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Assessment of Mital Valve Regurgitation Severity By Echocardiography in Comparison With Contrast Ventriculography

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Abstract

Background: To date, little is known regarding the correlation between Doppler & angiographic assessment of MR. This study was performed to test the hypothesis that Doppler assessment of MR can predict angiographic consequences of MR.
Objective: to show the exact correlation between Doppler &angiographic methods for the assessment of MR severity.
Type of study: retrospective study
Methods: A retrospective case-control study held in single cardiac center in Baghdad. From May 2017 to May 2018. Fifty patients with chronic organic compensated mitral regurgitation underwent LV angiography and Doppler imaging. The study group consist of (26) men & (24) women with mean age (53.8 ± 10.7) years.
Result: A clear relation existed between measurement of MR jet area by Doppler echocardiography & contrast ventriculography. The maximal jet area by color Doppler for patient with mild MR was less than 20% of LA area correlate with mild MR by LV angiography. Individual jet area for patient with moderate MR ranged from 20 % to 40 % of LA area correlate with moderate MR by LV angiography. Fore patient with severe MR was more than40% of LA area correlate with severe MR by LV angiography. Although overlaps was found between each three groups.
Conclusion: Assessment of MR severity by color Doppler transthoracic echocardiography was clearly correlated with angiographic severity of MR so we can predict the angiographic severity of valve lesion by Doppler study.

Keywords: Mital Regurgitation, Ventriculography.

Introduction

Mitral regurgitation (MR), characterized by the systolic backward flow of blood from the left ventricle into the left atrium, results either from disorders of the valve leaflets (primary / organic MR) or the mitral apparatus due to an altered LV geometry (secondary / functional MR)[1]. The most common finding in degenerative mitral valve disease is leaflet prolapse, caused by elongation or rupture of the chordae tendineae, resulting in leaflet malcoaptation, during ventricular contraction and subsequent MR[2]. Mitral valve prolapse, defined as systolic atrial displacement of the mitral valve by a minimum of 2mm above the mitral annulus, can be an inheritable condition[3].

MR causes sole volume overload to which the left ventricle responds with eccentric hypertrophy and the left atrium dilatation[1]. The degree of MR is defined by the:-

1. Severity of the valvular lesion (corresponding to the effective regurgitant orifice).
2. The resulting volume overload (quantified as the regurgitation volume and regurgitation fraction).
3. The driving force (pressure gradient between the left ventricle and atrium) .
4. The compliance of the left atrium.

Mild and moderate MR are both considered benign, in contrast to severe MR. Morbidity and mortality of the disease is related to the severity of regurgitation, presence of symptom, size of the left atrium, size and function of the left ventricle, as well as development of atrial fibrillation and pulmonary hypertension[4].

Mitral regurgitation may result from disorders of the valve leaflets themselves or from any of the surrounding structures that comprise the mitral apparatus. The leading cause of MR is rheumatic heart disease in developing areas of the world and degenerative forms of MV disease (myxomatous disease and fibroelastic deficiency) in the United States and other developed countries. Less common conditions include mitral annular calcification and congenital anomalies such as cleft MVs; other rare causes of MR are endomyocardial fibrosis, carcinoid disease with right – to – left shunting, ergotamine toxicity, radiation therapy, systemic lupus erythematosus, and diet – drug toxicity. The second leading cause of MR in developed countries is "functional" MR, which results from dilatation of the MV annulus or from myocardial infarction.

In particular, infarctions involving the inferolateral and the posteromedial papillary muscle produce tethering of the mitral leaflets that prohibits normal coaptation, leading to "functional" MR even though the valve leaflets themselves are normal[5].

Patients who develop acute severe MR usually present with symptomatic heart failure because their ventricles are ill prepared to accept the sudden increase in volume load. However, if the patient survives the acute episode or has slowly progressive worsening of MR, the left ventricle is able to develop compensatory changes. Symptoms are therefore either absent or slowly progressive over many years[6].

Although patients with compensated chronic MR may remain asymptomatic for many years, decompensation may eventually develop if the regurgitation is sufficiently severe. The LV ejection fraction in chronic MR may be greater than normal because of the increase in preload and the afterload – reducing effect of ejection into the low – impedance left atrium. Therefore, LV ejection fraction can be misleading as a measure of contractile function in this disorder. Advanced myocardial dysfunction may occur while LV ejection fraction is still well within the normal range [7]. Thus, outcome after MV surgery is poorer in patients with a preoperative ejection fraction of less than 60% than in those with higher ejection fraction[7,8].

The examination of the patient with chronic severe MR varies according to the degree of decompensation. The carotid upstroke is sharp in patients with compensated MR, but the volume of the carotid pulse is reduced in the presence of advanced heart failure[9]. The apical impulse is usually brisk and hyperdynamic; in those with severe chronic MR it may be enlarged and displaced laterally. The S_1 is usually soft, and a widely split S_2 is common. A diastolic rumble and S_3 may be present and do not necessarily indicate LV dysfunction.The systolic murmur of MR varies according to the etiology of the regurgitation. The murmur is usually heard best at the apex in the left lateral decubitus position. With severe degenerative MR, the murmur is holosystolic, radiating into the axilla[10].

Cardiomegaly due to LV and left atrial enlargement is common in patients with chronic MR. In patients with pulmonary hypertension, right – sided chamber enlargement is also a common finding.Kerley B lines and interstitial edema can be seen in patients with acute MR or progressive LV failure[7].

Left atrial enlargement and atrial fibrillation are the most common ECG findings in patients with MR. left ventricular enlargement is noted in approximately one – third of patients, and RV hypertrophy is observed in 15%[9].

Echocardiography is the most commonly used tool to evaluate the patient with suspected MR. It provides information about the mechanism and severity of MR, the size and function of the left and right ventricle, the size of the left atrium, the degree of pulmonary hypertension, and the presence of other associated valve lesions[8]. Doppler evaluation provides quantitative measures of the severity of MR that have been shown to be important predictors of outcome[7,8].

Cardiac catheterization is generally performed to assess the hemodynamic severity of MR when noninvasive testing is inconclusive or a discrepancy exists between clinical and noninvasive finding. Coronary angiography is indicated for patients who are planning to undergo surgery and are at risk of CAD[9].

Accurate grading of regurgitation severity is of utmost clinical importance, but one of the most difficult problems in vulvular heart disease (VHD) mainly due to the lack of a true "gold standard" and the dependence on changing hemodynamic conditions.[11].Echocardiography is currently the first line diagnostic tool for the grading of regurgitation severity and MRI is the second – line diagnostic tool in cases of echocardiographic uncertainty[12]. Regurgitation severity grades, which have historically ranged between three and five grades, are presently, according to a widely accepted consensus, classified into three grades, namely mild, moderate and severe[8].

Echocardiography is currently, as previously mentioned, the first – line diagnostic tool in the evaluation of VHD and uses an "integrative approach" of several qualitative, semi – quantitative and quantitative parameters for the grading of regurgitation severity[8].The assessment of LV linear and volumetric dimensions is an integral part in the evaluation of patients with chronic MR[8]. Although LV dilatation is a hallmark of severe chronic regurgitation and LV volumes are an additional valuable quantitative parameter in the "integrative approach", so far current guidelines include only thresholds for LV linear dimensions indicating severe LV dilatation secondary to severe regurgitation with poor prognosis[13]. MRI provides currently the most exact assessment of LV volumes with high reproducibility and has been validated extensively as a reference method ("gold standard")[8].

Valvular regurgitation can be evaluated by angiography. Angiographic evaluation of regurgitation severity is based on ejection of contrast media into the left atrium, through the affected mitral valve[14]. The severity of regurgitation is graded on a semi quantitative scale of 1+ to 4+.(Table 1).

Table 1: Angiographic grading of regurgitant severity of mitral valve

Grade	Mitral Regurgitation
1+	Contrast refluxes into the left atrium but clears on each beat.
2+	Left atrial contrast density gradually increases but never equals left ventricle density.
3+	The density of contrast in the atrium and ventricle equalize after several beats.
4+	The left atrium becomes as dense as the left ventricle on the first beat and contrast is seen refluxing into the pulmonary veins.

Aim of the study

To show the exact correlation between Doppler &angiographic methods for the assessment of MR severity.

Patients and Methods

Study group (patients): Aretrospective study done on fifty patients with chronic organic compensated mitral regurgitation (MR) admitted to Ibn Al – Bitar center for cardiac surgery from May 2017 to May 2018.

Inclusion criteria were adult age (age ≥ 28 years) and confirmed diagnosis of chronic organic compensated mitral regurgitation. The exclusion criteria were associated other cardiac valve stenosis or regurgitation, intra – cardiac shunt, pregnancy and deteriorated health status.

Methods: The data collection was carried out by the researcher with filling of a prepared questionnaire. The information was taken mostly from patients and some information was taken from their records.

The Questionnaire Included the Following:

1. Demographic characteristics of MR patients: Age and Gender.
2. Causes of MR.
3. Angiography findings.
4. Echocardiography findings.
5. Severity classification of MR.

The enrolled patients underwent Doppler imaging and LV angiography . Commercially availableEcho – Doppler machine (vivid E9. GEM system) used with a standard 5 MHZ transducer was used for study.

Two dimensional image was optimized in each of the two orthogonal planes (parasternal long axis and apical four chamber views)the optimal depth and sector angle capable of measuring entire jet area were used. The gain setting were optimized to the level was just below the point of appearance of color noise artifact. Severity was graded according to ASE guidelines.

Left ventriculograph accomplished for all patients. A pigtail catheter was positioned in LV retrograde from the femoral artery. Left ventriculography was performed with use of non-ionized contrast material. MR was graded on the basis of the Sellar criteria.

Statistical Analysis

The data were analyzed by Microsoft excel program and Statistical Pakage for Social Sciences (SPSS) version 23. Outcome of analysis were arranged in scales variables (means and standard deviation) and in categorical variables. Chi square test was used for comparison between categorical data (Fishers exact test applied when expected variable was less than 20% of total). One way ANOVA analysis was used to compare between more than two means. Linear regression analysis was used to predict the relationship between different variables.

The level of significance (P value) was set as ≤ 0.05.

Results

This study included 50 mitral regurgitation patients with mean age of 53.8 ± 10.7 years; 18% of them were in age group less than 40 years, 12% of them were in age group 40 – 49 years, 38% of them were in age group50 – 59 years, 24% of them were in age group 60 – 69 years and 8% of them were in age group ≥ 70 years. Male patients with MR were more than female patients with male to female ratio as1.1:1. (Table 2.)

Table 2: Demographic characteristics of MR patients.

Variable	No.	%
Age meant SD (53. 8 ± 10. 7 years)		
< 40 years	9	18.0
40 – 49	6	12.0
50 – 59	19	38.0
60 – 69	12	24.0
≥ 70 years	4	8.0
Total	50	100.0
Gender		
Male	26	52. 0
Female	24	48. 0
Total	50	100.0

The angiography findings of MR patients revealed the followings; 28% of patients had mild MR, 22% of patients had moderate MR and 50% of patients had severe MR. (Table 3)

Table 3: Angiography findings of MR patients.

Variable	No.	%
Angiography Findings		
Mild MR	14	28.0
Moderate MR	11	22.0
Severe MR	25	50.0
Total	50	100.0

Mean Regurgitation fraction**(**RF) of MR patients was 49.4 ± 19.8%, 56% of them had severely elevated RF. Mean Regurgitation volume(RV) of MR patients was 56.2 ± 29 ml, 50% of them had severely elevated RV. Mean Venacontracta(VCW) of MR patients was 0.6 ± 0.3 cm, 56% of them had VCW > 7 mm. (i,e sever MR) Mean Regurgitation orifice area(ROA) of MR patients was 0.4 ± 0.2 cm2, 56% of them had severely elevated ROA. Mean Jet area of MR patients was 39.5 ± 21%, 56% of them had severe jet area. Mean LA size of MR patients was 42.5 ± 9.7 mm, 64% of them had dilated LA. (Table 4).

Table 4: Echocardiography parameters of MR patients.

Variable	No.	%
Regurgitation fraction mean ±SD (49.4± 19.8%)		
Mild	14	28.0
Moderate	8	16.0
Severe	28	56.0
Total	50	100.0
Regurgitation volume mean ±SD (56.2± 29 ml)		
Mild	14	28.0
Moderate	11	22.0
Severe	25	50.0
Total	50	100.0
Vena contracta mean ±SD (6.0± 0.3 cm)		
Mild	14	28.0
Moderate	8	16.0
Severe	28	56.0
Total	50	100.0
Regurgitation orifice area mean ±SD (0.4± 0.2 cm^2)		
Mild	14	28.0
Moderate	8	16.0
Severe	28	56.0
Total	50	100.0
Jet area (LA) mean ±SD (39.5 ± 21 %)		
Mild	14	28.0
Moderate	8	16.0
Severe	28	56.0
Total	50	100.0
LA size means ±SD (42.5 ± 9.7 %)		
Normal	18	36.0
Dilated	32	64.0
Total	50	100.0

The echocardiography parameters for MR patients revealed that 28% of patients had mild MR, 16% of them had moderate MR and 56% of them had severe MR. (Table 5)

Table 5: Echocardiography severity of MR patients.

Variable	No.	%
Echocardiography Severity		
Mild	14	28.0
Moderate	8	16.0
Severe	28	56.0
Total	50	100.0

The causes of mitral regurgitation were ischemic heart disease (48%), dilated cardiomyopathy (20%), mitral valve prolapsed (12%), rheumatic heart disease (10%), hypertrophic cardiomyopathy (6%) and connective tissue disease (4%). (Table 6 and Figure 8).

Table 6 : Mitral regurgitation causes.

Variable	No.	%
Causes of MR		
Ischemic heart disease	24	48. 0
Dilated cardiomyopathy	10	20. 0
Mitral valve prolapse	6	12. 0
Rheumatic heart disease	5	10. 0
Hypertrophic cardiomyopathy	3	6. 0
Connective tissue disease24	2	4. 0
Total	50	100.0

No significant differences between MR patients with different severity of angiography findings regarding gender of patients (P = 0.1). (Table 7)

Table 7: Distribution of demographic characteristics according to angiography finding.

variable	MR Angiography Findings						P
	Mild		Moderate		Severe		
	No.	%	No.	%	No.	%	
Age							**0.009** * Significant
< 40 years	3	21.4	3	27.3	3	12.0	
40 – 49 years	0	-	4	36.4	2	8.0	
50 – 59 years	3	21.4	1	9.1	15	60.0	
60 – 69 years	6	42.9	3	27.3	3	12.0	
≥ 70 years	2	14.3	0	-	2	8.0	
Means ±SD (years)	57 ± 10.9		49.1 ± 9.6		55.8 ± 9.4		**0.1** **
Gender							**0.1** * Not Significant
Male	8	57.1	8	72.7	10	40.0	
Female	6	42.9	3	27.3	15	60.0	

*Fishers exact test. ** One way ANOVA. ***Chi – square test.

There were a highly significant association between higher RF mean and severe angiography finding (P < 0.001). A highly significant association was observed between higher RV mean and severe angiography finding (P < 0.001). similarly, there was a highly significant association between higher means of each VCW and Jet area with severe angiography finding (P < 0.001). MR patients with dilated LA were significantly associated with severe angiography finding (P < 0.001). (Table 8)

Table 8: Distribution of echocardiography parameters according to angiography findings.

Variable	MR Angiography Findings						P
	Mild		Moderate		Severe		
	No.	%	No.	%	No.	%	
Regurgitation Fraction							< 0.001 * Highly Significant
Mild	14	100.0	0	-	0	-	
Moderate	0	-	8	72.7	0	-	
Severe	0	-	3	27.3	25	100.0	
Mean ± SD (%)	23.3 ± 1.9		47 ± 11.6		66.8 ± 4		< 0.001 **
Regurgitation Volume							0.2* Not Significant
Mild	14	100.0	0	-	0	-	
Moderate	0	-	11	100.0	0	-	
Severe	0	-	0	-	25	100.0	
Mean ± SD (ml)	22.5 ± 3.9		43.6 ± 6.7		84.7 ± 7.9		< 0.001 **
Vena Contracts							< 0.001 * Highly Significant
Mild	14	100.0	0	-	0	-	
Moderate	0	-	8	72.7	0	-	
Severe	0	-	3	27.3	25	100.0	
Mean ± SD (cm)	0.2 ± 0.001		0.5 ± 0.1		0.8 ± 0.05		< 0.001**
Regurgitation Orifice Area							< 0.001 * Highly Significant
Mild	14	100.0	0	-	0	-	
Moderate	0	-	8	72.7	0	-	
Severe	0	-	3	27.3	25	100.0	
Mean ± SD (cm^2)	0.1 ± 0.001		0.3 ± 0.09		0.5 ± 0.06		< 0.001 **
Jet Area							< 0.001 * Highly Significant
Mild	14	100.0	0	-	0	-	
Moderate	0	-	8	72.7	0	-	
Severe	0	-	3	27.3	25	100.0	
Mean ± SD (%)	12.1 ± 1.8		34.8 ± 4.8		58.8 ± 4.8		< 0.001 **
LA size							< 0.001***
Normal	14	100.0	4	36.4	0	-	
Dilated	0	-	7	63.6	25	100.0	
Mean ± SD (mm)	39.9 ± 1.7		41.1 ± 6.1		49.7 ± 5.3		< 0.001**

*Fisher Exact test, **One Way ANOVA, ***Chi-Square test

There were a highly significant association between patients with severe echocardiography findings and severe angiography findings (P < 0.001); however, 3 patients with severe angiography MR were detected by echocardiography as moderate. (Table 9)

Table 9: Distribution of echocardiography severity according to angiography findings.

Variable	MR Angiography Findings						P
	Mild		Moderate		Severe		
	No.	%	No.	%	No.	%	
Echocardiography Severe							**< 0.001 * Highly Significant**
Mild	14	100.0	0	-	0	-	
Moderate	0	-	8	72.7	0	-	
Severe	0	-	3	27.3	25	100.0	

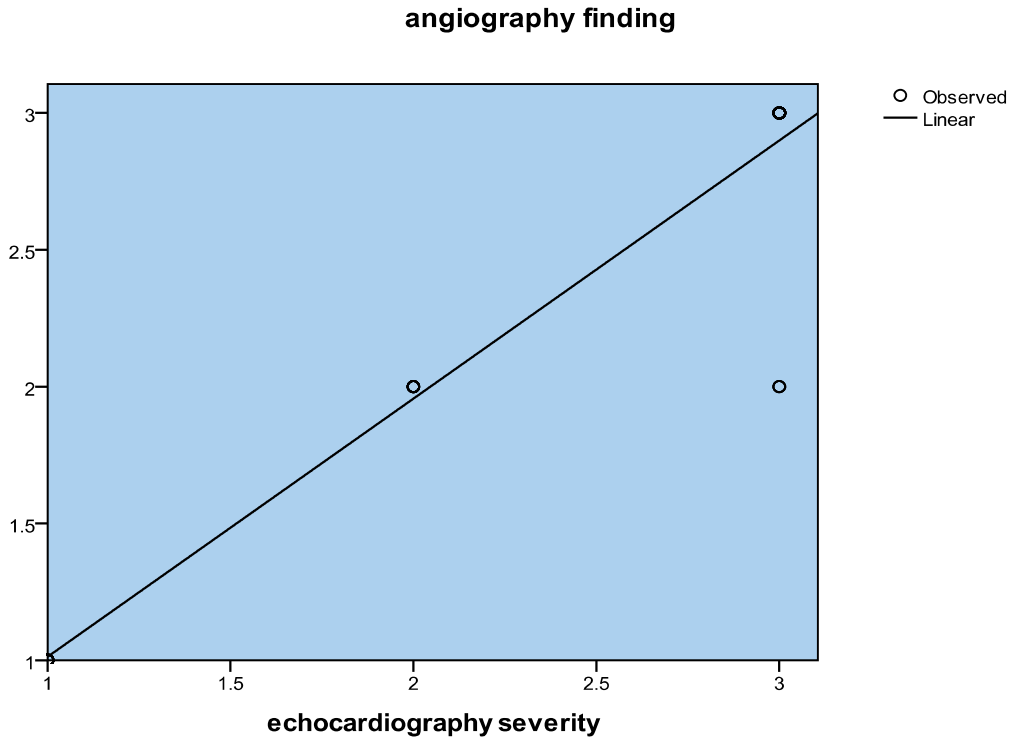

Figure 1: Linear regression of echocardiography and angiography severity.

Discussion

In current study, the echocardiography parameters for patients revealed that 28% of patients had mild MR, 16% of them had moderate MR and 56% of them had severe MR while by left ventriculography, 28% of patients had mild MR 22% of patients had moderate MR and 50% of patients had severe MR.

The study showed a highly significant association between severity assessment of MR by Doppler echocardiography and severity assessment of MR by left ventriculography ($P < 0.001$). this finding is consistent with results of Jacobs et al[15] in USA which revealed that severity findings of Doppler echocardiography was correlated with severity findings of left ventriculography.

In our study, the Doppler echocardiography showed that 3MR patients as severe, while those 3 patients were classified as moderate by left ventriculography. This discordance in severity classification was also reported by Uretsky et al[16] in comparing accuracy of echocardiography and MRI in assessment of MR severity and specifically in moderate category. In Turkey, Fehmi et al[17] study reported that both Doppler echocardiography and left ventriculography were correlated in predicting severity of MR with small difference in moderate severity assessment that might be attributed to difference in difference in regurgitant jet area. Many authors conducted multiple studies examining the validity of echocardiography in severity assessment of mitral regurgitation. The American Heart Association and American College of Cardiology reported that echocardiography is better than left ventrculography for assessing the severity of mitral regurgitation[18] linear regression analysis revealed that the echocardiography severity of MR is a significant predictor for MR angiography severity. ($P < 0.001$), this finding is similar to results of Marechaux et al[19] inFrance which reported that echocardiography is reliable method in severity grading of mitral regurgitation with exception of moderate severity. The current American Society of echocardiography guidelines documented that application of different echocardiography techniques in incorporated approach is needed to acquire most reliable results[20].

Our study showed that causes of mitral regurgitation were ischemic heart disease (48%), dilated cardiomyopathy (20%), mitral valve prolapsed (12%), rheumatic heart disease (10%), hypertrophic cardiomyopathy (6%) and connective tissue disease (4%). These finding are in agreement with results of Roberts et al[21] in USA which documented that the causes of pure mitral regurgitation are multiple but the main causes were ischemic heart diseases, mitral valve prolapse, idiopathic dilated cardiomyopathy, anemia etc. Current study revealed that patients with ischemic heart diseases were significantly associated with severe mitral regurgitation ($P < 0.001$); while patients with dilated cardiomyopathy were significantly associated with mild mitral regurgitation. These finding are similar to results of Pierard et al[22] in Belgium which reported that ischemic mitral regurgitation is commonly severe and always associated with worsen prognosis.

Mean age of studied MR patients was 53.8±10.7 years; there was a significant association between younger age patients and moderate severity MR ($P=0.009$). this finding is consistent with results of Trochu et al[23] study in UK which showed that risk and severity of mitral regurgitation was increased with advanced age of patients.

This study revealed that all echocardiography parameters (regurgitation fraction, regurgitation volume, vena contracta, regurgitation orifice area, jet area and LA size) were accurately prognostic for severity of MR detected by angiography. These findings are similar to Grayburn study in USA[24] and Lancellotti et al[25] in Spain. However, the limitation in echocardiography parameters prediction for MR severity was in moderately severe especially in regurgitation fraction, vena contracta regurgitation orifice area and jet area as 3 (27.3%) MR patients with moderate angiography classification were detected as severe by echocardiography. This finding is similar to results of Lee et al[26] in Canada which found a discrepancy in echocardiography parameters regarding moderate grading of mitral regurgitation severity, but they concluded that Doppler echocardiography based on left ventricular early inflow – outflow index is an accurately diagnostic method for severity categorization of mitral regurgitation.

Conclusion

1. The Doppler echocardiography is an accurate diagnostic imaging technique for categorization of mitral regurgitation severity.
2. The weakness of Doppler echocardiography in severity assessment of mitral regurgitation is in moderate classification.

Recommendations

1. Adapting the Doppler echocardiography as the first line diagnostic method for severity classification of mitral regurgitation with cautions regarding limitation of moderate classification.
2. Further large sized longitudinal studies on severity classification of mitral reguragitation is recommended.

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