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Role of speckle tracking echocardiography to predict LV dysfunction post mitral valve replacement surgery for severe mitral regurgitation

Role of Speckle Tracking Echocardiography to Predict Left Ventricular Dysfunction Post Mitral Valve Replacement Surgery for Severe Mitral Regurgitation

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Abstract

Background: **Despite improvement in the surgical procedure and strictly following the guidelines for mitral valve replacement (MVR), left ventricular dysfunction still occurs. Novel echocardiographic indices can predict development of LV (left ventricle) dysfunction post MVR. LV-GLS (global longitudinal strain) derived from speckle tracking echocardiography, has been proposed as a novel measure to better depict latent LV dysfunction.**

Methods: **A total of 100 patients with severe MR (mitral regurgitation) planned for MVR were included. Speckle tracking echocardiography was performed at baseline and at follow up post MVR. ROC (Receiver operating characteristics) curve was plotted to derive the cutoff value of LV-GLS for prediction of LV dysfunction post MVR. Univariate and multi variate regression was analyzed to predict the independent predictors of LV dysfunction after MVR.**

Results: **LV-GLS was decreased from baseline data (−19.9 vs. −17.7) in patients with LVEF <50% after MVR compared to patients with LVEF≥ 50%. Baseline value of LVESD (35.36 mm vs. 28.23 mm) and LVEDD (49.33 mm vs. 45.10 mm) were significantly higher in patients with LVEF<50% compared to LVEF ≥50% at 3 months follow up. A cutoff value of GLS -19% with sensitivity of 80.3% and specificity of 75.7% was associated in patients with LV dysfunction after MVR. In multivariate regression model GLS < -19% (OR = 21.8, CI:6.61−82.4, P=<0.001) was an independent predictor of LV dysfunction post MVR.**

Conclusion: **A GLS value of less than −19% was demonstrated as an independent predictor of short term LV dysfunction after mitral valve surgery, LVESD ≥40 mm was also verified additional parameter to predict the LV dysfunction post MVR.**

Keywords: Mitral valve replacement, Left ventricular dysfunction, Global longitudinal strain

1. Introduction

Mitral valve regurgitation is the most common type of valvular heart disease. The long-term development of left ventricular dysfunction after mitral valve replacement is a major debatable concern in the management of patients with moderate to severe mitral valve regurgitation and causes increased risk of major cardiac complications. The evaluation and long term prognosis of patients with mitral valve regurgitation have been very challenging for clinicians due to consequence of various causes, etiology, dynamic nature and stealthy progression [1,2].

According to European and American guidelines mitral valve surgery must be recommended to

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symptomatic patients with severe mitral regurgitation [3,4]. And in asymptomatic patients with primary severe MR, the indication for surgery depends on 2d echocardiography parameters and other clinical parameters like presence of atrial fibrillation and pulmonary hypertension [3]. On the other side untreated MR patients could develop chronic volume overload and as a result LV dysfunction and heart failure [5,6]. Hence, the early detection of deteriorating systolic function in asymptomatic patients with LVEF >60% or LVESD <45 mm and in isolated severe mitral regurgitation is a major concern. Conventional echocardiography parameters have low sensitivity to detect latent subclinical myocardial damage. For early detection of the LV dysfunction before it reached the advanced stage, we need to identify additional parameters that predict the LV dysfunction after mitral valve surgery. Advances in the cardiovascular imaging technology could allow better identification of MV disease and its consequent myocardial alteration in a view to obtain early decision making [7].

GLS analyzed by speckle tracking is an echocardiographic imaging procedure that examines the motion of tissues in the heart muscle by using the naturally occurring speckle pattern in the myocardium. Myocardial strain imaging is nowadays used to evaluate longitudinal contraction of LV and reflected LV myocardial function accurately. Findings from the longitudinal strain measurement may detect underlying LV dysfunction in presence of normal EF [8,9]. Speckle tracking echocardiography has been shown to be an early diagnostic and prognostic marker in several clinical scenarios. Therefore, our study was aimed to investigate the value of global longitudinal strain (GLS) to predict LV dysfunction after MV replacement.

2. Methods

2.1. Study population and data collection

In the current prospective observational study, patients who underwent mitral valve replacement surgery in our tertiary cardiac care institute between January 2018 to December 2019 were enrolled. The study was approved by institutional ethics committee (UNMICRC/CARDIO/2017/19). Informed consent was taken from all participants.

Patients who presented with severe organic MR and underwent MVR were included in the study. Patients with LVEF <60%, associated congenital or acquired significant valvular disease, prior myocardial infarction, coronary revascularization, cardiac surgery or associated significant CAD and patients with concommitant tricuspid valve repair were excluded from the study. Patients data were prospectively collected in pre designed data collection form. Data collection form included information about demographic details, clinical data, etiology of MR, surgery data, echocardiographic data and speckle tracking data. Echocardiographic evaluation was done in all patients before surgery and was repeated at 3 months after corrective MVR in order to assess the incidence of LV dysfunction. Patients were monitored during the period of hospital stay to note their outcome or any cardiac event at the time of follow-up.

Abbreviations

GLS	Global longitudinal strain
LVEDD	Left Ventricle End Diastolic Dimension
LVESD	Left Ventricle End Systolic Dimension
MVR	Mitral valve replacement
MR	Mitral regurgitation
NYHA	New York Heart Association

2.2. Echocardiographic evaluation

Transthoracic echocardiography was performed with commercially available systems Vivid 7 and E9, GE). using a 3.5 MHz transducer. According to ACC-AHA (2014) [10] the current recommendations, severity of MR was assessed using a multiparametric approach based on colour-flow and continuous wave (CW) Doppler images, including proximal regurgitant jet width (vena contracta), effective regurgitant orifice area (using the proximal iso-velocity surface area method), and regurgitant volume. At follow-up after MVR, LV dysfunction was defined as LVEF <50%.

2.3. Speckle-tracking strain analysis

Longitudinal strain, evaluating the shortening (negative strain) and lengthening (positive strain) of the myocardial wall, was measured from the three views i.e. apical 4-chamber, apical 3 chamber and apical 2-chamber views. Strain measurement was done by manually tracing LV endocardial border in the end-systolic frame. The software automatically extracted a strain curve from the gray-scale images. The longitudinal and circumferential strains were global strains that were measured as changes of the whole myocardium, not an averaged value of each segmental strain. Peak strain was defined as the peak negative value on the strain curve during the entire cardiac cycle. GLS was calculated by averaging the peak value of 3 apical views [11].

2.4. Surgical technique

All patients were operated with invasive arterial and pulmonary artery pressure monitoring. Surgery was performed using cardiopulmonary bypass with bi-caval and aortic cannulation and standard moderate hypothermia (≈28 °C–32 °C), after adhesiolysis. After aortic cross clamp antegrade root cardioplegia was delivered and repeated every 20min. Left atrium was approached either via watersons groove or via trans-septal. For replacement, we had used interrupted pledgeted sutures with pledget on left atrial side and LA was closed after sutures. Hot shot cardioplegia was delivered and aortic cross clamp was detached once heart started beating. Total chordal preservation was done in all subjects.

2.5. Data analysis

All statistical studies were carried out using Statistical Package for Social Sciences (SPSS vs.22.0). The quantitative variables were expressed as the mean ± standard deviation and qualitative variables were expressed as percentage (%). A comparison of parametric values between two groups was performed using the independent sample t test. Categorical variables were compared using the chi-square test. And were presented as frequencies and percentage. Logistic regression was used to predict the different risk factors for presence of left ventricular dysfunction. A nominal significance was taken as a two tailed p value < 0.05.

3. Results

Table 1 shows the baseline characteristics of the population. Male to female ratio was 1:1.7. Maximum patients were mildly symptomatic (NYHA class II) and major number of patients had complaint of dyspnea. Patients with rheumatic etiology were 67%, infective endocarditis were 10%, and mitral valve prolapse were 23%.

Table 2 presents the echocardiographic parameters at baseline and at follow up time. LV ejection fraction, LV end-systolic diameter and LV end-diastolic diameter were decreased at follow up time in our study population. LVEF was relatively preserved. At baseline LVESD, LVEDD were 33.8 ± 7.7 and 49.8 ± 6.8 which was improved to 30.7 ± 6.3 and 46.5 ± 4.5 at post surgery.

Table 1. Baseline characteristics of population.

Variables	N=100
Age	41.96±14.96
Gender	
Male	37 (37%)
Female	63 (63%)
NYHA class	
NYHA class I	30 (30%)
NYHA class II	50 (50%)
NYHA class III	16 (16%)
NYHA class IV	04 (4%)
Chief complaints	
Dyspnea	80 (80%)
Angina	04 (4%)
Palpitation	12 (12%)
Syncope	02 (2%)
Fatigue	02 (2%)
Etiology of Mitral valve regurgitation	
Rheumatic	67 (67%)
Infective Endocarditis	10 (10%)
Mitral valve Prolapse	23 (23%)

(NYHA: New York Heart Association)

Table 2. Comparison of baseline and follow up echocardiographic parameters.

Echo parameters	At baseline	At follow up
LV ejection fraction (%)	60.3 ± 1.4	50.6 ± 12.6
LV end-systolic diameter (mm)	33.8 ± 7.7	30.7 ±6.3
LV end-diastolic diameter (mm)	49.8 ± 6.8	46.5 ± 4.5

There was no difference at follow up in age, sex, hypertension, and atrial fibrillation between both the groups. LV end diastolic diameter (P = 0.01), LV end systolic diameter (P=<0.001) were significantly raised in the patients with LVEF <50% as compared to patients with LVEF ≥50% and LV global longitudinal strain was significantly reduced in LVEF<50% group (P=<0.001) presented in Table 3.

Fig. 1 represents ROC curve of GLPSS value to predict LV dysfunction. GLPSS value > -19 predicted LV dysfunction with sensitivity of 80.3% and specificity of 75.7% (AUC 0.829, 95% CI 0.775 to 0.875 p < 0.0001).

Table 4 shows the predictors of post MVR left ventricular dysfunction. Atrial fibrillation, presence of symptoms, LVESD ≥40 mm and LV-GLS > −19% were found significantly associated with LVEF <50%. While on multi variate analysis LVESD ≥40 mm and LV-GLS < −19% were found significant predictors of LVEF <50% after surgery.

4. Discussion

The main findings of the current study are summarized as follows: 1) Patients with reduced left ventricular ejection fraction after surgery (LVEF <50%) had significantly increased LVEDD, LVESD and significantly reduced LVGLS in comparison to

Table 3. Comparison of clinical and echocardiographic parameters in patients with LVEF ≥50% and <50% on follow-up after mitral valve corrective surgery.

Variable	LVEF ≥ 50% (n=81)	LVEF < 50% (n=19)	p - value
Age (years)	49.95±12.35	52.87±14.56	0.2903
Men	26 (32.10%)	08 (42.10%)	0.5757
Atrial fibrillation	25 (30.86%)	06 (31.58%)	0.8298
Hypertension	17 (20.99%)	03 (15.79%)	0.8484
LV end-diastolic diameter (mm)	45.10 ± 2.67	49.33± 2.11	<0.0001
LV end-systolic diameter (mm)	28.23 ±3.06	35.36 ± 5.96	<0.0001
Right ventricular systolic pressure (mmHg)	41.9±1.25	42.3±1.20	0.1225
LV global longitudinal strain (%)	-21.1 ± 2.49	-17.7± 2.82	< 0.0001

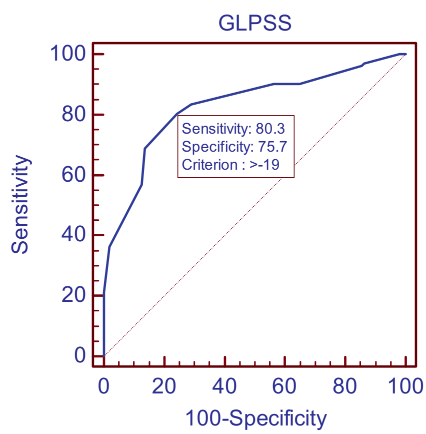

Fig. 1. Receiver operating characteristic analysis of Global longitudinal strain.

patients with LVEF ≥50%. 2) regression analysis for the prediction of LVEF< 50% found AF, presence of symptoms, LVESD ≥40 mm and LV_GLS < -19 were the predictors of LVEF <50% after surgery.

The reported incidence of long term post-operative LV dysfunction (<50%) varies from 18.4% to 44.19% in operated patients [5,12]. While in our study 19% patients with mitral valve regurgitation patients developed LV dysfunction <50% after MVR at 3 months follow up. In the current study the LVEF reduced in average from 60.15% to 35.55% at short term follow up.

The promising result and success of mitral valve surgery for LV performance is mainly considered by significant decrease in left ventricular size during post-operative follow up. In current study the post-operative echocardiography at 3 months follow up patients with reduced LVEF <50% were found to have significantly higher baseline LVESD (35.36 vs. 28.23) and LVEDD (49.33 vs. 45.10) compared to patients with >50% LVEF. Similar results were shown in the earlier reported study by Jeong cho et al. [5], where the LVESD (34.04 mm−29.91 mm) and LVEDD (58.04 mm−47.55 mm) value were significantly low in patients with non-remodeling (preserved LVEF and decrease in LVED after MVR) group in comparison to remodeling (reduction in LVEF or increase of LVED after MVR) group at 3 months follow up. Hence, the value of LVEDD and LVESD may be also considered as parameters to predict the LV dysfunction after mitral valve surgery.

In the prospective study done by Mascle et al. [13] included 88 patients with severe degenerative MR, showed the LV GLS value of −18% is an

Table 4. Predictors of LV dysfunction (LVEF <50%) on follow-up after mitral valve corrective surgery.

Predictors	Univariate Analysis			Multivariate Analysis		
	Odds ratio	95% CI	P value	Odds ratio	95% CI	P value
Atrial fibrillation	2.41	1.09 - 5.12	0.047	1.97	0.71 − 6.03	0.27
Presence of symptoms	3.04	1.14 − 8.1	0.043	2.29	0.76 − 8.23	0.173
LVEF ≤ 60%	7.04	2.97 − 15.2	<0.001	2.53	0.99 − 7.56	0.07
LVESD ≥ 40 mm	9.88	3.92 − 24.05	<0.001	6.6	1.97 − 23.64	0.004
LV-GLS > -19%	22.6	8.02 − 73.21	<0.001	21.8	6.61 − 82.41	<0.001

independent predictor of LV dysfunction with OR = 4.2 (CI:1.4−13). This study demonstrated that considering the independent preoperative LV GLS value is beneficial to predict the postoperative LV dysfunction. Similar LV GLS value reported by Ternacle et al. [14] showed that LV GLS value less than −18% was associated with presence of significantly higher mortality with OR = 2.4 (P = 0.04) at 30 days follow up in patients with left heart valve surgery. They concluded that in patients with preserved ejection fraction LV GLS enables prediction of risk stratification for risk of early post-operative death after left sided cardiac surgery. In the retrospective study conducted in 130 patients by Pandis et al. [15] shown LV GLS value of −17.9% predicted the LVEF changes after MVR in patients with chronic severe degenerative MR with OR = 0.8 (CI:0.73−0.88) at follow up. This study found the LV GLS value of −18% was associated with significant mortality with OR = 2.4 (P = 0.04). While in the current study regression analysis for prediction of LVEF <50% after mitral valve surgery found the LVESD ≥40 mm and LVGLS < -19% were the better predictors with OR = 6.6 (95%CI 1.97−23.64) and 21.8 (95%CI 6.61−82.41) respectively. A meta-analysis from 8 studies with severe MR and preserved left ventricular ejection fraction has shown that reduced LV GLS before surgery was a predictor of worse post-operative survival and LVEF with HR = 1.13, 95% CI 1.02−1.26 [16]. While the study published by Tomasz et al. [8] reported similar values of LVESD ≥40 mm and LVGLS > -19.9% were the better predictors of LVEF <50% after surgery with OR = 6.71 (1.91−23.52) and 23.16 (95%CI 6.53−82.10) respectively. Although study by Hiemstra et al. [17] found the preoperative value of −20.9% was associated with worse survival outcome at long term. Most of published studies reported that the LV GLS value for prediction of post MVR LV dysfunction varies between −20.9% and −18%, which is similar to present study.

In the present work, majority of patients had rheumatic etiology (67% patients with rheumatic heart disease) who underwent mitral valve replacement, which gives additional new data of LV GLS in this population as compared to other studies about the measurement of LV GLS value in patients with severe mitral regurgitation [13,14,17] Majority of studies have demonstrated the prognostic value of LV GLS measurement in the setting of mitral valve repair while our study included patients who underwent mitral valve replacement and reported the LV GLS value in those patients [1,7,17]. Choral preservation plays an important role in preserving LV function post mitral valve surgery. All patients in our study underwent mitral valve replacement with total chordal preservation which makes our study comparable to other studies where MV repair was done for severe mitral regurgitation.

In asymptomatic patients with severe MR, LVEF >60% is maintained by progressive LV eccentric hypertrophy. An increase in heart's muscle mass stress leads to myocardial dysfunction. Despite the careful adherence to current guidelines during the surgical procedure, postoperative LV dysfunction occurs. Recently LV deformation strain parameter as assessed with different imaging techniques have proposed to predict the LV dysfunction after mitral valve surgery. Global longitudinal strain derived by speckle tracking echocardiography has a strong direct correlation with LVEF.

4.1. Limitation

Firstly, limited sample size of the study averts an accurate assessment of the optimal cut-off value for LV-GLS. Secondly, use of single echocardiography instrument for calculation of LV GLS might prevent precise results of GLS value. Thirdly, different population may have different set of normal values of GLS so this value may not be generalized. Finally, we have measured only GLS as principle myocardial deformation measure in our study, which may not reflect true function of myocardium considering the complex architecture of myocardium which has three layers of sub-endocardial longitudinal, mid circumference and sub epicardial longitudinally arranged myofibers.

5. Conclusion

Reduced LV-GLS value derived by 2D speckle tracking echocardiography and increased value of LVESD and LVEDD preoperatively can predict development of LV dysfunction post MVR. Identification of latent subclinical myocardial dysfunction prior to mitral valve replacement or repair surgery can help in determining the timing of surgery, nature of surgical procedure and planning vigilant post-operative care of those patients for better post-operative outcome of these patients.

Author contribution

Conception and design of Study: PS, PV, HJ. Literature review: IP, JP, SS. Acquisition of data: PS, PV, HJ, GD. Analysis and interpretation of data: PS, PV, IP, HJ. Research investigation and analysis: PS, PV, HJ, IP. Data collection: PS, IP. Drafting of manuscript: PS, PV, IP. Revising and editing the manuscript critically for important intellectual contents: PS, PV, IP. Data preparation and presentation: PS, PV, HJ, IP, GD. Supervision of the research: HJ, GD. Research coordination and management: IP, JP, SS.

Conflict of interest

There is no conflict of interest in present study.

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