up period had been noticed. LVEF was largely unaltered. Following surgery, LV-END-SD and LV-END-DD improved to 37.4 ± 7.5 and 48.3 ± 6.9 from baseline values of 40.1 ± 8.9 and 52.1 ± 6.9.

Table 4

Echocardiographic parameters from the follow-up and baseline are compared.

Echo Vvariables	At baseline	At follow up
LVEF (%)	54.8 ±7.4	42.3 ± 12.0
LV-END-SD (mm)	40.1 ± 8.9	37.4 ± 7.5
LV-END-DD (mm)	52.1 ± 6.9	48.3 ± 6.9

At follow-up, there were no variations in age, sex, hypertension, and atrial fibrillation between the two groups.The patients with LVEF <50% exhibited remarkably high rise LVEDD and LVESD (P = 0.01) and Left Ventricular echocardiographic GLS (P = 0.001) contrast to the patients with LVEF ≥50%. These findings are displayed in Table 5.

Table 5

Indicators of left ventricular impairment (LVEF <50%) during the follow-up period following mitral valve replacement.

Indicators	Univariate Analysis			Multivariate Analysis		
	Odds ratio	95% CI	P value	Odds ratio	95% CI	P value
Atrial fibrillation	2.97	1.49 – 4.27	0.037	1.23	0.51 – 8.39	0.340
Presence of symptoms	5.05	1.43 – 6.7	0.089	1.39	0.53 – 7.35	0.371
LVEF ≤ 60%	1.14	0.64 – 2.05	0.655	1.03	0.89 – 2.23	1.000
LV-END-SD ≥ 40 mm	0.23	0.05 – 1.01	0.052	0.26	0.06 – 1.15	0.076
LV-GLS > −19%	19	7.08 – 54.55	1.000	18.7	5.65 – 63.21	1.000

4. Discussion

The following is a summary of the primary findings of the present investigation: 1)In contrast to patients with LVEF≥50% with ejection fraction of left heart post operative (LVEF<50%) exhibited remarkably higher LVEDD, LVESD and considerably lower LVGLS. Regression analysis was conducted to anticipate LVEF<50%post surgery .Findings revealed that AF,occurance of symptoms,LVESD ≥40mm,and LV _GLS<-19 were the prognosticator.

In individuals who have undergone sur gery, the documented occurrence of pr olonged post-

surgical left ventricular impairment (<50%) ranges from 18.4% to 44.19% [Pandis et al., 2014,Soofi et al., 2015]. In our research, at the six-month follow-up, 19% of patients with the regurgitation of mitral valve had experienced dysfunction of LV <50% following MVR. In brief follow-up of recent study, the EF of left heart fell on average from 60.15% to 35.55%.

The main indicator of the positive outcome and favourable outcome of Mitral Valve surgery for left ventricular function is a marked reduction in LV size at after surgery follow-up. In the recent study, patients with reduced left heart EF <50% had remarkably greater threshold (40.1 vs. 37.4) LV-END-SD and (48.33 vs. 52.10) LV-END-DD on after surgery ECHO at 3-month follow-up than patients with >50% LVEF. Apparently identical findings were reported in the erlier published literature by Cho *et al*., which indicated that patients in the non-remodeling group (preserved left heart EF and decrease in LVED following replacement of mitral valve) at three months's follow-up exhibited noteably decrease Left Ventricular End Systolic Dimension (34.04 mm–29.91 mm) and Left Ventricular End Diastolic Diameter (58.04 mm–47.55 mm) values compared to those in the remodeling group (characterized by decrease in left heart EF or increase in Left Ventricle End Diastolic after replacement of mitral valve).Therefore, after mitral valve surgery, the values of LV-END-DD and LV-END-SD may also be taken into account as variables to indicate dysfunction of LV.

In a prospective study 88 patients with severe deteriorative M R, Ueyama *et al* found that an LV GLS value of −18% independently predicts dysfunction of LV yielding an OR = 4.2 (CI:1.4–13).This research dipicted that the independent preoperative LV GLS measurement is helpful for predicting postoperative Left Ventricle impairment.Comparable LV GLS measurements noted by Ternacle *et al*. [Kusunose et al 2014, Enriquez-Sarano et al., 2010] showed that in patients who underwent for left heart valve surgery, LV GLS values < −18% was linked to a noteably increased mortality with OR = 2.4 (P = 0.04) at 30 days of follow-up. They interpreted that LV GLS enables indication for the risk stratification of early post-surgical mortality following left-sided cardiac surgery in patients with preserved EF. Pandis *et al*.'s retrospective analysis, encompassing 130 patients,

demonstrated that an LV GLS measurement of - 17.9% could indicate , during follow-up, the alterations in LVEF following Mitral Valve Replacement in patients with critically deteriorative Mitral regurgitation, yielding an OR = 0.8 (CI:0.73–0.88).

According to this study, there was a notable mortality correspondence between Left Ventricle Global Longitudinal Strain value of −18% and OR = 2.4 (P = 0.04). Regression analysis was conducted in the current study to forecast Left heart Ejection Fraction <50% after surgery of MV. The results showed that the best predictors were Left Ventriclular End Systolic Dimension ≥40 mm and Left Ventricle Global Longitudinal Strain < −19%, with OR = 0.26 (95% CI 0.06 – 1.15 and 18.7 (95% CI 5.65 – 63.21), individually. Decreased left heart EF before surgery was a indicator of poorer survival of after surgery and left heart EF (HR = 1.13, 95% CI 1.02–1.26), as per quantitative review of eight studies with severe Mitral Regurgitation and maintained left heart EF [Canessa et al., 2020]. Kitai et al.'s study discovered that Left Ventricle End Systolic Diameter ≥40 mm and Left Ventricle Global Longitudinal Strain > −19.9% were identical values and were good indicators of Left heart EF <50% following surgery, yielding OR = 6.71 (1.91–23.52) and 23.16 (95%CI 6.53–82.10), correspondingly. While Hiemstra *et al.*'s study showed that a prior surgery value of −20.9% was associated to a poorer long-term outcome of viability. Similar to the current study, the majority of published studies reported that the Left Ventricle Global Longitudinal Strain value for after replacement of mitral vavlve Left Ventricle impairment foretell ranges between −20.9% and −18%.

In contrast to previous studies concerning the measurement of LV GLS value in patients with severe mitral regurgitation, the most of the patients in the current work (67% of patients with rheumatic heart disease) had a rheumatic etiology and had mitral valve replacement. This offers extra data about Left Ventricle Global Longitudinal Strain in this group. Although our research encompassed, patients who had replacement of mitral valve and documented the Left Ventricle Global Longitudinal Strain value in those patients, most of the studies have displayed that the foretelling value of Left Ventricle Global Longitudinal Strain measurement in managing mitral valve

restoration [Tomasz et al., 2013, Dona et al., 2021, Hiemstra et al., 2020]. To preserve left ventricular function post mitral valve surgery, choral management is crucial. Our study is same as that studies where Mitral Valve restoration was conducted for severe MR as all of the patients received mitral valve replacement with complete chordal sustaination.

Gradual LV eccentric hypertrophy maintains LVEF >60% in patients who were without symptoms with severe MR. Myocardial dysfunction results from an increase in stress on the heart's muscle mass. Postoperative left ventricular dysfunction happens even when current guidelines are closely followed during the surgical procedure. Recently, it has been suggested that the parameter of LV deformation strain, as determined by various imaging techniques, can predict the likelihood of LV dysfunction following mitral valve surgery. LV- echocardiographic GLS and left heart EF (LVEF) are highly correlated.

4.1. Limitation

First off, the study's small sample size makes it impossible to findout the ideal cut-off value for Left Ventricle-GLS with accuracy. Second, using a single echocardiography device to calculate LV GLS may not yield accurate GLS value results. Thirdly, this value might not be generizable as various groups could possess distinc t sets of GLS normal values. Ultimately, the primary measure of myocardial deformation that we used in our research was GLS. Given the complex structure of the my ocardium—which is composed of 3 layers of longitudinally arranged myofibers—this this might not truly represent the myoc ardium's actual function.

5. Conclusion

An increase in LV-END-SD and LV-END-DD values prior to surgery and a decrease in the Left Ventricular – Global Longitudinal Strain value obtained from 2D echocardiographic GLS can indicate the onset of LV dysfunction following MVR. Before replacement of mitral vavlve or repair surgery, it can be helpful to identify any latent subclinical myocardial dysfunction. This will allow surgeons to better plan the surgical procedure and

timing of the operation, as well as the patient's careful post-operative care for a better outcome.

Acknowledgment

NICVD provided its own support for this work; no particular grant from a commercial or nonprofit organization was obtained.

Abbreviations

GLS	Global longitudinal strain
LV-END-DD	Left Ventricle End Diastolic Dimension
LV-END-ESD	Left Ventricle End Systolic Dimension
MVR	Mitral valve replacement
MR	Mitral regurgitation
NYHA	The New York Heart Association

Footnotes

Conflict of interest

In the current study, there is no conflict of interest.

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