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Value of Left Ventricular Strain Imaging Echocardiography in Predicting Outcomes after Severe Mitral Valve Regurgitation Surgery

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Abstract

Purpose: A new indicator of measuring ventricular systolic function is myocardial strain. However, it is unclear if longitudinal strain following mitral valve surgery has any predictive utility in clinical settings. The best time of operation is usually detected through the left ventricular internal dimensions as well as the function.. So this study aimed to evaluate the utility of myocardial strain by echocardiogram with other parameters in forecasting postoperative outcomes after primary MR surgery.

Methodology: This prospective study enrolled 514 patients (279 males and 235 females; mean age (SD) of male participants was 57.3 (12.9). Included patients had severe primary mitral valve regurgitation and were candidates for valve surgery from April 2018 to April 2022. Patients with combined valvular disease as severe mitral stenosis, redo mitral valve replacement, and previous CABG and ischemic heart disease were excluded. Global longitudinal strain (GLS) was performed. Hospital re-admission for heart failure symptoms, reoperation and mortality were followed up as Cardiac incidents.

Findings: In median follow-up of about four years, Age, previous ischemia, concomitant CABG, left atrial size, LVEF%, atrial fibrillation and Global longitudinal strain were all predictive of heart incidents. Age, left atrial dimension, and GLS were independent predictors to heart incidents on multivariate analysis (HR: 1.386, 95% CI: 1.083-1.776; P <0.004, HR: 1.003, 95% CI: 0.976-1.031; p value 0.018, HR: 1.192, 95% CI: 1.101-1.291; P <0.001 respectively). All-cause mortality was linked to impaired GLS (HR: 0.003, 95% CI: 0.973-1.102; P =0.039).

Recommendation: GLS has a substantial link to clinical outcomes and is a stronger forecaster to cardiac issues than standard measurements. Measuring pre-operative GLS among those with severe primary MR is essential for anticipating post-operative results and determining the ideal time to plan operation.

Keywords: *Mitral valve, GLS, surgery, regurgitation*

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INTRODUCTION

Primary mitral valve regurgitation (MR) is one of the most frequent valvular disorders [(1)]. Although there is a higher risk of morbidity and mortality in severe degenerative MR, effective surgery improves the prognosis[(2)]. The best time to perform surgery on individuals having marked MR is still debatable[(3,4)]. The guidelines recommended intervention in treating MV among symptomatic severe mitral regurgitation (MR), or asymptomatic patients who develop symptoms or Atrial fibrillation (AF), with LV systolic function EF $\leq$ 60 % $\pm$ LV dilatation (ESD $\geq$ 45mm)[(5)].

The parameters suggested in the guidelines is challenging to interpret. LVESD is seldom more than 45mm in asymptomatic patients. Additionally, because to the MR's tendency to diminish LV afterload, subclinical LV dysfunction may go unnoticed with severe MR whose LVEF frequently normal or higher. Early-stage LV dysfunction having normal LVEF indicates a poor outcome postoperatively[(6)]. So, among those with chronic severe MR, it is extremely difficult in detecting probable LV failure early and for conducting surgery for stopping the development of irreversible LV dysfunction.

For clinical decision-making, current recommendations commonly mention assessment of systolic function through EF%[(7)]. However, during the past ten years, myocardial deformation imaging especially strain echocardiogram, has become increasingly clear as a vital tool for assessing heart function. GLS, in particular, provide additional diagnostic and prognostic data and has potential to be a crucial parameter in treatment of individuals having a variety of valvular disorders[(8)].

Aim of the Study

The purpose of this research was evaluating the utility of LV longitudinal strain through echocardiogram with other parameters in forecasting postoperative outcomes after primary MR surgery.

METHODOLOGY

The research was done on 514 cases having severe MR and enrolled in surgical MV replacement or repair at the National Heart Institute, Egypt between the periods of April 2018 to April 2022. Patients with combined valvular disease as severe mitral stenosis, patients with redo mitral valve replacement, patients with previous CABG and ischemic heart disease were all excluded. The ethical committee was approved and authorized by General Organization for Teaching Hospitals and Institutes at Egypt, all patients had written consent about the benefits and possible risks of this study.

Transthoracic echocardiogram was done to all patients and severe mitral regurgitation was confirmed by either or combined of Effective regurgitant orifice (ERO) $\geq$ 0.40 cm^2, mitral regurgitation volume $\geq$ 60mL, regurgitatant fraction (RF) $\geq$ 50%, vena contracta (VC) width $\geq$ 7mm or color flow area $\geq$40% of left atrial (LA) size[(9)]. Chamber dimensions and LVEF as well EPASP (estimated pulmonary artery systolic pressure) were taken. A dimensionless way to evaluate tissue deformation is myocardial strain. It is described as the shift in an object's relative length in a certain direction. Spatial orientation of myofibers, which contract in different directions and result in three-dimensional deformation, is what determines how the myocardium deforms. The ventricle shortens longitudinally and circumferentially (indicated by negative strain values) and thickens radially during systole (presented through positive strain values). GLS is deformation component that is most frequently used[(10)].

GLS was performed from the 2-d echo images from short axis (mid papillary level), parasternal 4-chambers view, parasternal 2-chambers view and the parasternal 3-chambers view, using the available commercial software. GLS was determined by the average of peak negative value at three apical views curve. Up to April 2022, the research population was tracked. Cardiac incidents and all-cause mortality were utilized to evaluate results. Cardiac events were categorized as follow-up of cardiac death, reoperation for failed MV surgery, and hospitalization for worsening heart failure (HF).

Statistical Analysis

Quantitative data was analyzed by inspecting the distribution and employing normality tests. Values were provided in the form of the mean (SD), median (range). Among parametric data t-test was employed to groups. When comparing groups regarding qualitative data, Chi-square test and Fisher's exact tests were utilized. Kaplan-Meier technique with log-rank test was used to compare survival curves among $\geq$ 2, Cox proportional-hazards regression for detecting numerous risk variables' influence on survival. Confidence interval was set to 95% and margin of error was set to 5%. So, P-value was considered significant as following: P-value <0.05: highly significant, P-value <0.001: P-value >0.05: insignificant. SPSS, Version 23.0 was used to perform the analysis.

RESULTS

The study demonstrated that No appreciable variations regarding gender and risk factors between groups were noted (P >0.05). Nevertheless, individuals who experienced cardiac problems were older and had previously undergone revascularization, AF, stroke, or MI (P <0.05).

Table 1: Socio-demographic data of included patients

	Cardiac Events		
	No (n=447)	**Yes (n=67)**	**P Value**
Age (yrs.)	57.3±12.9	65.9±12.5	<0.001**
Gender (male)	248 (55.5%)	31 (46.3%)	0.159
SBP (mm Hg)	107 ± 8.6	106 ± 3.4	0.348
DBP (mm Hg)	75.7±18.4	72.8±15.4	0.220
BMI (kg/m)	23.8±3.7	23.7±3.3	0.835
HTN	207 (46.3%)	34 (50.7%)	0.501
Dyslipidemia	69 (15.4%)	9 (13.4%)	0.671
DM	176 (39.4%)	28 (41.8%)	0.708
Smoking	274 (61.3%)	39 (58.2%)	0.628
Stroke	15 (3.4%)	6 (9.0%)	0.032*
AF	177 (39.6%)	39 (58.2%)	0.004*
Previous MI	4 (0.9%)	3 (4.5%)	0.018*
Previous revascularization	8 (1.8%)	4 (6.0%)	0.034*

NYHA functional class			
I	152 (34.0%)	15 (22.4%)	
II	220 (49.2%)	36 (53.7%)	0.010*
III	68 (15.2%)	11 (16.4%)	
IV	7 (1.6%)	5 (7.5%)	
Etiology of MR			
Degenerative	403 (90.2%)	57 (85.1%)	
Rheumatic	40 (8.9%)	10 (14.9%)	0.234
Ischemic	4 (0.9%)	0 (0.0%)	
Surgery type			
MV replacement (mechanical)	344 (77.0%)	39 (58.2%)	
MV replacement (bioprosthetic)	50 (11.2%)	17 (25.4%)	0.002*
MV repair	53 (11.9%)	11 (16.4%)	

*Data presented as mean±SD, using: t-test. Data expressed as Number (Percentage): Exact p-value >0.05;*p-value <0.05; **p-value <0.001*

In individuals with and without cardiac episodes, the results for LV internal dimensions and RVSP were comparable. But the LVEF% was lower and the LA dimensions was bigger in the patients who experienced cardiac events with statistically significant difference (61.9±9.1 versus 59.5±10.1; P = 0.048) and (56.2±10.6 versus 63.1±13.6; P <0.001) respectively. Mean GLS was -20.2±4.2 and the mean circumferential strain was -26.8±6.9. Both Global longitudinal and circumferential strains (-20.2±4.2 versus -16.8±4.1; P <0.001) and (-26.8±6.9 versus -24.5±7.0; P = 0.011 respectively) were markedly hampered among those who experienced cardiac episodes throughout the follow-up as shown in table 2.

Table 2: Echocardiographic characteristics in MV surgery cases with and without cardiac incidents

	Cardiac Events		
	No (n=447)	**Yes (n=67)**	**P Value**
LVEF (%)	61.9±9.1	59.5±10.1	0.048*
LVEDD (mm)	60.4±8.1	61.1±8.1	0.510
LVESD (mm)	40.0±7.0	40.7±10.1	0.475
LVEDV (ml)	169.3±55.8	166.9±79.3	0.758
LVESV (ml)	64.0±29.2	68.0±43.6	0.332
LA dimension (mm)	56.2±10.6	63.1±13.6	<0.001**
RVSP (mm Hg)	49.3±17.1	49.1±15.9	0.928
GLS (%)	-20.2±4.2	-16.8±4.1	<0.001**
GCS (%)	-26.8±6.9	-24.5±7.0	0.011*

*Data were presented as mean±SD: p-value >0.05; *p-value <0.05; **p-value <0.00.*

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Cardiac events' predictors: Age, LV ejection fraction, LA size, AF occurrence, prior ischemia, concurrent CABG, GLS, and GCS all demonstrated statistically significant correlations to cardiac incidents through follow-up as shown in table 3.

Table 3: Univariate analysis for cardiac incidents and death

	Univariate Analysis		
	HR	**95% CI**	**p Value**
Cardiac incidents			
Age (years)	1.502	1.206-1.870	<0.001**
LVEF (%)	0.937	0.912-0.962	0.012*
LVESD (mm)	0.985	0.952-1.019	0.385
LVESV (ml)	0.965	0.950-0.982	0.565
LA dimension (mm)	1.017	0.995-1.038	<0.001**
RVSP (mm Hg)	0.978	0.964-0.991	0.278
AF	2.097	1.270-3.466	0.003*
GLS (%)	1.164	1.097-1.235	<0.001**
GCS (%)	1.017	0.979-1.057	0.016*
All-cause mortality			
Age (years)	2.390	1.782-3.207	<0.001**
LVEF (%)	0.978	0.946-1.010	0.620
LVESD (mm)	0.622	0.910-0.982	0.175
LVESV (ml)	0.950	0.926-0.973	0.079
LA dimension (mm)	1.007	0.985-1.029	<0.001**
RVSP (mm Hg)	0.983	0.968-0.997	0.084
AF	1.931	1.137-3.281	0.011*
GLS (%)	1.069	1.004-1.138	0.002*
GCS (%)	1.000	0.960-1.042	0.132

CI*: 95%. p-value >0.05; *p-value <0.05; **p-value <0.001*

Age (HR: 1.386; p value 0.004), LA dimension (HR: 1.003; p value 0.018) and GLS (HR: 1.192; p < 0.001) are significant predictors of cardiac events through Multivariate regression analysis as shown in table 4 and figure 1.

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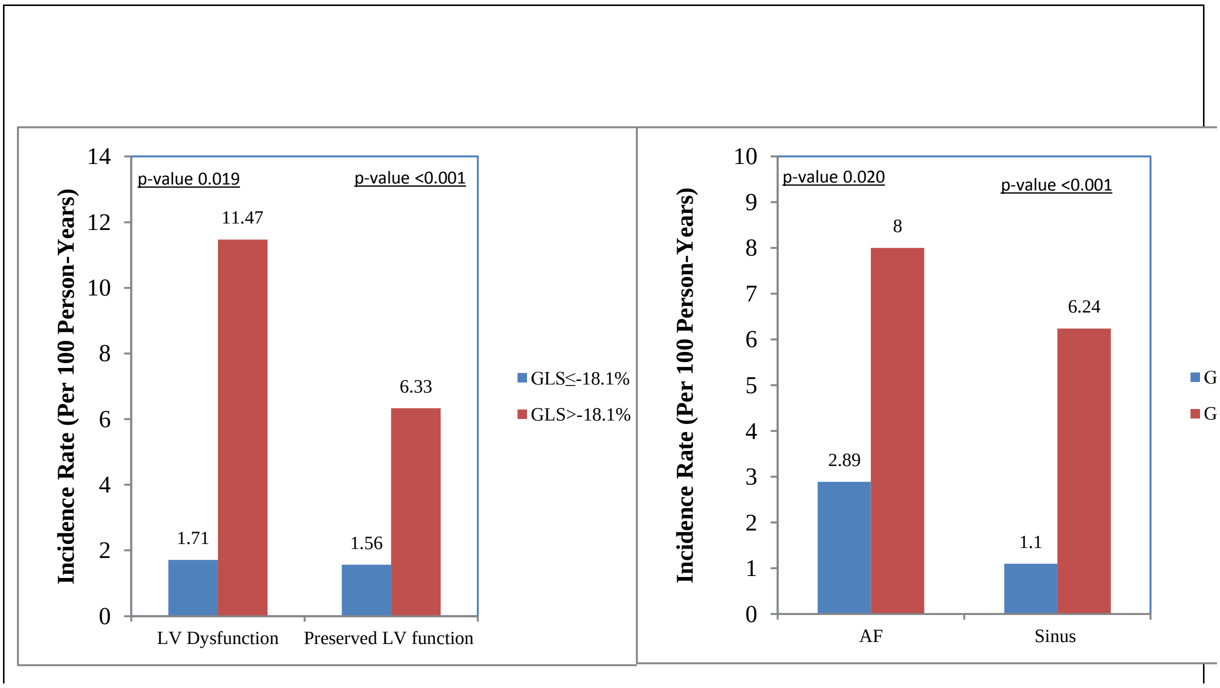
Table 4: Multivariate analysis for predictors of cardiac incidents

	Multivariate Analysis		
	HR	**95% CI**	**P Value**
Age, decade	1.386	1.083-1.776	0.004*
LVEF (%)	0.994	0.949-1.030	0.173
LA dimension (mm)	1.003	0.976-1.031	0.018*
AF	1.159	0.631-2.129	0.550
GLS (%)	1.192	1.101-1.291	<0.001**
GCS (%)	0.957	0.908-1.009	0.597
Age (years)	2.301	1.706-3.103	<0.001**
LA dimension (mm)	1.000	0.975-1.026	0.016*
AF	0.852	1.137-3.281	0.664
GLS (%)	0.003	0.973-1.102	0.039*

CI: *95%. p-value >0.05; *p-value <0.05; **p-value <0.001*



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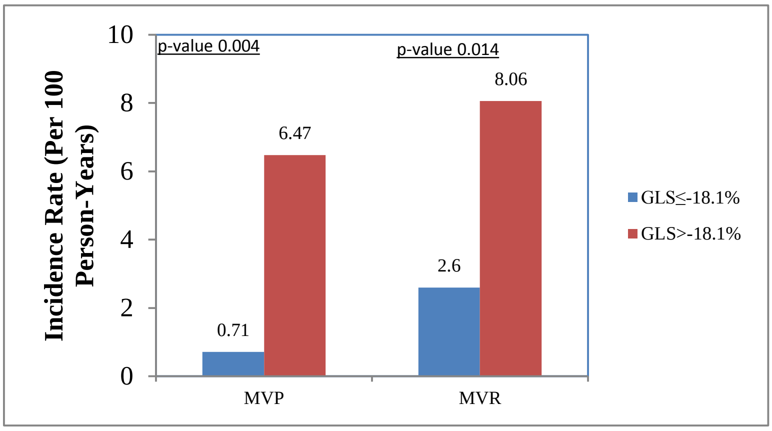

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Figure 1: Annual incidents based on LVD, Atrial fibrillation, and mitral surgery type

DISCUSSION

This investigation showed that preoperative strain measures were the most reliable metric for identifying an early LV dysfunction after MV surgery among those having degenerative MR despite preserved LVEF%. So GLS to be useful on forecasting predicting postoperative prognosis and choosing best operation time among those with severe MR because it allows for early diagnosis of mild LV dysfunction (LVD).

In the current ESC guidelines, it is still difficult to determine whether those with severe asymptomatic MR should have surgery or not [11]. Although left ventricular function is usually overestimated as the result of severe MR. New cohort investigation demonstrated that GLS was linked to death (among individuals having asymptomatic sever MR, normal LV dimension, and maintained LVEF) and offered additional predictive usefulness to previously recognized predictors. Additionally, GLS is more accurate metric for detecting subclinical myocardial impairment than LVEF [12].

In this study, MV surgery was performed on 447 patients who did not have LV dysfunction as per the recommended criteria of the guidelines. By comparing LVEF% and LV internal dimensions utilized according to the recent recommendations, to GLS; GLS had a higher therapeutic value among those with severe MR who had surgery. Longitudinal function assessment may aid to detect LV dysfunction early. Among those with MR, earlier longitudinal function was compromised. The LV dilates and spherically transforms as the MR proceeds, impairing longitudinal motion (more sensitive in identifying mild LV failure) [13].

Among those with severe MR undergoing operation, GLS has been proven to be able to identify postoperative LV dysfunction, according to prior researches [14,15]. In this research, GLS's ability to predict both heart incidents and postoperative LVD was verified. LVD was also more observed with those whose GLS ≤18.1%. Although LV dysfunction is a helpful proxy to postoperative results, it may not accurately represent fundamental purposes of surgery.Findings of this study improved our knowledge of advantages of GLS for projecting actual outcomes following surgical management.

CONCLUSION

Among those having marked primary MR with MV surgery, pre-operative GLS showed strong correlation to clinical outcomes and have a better cardiac events' predicting abilities. Nevertheless, for making meaningful conclusions in individuals having valve disease, a thorough knowledge of the complicated relationship between loading circumstances, chamber geometry, and contractility is required.

RECOMMENDATIONS

Assessment of LV strain by echocardiogram should be done as a helpful marker that can help clinicians to decide if subjects having marked MR may acquire symptoms or having a bad prognosis.

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