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Recent Echocardiography Parameters for Predicting Better Functional Result After Mitral Valve Correction Surgery in Patients with Primary Mitral Regurgitation

Indah Puspita[1], Amiliana M Soesanto[2], Estu Rudiktyo[2], Rina Ariani[2], BRM Ario S Kuncoro[2]

Abstract

Objectives: We analyzed whether some echocardiographic parameters are good predictors of functional result after mitral valve correction surgery.

Background: Ejection fraction was not the only parameter to decide optimal time for surgery, nor an indicator for a better functional result after surgery. Severity measurement being a main consideration in surgery decision. Reduced left ventricle dimension after surgery reflect a better functional result.

Methods: In 2019, 67 patients was included in this analysis. Age 53 (17-67) years, male 52,2%. All patients are with severe primary mitral regurgitation and treated by mitral valve surgery (mitral valve repair or replacement). Retrospective echocardiographic analysis was performed, to find the best parameter for predicting better functional outcome after surgery.

Results: Data was collected from January to December 2019. From 262 primary mitral valve surgery underwent in National Heart Center Harapan Kita, there was 67 patients included, the other was excluded due to probability of secondary mitral regurgitation mechanism, concomitant congenital heart disease and or other significant valves disease, missing post-surgery data due to referral flow to the prior hospital and less complete echocardiographic views for further analysis. In bivariate analysis, end-diastolic volume (EDV) and regurgitant volume (RV) were strong predictor of decreasing left ventricle diameter after surgery (p 0.0001 and p 0.05). End-diastolic volume 133.5 ml or more is predictive for decreasing left ventricle diameter if surgery was conducted (sensitivity 87.3%, sensitivity 66.7%).

Conclusion: EDV and RV found to be good predictors for functional outcome of primary mitral valve surgery than other echocardiographic parameters. Measuring EDV before deciding timing of surgery will be helpful in targeting better functional result after surgery.

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Keywords: mitral regurgitation, end-diastolic volume, regurgitant volume

[1] Department of Cardiology and Vascular Medicine, Mohammad Hoesin General Hospital,Palembang
[2] Department of Cardiology and Vascular Medicine, Faculty of Medicine, Universitas Indonesia/ National Cardiovascular Center Harapan Kita, Jakarta

Correspondence:
Indah Puspita,
Department of Cardiology and Vascular Medicine, Mohammad Hoesin General Hospital,
Palembang.
Email: viva_indah@yahoo.com

Introduction

Early compensation of mitral regurgitaion (MR) showed in acute MR due to Frank-Starling mechanism utilisation, that gradually followed by chronic remodelling process; increase of left ventricle dimension. The adapted compensatory process is possible to be failed, causing left ventricle disfunction and transition to became chronic decompensation phase of MR. [1,2.] Advanced phase of chronic MR signed by existing of some heart failure symptoms, but sometime the progression of those symptoms was not reported due to less self awareness of the patient. It become priority to detect functional and structural remodelling of left ventricle as early as possible, before permanent left ventricle disfunction occur. Moreover, decision for appropriate time for surgery will prevent advanced decompensation phase. Decompensation phase of MR mainly characterized by progressive and substantial left ventricle dilatation, increase of left ventricle pressure, increase of systolic wall stress and ejection fraction reduction <50%. Management of MR was depend on severity of MR based on echocardiographic measurement. Some parameters for MR severity measurement are regurgitant volume, MR fraction, effective regurgitant orifice area (EROA).[3] Some research analyze parameters to predict the outcome of surgery, such as left atrial dilatation,[4] atrial fibrillation,[5] pulmonary hypertension,[6] ejection fraction,[7,8,9] end systolic volume[10] and myocardial strain.[11,12] More research with different sample characteristics in finding significant parameters and value were needed to support decision of optimal timing for surgery, to finally achieve better functional result after surgery.

Methods

Study Design

This study design is cross-sectional study. The data from surgery medical records of 262 patients with severe primary MR who underwent repair or replacement surgery were retrospectively listed. All the patients were examined and underwent the surgery at National Heart Center Harapan Kita, Jakarta, Indonesia between January and December 2019. Amount of 195 patients were excluded due to combined other significant valve disease, congenital heart disease and possibility of secondary mechanism of MR. Patients with loss follow-up and uncomplete echocardiographic data were also excluded.

Echocardiography

Echocardiography was performed, trans-thoracal and trans-esophageal. All subjects was examined with conventional 2-dimensional, M-Mode, conventional and color doppler ultrasonography by cardiologist and experienced sonographer, based on American Society Echocardiography guidelines [13]. Severe MR was obtained from echocardiographic image, include

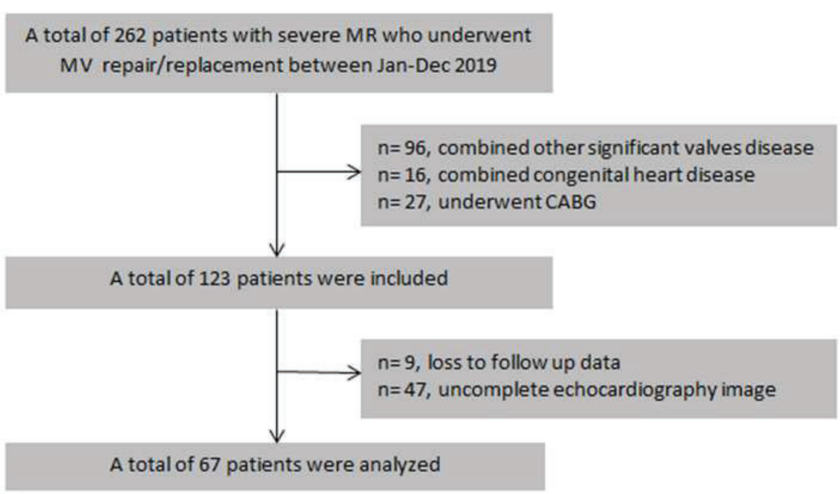

Figure 1. Study Population

Table 1. Baseline characteristics and echocardiographic parameter

	N = 67 Mean/Median + SD
Age, years	53 (17-67)
Male n(%)	35(52.2)
Female n(%)	32 (47.8)
Body surface area, m2	1.6 ± 2
LVEF, %	67.5 ± 7.0
MVD, mm	4.3 (3.4-7.8)
LVEDd,mm	58.4 ± 7.7
MSV, ml	542.8 ± 266.2
RV, ml	77(10-504)
EDV, ml	173.1 ± 52.9
MR VTI, m/s	120.8 ± 31.7
MV VTI, m/s	40.6 (16-92.1)
MR mean PG, mmHg	46.2 ± 20.6
MR maximal velocity, m/s	4.2 (4-6.1)
MV mean PG, mmHg	4 (5-32)
MV maximal velocity, m/s	1.2 (2-10.8)
LA diameter, mm	48.6 (28-87)
LAVI, ml/m2	89 (35-889.5)

LVEF, Left ventricle ejection fraction. MVD, Mitral valve diameter. MSV, Mitral stroke volume. RV, Regurgitant volume. EDV, End diastolic volume. MR VTI, Mitral regurgitation velocity time integral. MV VTI, Mitral valve velocity time integral. PG, Pressure gradient. LA, Left atrium. LAVI, Left atrium volume index

structural (severe valve lesions, dilated left ventricle and left atrium size), qualitative doppler (large central jet or eccentric wall impinging jet, large flow convergence throughout systole), semiquantitative (vena contracta width >7 cm, sometime accompanied by systolic flow reversal, E-wave dominant >1.2 m/s of mitral inflow) and quantitative (EROA >0.40 cm^2, regurgitant volume >60 mL, regurgitant fraction >50%).[14] LV end-diastolic dimension and LV end-diastolic volume (EDV) was calculated by using M-mode, 2 dimensional image. LV end-diastolic dimension was calculated pre and post surgery. Decreasing LV dimension indicate an improvement functionally, the same or increase dimension not indicate a better functional result after surgery.

Statistical Analysis

Statistical analysis was performed using SPSS software (SPSS, Chicago, IL). Data are expressed as mean + SD for normal data, and median (range) for abnormal data, with Kolmogorov-Smirnov test. Bivariate analysis was used. Different probability treshold was obtain using receiver operating characteristic (ROC) curves as predictive model

Table 2. Baseline characteristics according to decreasing left ventricle diameter after surgery

Variables	Decreasing Left Ventricle Diameter after surgery (mean/median ± SD)		p-value
	Yes	No	
Age, years	52(17-67)	54.5 (19-64)	0.987
Sex			
Male	30(85.7)	5 (14.3)	0.624
Female	25 (78.1)	7 (21.9)	
Body surface area, m2	1.6 ± .2	1.5 ± 2	0.490
Type of MR Surgery			
Repair	42 (91.3)	4 (8.7)	0.006
Replacement	13 (61.9)	8(38.1)	

Results

Study population.

Table 1 explain baseline characteristic of the patient. Median age is 53 years with range 18-67 years, 52.2% are male. Mean pre-operative ejection fraction is 67.5 (+7)%, EDV 173.1-952.9)ml, LA diameter 48.6 (28-87)mm, LAVI 89 (35-889.5) ml/m2.

Echocardiography.

Significant decrease of left ventricle dimension after surgery was found in different type of surgery, whether repair or replacement surgery (p=0.006). There was also significant different of regugitant volume and end-diastolic volume for patients with and without decreasing of left ventricular dimension after surgery (p=0.028 and p=0.001). Significant correlation was found between regurgitant volume and decreasing left ventricular dimension after surgery (p=0.05). Stronger significant correlation was found between end-diastolic volume and decreasing left ventricular dimension after surgery (p<0.001). Those correlations was explain in Table 4.

ROC curve was expressed in Figure 2. There is EDV tresh hold of 133.5 ml (Sensitivity 87.3%, specificity 66.7%) for best functional outcome after surgery.

Table 3. Baseline echocardiographic parameters in patients with and without decreasing LV diameter after mitral valve surgery

	Decreasing Left Ventricle Diameter after surgery (mean/median ± SD)		p-value
	Yes (n= 55)	No (n= 12)	
LVEF, %	67.6 ± 6.9	67.1 ± 7.7	0.831
MVD, mm	4.3 (3.4 – 7.8)	4.3 (3.4 – 5.8)	0.560
MSV, ml	559. 2 ± 274.8	467.6 ± 216.9	0.283
RV, ml	73 (10 – 504)	168.5 (55 – 374)	0.028
EDV, ml	182.8 ± 51.4	128.5 ± 34.3	0.001
MR VTI, m/s	119.6 ± 31.2	126.6 ± 34.6	0.492
MV VTI, m/s	40.7 (16 – 92.1)	38.8 (19.1 – 47.7)	0.524
MR mean PG, mmHg	44.7 ± 20.6	52.9 ± 20.0	0.216
MR maximal velocity, m/s	4.1 (0.9 – 6.1)	4.5 (4 – 5.5)	0.551
MV mean PG, mmHg	4 (0.8 – 32)	3.7 (5 – 7)	0.550
MV maximal velocity, m/s	1.1 (0.2 – 10.8)	1.6 (0.3 – 2.0)	0.409
LA diameter, mm	50 (28 – 87)	47.4 (43 – 75)	0.935
LAVI, ml/m2	89 (35 – 707)	87.5 (45 – 889.5)	0.967

Table 4. Correlation some baseline characteristics and echocardiographic parameters with decreasing LV dimension.

	Decreasing LV diameter, p Value, (n=55)	
	r	P value
Age, years	0.02	0.896
Body surface area, m2	-0.1	0.469
Days after surgery to echocardiography	0.07	0.591
LVEF, %	-0.06	0.645
MVD, mm	0.12	0.399
MSV, ml	0.12	0.392
RV, ml	0.27	0.05
EDV, ml	0.60	0.0001
MR VTI, m/s	0.15	0.264
MV VTI, m/s	0.20	0.134
MR mean PG, mmHg	0.22	0.106
MR maximal velocity, m/s	0.22	0.102
MV mean PG, mmHg	0.22	0.10
MV maximal velocity, m/s	0.24	0.07
LA diameter, mm	0.10	0.475
LAVI, ml/m2	0.13	0.343

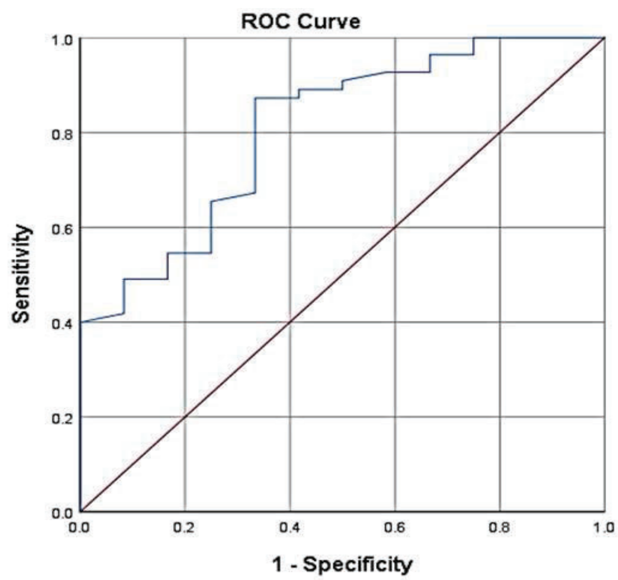

Figure 2. ROC curve for EDV and decreasing LV dimension after surgery.

Discussion

In this study, we found that regurgitant volume and end-diastolic volume were a strong predictor of better functional outcome after surgery. Functional outcome was concluded from LV dimension changes over the changes of LVEF, LA or LAVI. There was no correlation between day of echocardiography in this study was performed with the changes of LV dimension, exact time course of LV remodelling still need further study.

LVEF and stroke volume

Ejection fraction from many studies show a fluctuative result that not always accordance to clinical patient's manifestation, thus not always become the only parameter in making decision for timing of surgery. Patient with compensated severe MR, increased preload and LV volume and dereased afterload maintain LVEF within normal or supernormal values for long period.[15,16] LVEF shows to be increased in long time follow up, reflecting normalization of LV systolic function after surgery.[17] Relative impairment of LV performance also possibly occur, showed by significant decrease LVEF and stroke volume acutely after operation with a partial recovery at long-term follow up.[18,19] In other study, both forward stroke volume and forward LVEF significantly increased immediately after successful correction of MR.[20]

LA dimension and LAVI

This study showed no significant correlation between LA dimension and LAVI with decreasing of LV dimension. Previous studies show parameter LA and LAVI, that found to be predictors of outcome.[21, 22] Left atrial reverse remodelling (LARR) as a mechanism of LA and LAVI changes after mitral surgery, occured during early postoperative period. LV global longitudinal strain, age and LA volume at surgery determined the degree of early LARR after MV surgery in patient with chronic severe MR.[21] LARR occured frequently after mitral valve surgery and is associate with preoperative LVEF higher than 63.5%. [22] Preoperative LAVI, bood pressure, postoperative transmitral mean pressure gradient, residual MR, and age >45 were related to LAVI reduction.[23]

End-diastolic volume

Significant correlation between end-diastolic volume and decreasing LV dimension after surgery was found in this study ($p<0.001$). There is EDV tresh hold of 133.5 ml (sensitivity 87.3%, specificity 66,7%) for best functional outcome after surgery. Previous study showed significant changes overtime in LV end-diastolic ($p<0.001$) and end-systolic ($p=0.009$) volume index. Immediately after mitral valve repair, both LV end-diastolic and end systolic volume indices decreased significantly in comparison with baseline ($p<0.001$), but the reduction in LV end-diastolic volume index was more pronounced. At long-term follow up, LV end-diastolic volume index showed significant increase ($p<0.001$) but remained signficantly smaller in comparison with baseline values ($p<0.001$).[20]

Mitral regurgitant volume

Significant correlation between mitral regurgitant volume and decreasing LV dimension after surgery was found in this study ($p=0.05$). No significant correlation was found between ratio of mitral regurgitant volum to end-diastolic volume and decreasing of LV dimension after surgery in this study ($p>0.05$). Mitral regurgitant volume is common evaluation during chronic phase of MR, to determine the mitral regurgutation severity. Two randomized clinical trials analyzed the ratio of mitral regurgitant volume to end-diastolic volume was performed in different study population compared with this study. Those were in population of transcatheter edge-to-edge mitral valve repair with secondary mitral regurgitation.[24]

Study Limitations

End-diastolic volume as a predictor for mitral surgery outcome, needs further study with longer period of echocardiography measurement, before and after surgery. This is a retrospective analysis with limited echocardiographic measurement. Prospective study with more new parameters will give accurate parameter for predicting best outcome of mitral corrective surgery.

Conclusion

End-diastolic volume and regurgitant volume before mitral corrective surgery showed significant correlation with decreasing LV dimension after surgery, that is make them potential to become echocardiography parameters in predicting better functional outcome after mitral surgery. End-diastolic volume 133,5 ml or more will give better predictive outcome after surgery. Measuring both parameters will be helpful in determine optimal timing of surgery.

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