ORIGINAL RESEARCH PAPER

Cardiology

EFFECT OF PERCUTANEOUS TRANSVENOUS MITRAL COMMISSUROTOMY ON MITRAL VALVE RESISTANCE INDEX AND ITS ROLE IN ASSESSMENT OF SEVERITY OF MITRAL STENOSIS.

KEY WORDS: Mitral valve resistance index, Pressure half time, Diastolic filling period.

Dr.Kumaran Srinivasan	Assisstant Professor. Institute of Cardiology . Madras Medical College . Chennai.3
Dr. Elamaran Chidambaram	Senior Assisstant Professor. Institute of Cardiology. Madras Medical College. Chennai-3.
Dr.Nambirajan Jayabalan	Senior Assisst Professor . Institute of Cardiology. Madras Medical College. Chennai-3.
Dr.Justin Paul Gnanaraj	Professor . Institute Of Cardiology. Madras Medical College. Chennai-3.
Dr.Swaminathan Nagarajan	Director & Head of Department. Institute of Cardiology. Madras Medical College.Chennai-3

ABSTRACT

Objective: To assess the effect of Percutaneous trans venous mitral commissurotomy (PTMC) on mitral valve resistance index in patients with mitral stenosis and its role in assessment of severity by transthoracic echocardiogram.
Materials and methods: This is a single centre prospective observational study carried out on 20 patients for one year between 2015-2016 at Institute of cardiology,Madras Medical College, Chennai. Patients with isolated severe Rheumatic mitral stenosis were chosen for the study. Mitral valve resistance index using transthoracic echo pre and post PTMC derived .Its role as adjunctive tool in evaluating mitral stenosis severity was analysed.
Results: Out of 20 patients with severe mitral stenosis suitable for PTMC were aged between25 to 45 years. Females out numbered males. Mitral valve area increased from 1.0 to1.5 as measured by planimetry. Mean stroke volume increased by 20%. Mitral valve resistance diminishes from 182 Dynes.cm-^{5} to 74 Dynes.cm-^{5}. Mitral valve area and resistance are inversely related and found to be statistically significant with P value0.001.
Conclusion: Mitral valve resistance index correlates with severity of mitral stenosis and it is inversely related to mitral valve area. It can be an alternative tool in assessment of severity apart from conventional echo parameters. Mitral valve resistance index is the strong predictor of systolic pulmonary artery pressure both before and after balloon valvotomy.

Introduction:

Rheumatic heart disease is a common cardiac ailment in developing countries with greater morbidity and mortality which can be preventable. Echocardiography is an important non invasive, cost effective investigation to assess valvular heart disease. Assessment of severity of mitral stenosis by echocardiography utilizes many parameters using 2D ECHO, M-Mode and Doppler methods. Routine methods include mitral valve area assessment by planimetry and pressure half time method, mean and peak gradients with Bernoulli's equation and mitral valve separation index. In most clinical situations functional and hemodynamic status of the valve lesions decide modality of treatment. In a given mitral valve orifice area, different hemodynamic profiles are present. Mitral valve resistance index is an important tool which describes mitral stenosis in physiological terms. If it is added to other parameters which are anatomical can give a fool proof ECHO assessment of mitral valve. By measuring mitral valve resistance index pre and post Percutaneous Transvenous Mitral Commisssurotomy along with other ECHO parameters make the evaluation more complete . Mitral valve reistance index is measured by MVR= TMMG/QX1333 where TMMG-Transmitral mean gradient, Q-Trans mitral flow rate and 1333 is used to convert resistance into dynes.cm-5. Q is calculated by expression of stroke volume in terms of diastolic filling period. Since mitral valve resistance index incorporates both duration of trans mitral flow and quantity of blood flow across the valve, it negates the disadvantage faced by other parameters like pressure gradients. The hemodynamic burden of mitral stenosis is reflected by pulmonary artery pressure and the symptoms of stenotic lesions closely parallel the magnitude of pulmonary arterial hypertension. Simultaneous measurement of pulmonary artery pressure using Doppler estimation of systolic pressure gradient between right atrium and right ventricle, gives the hemodynamic burden of mitral stenosis.

Material and Methods:

This is a prospective observational study at Institute of Cardiology Madras Medical College for a period of one year between December 2015-2016 carried out on 20 patients with severe Rheumatic Mitral Stenosis who are eligible and agreed to undergo PTMC. Necessary pre and post procedure biochemical , radiological and ECHO assessment were done. Patients with adequate tricuspid regurgitant jet for systolic pulmonary artery pressure calculation before and after PTMC were selected. Patients with left atrial thrombus, more than mild mitral regurgitation and involvement of aortic valve were excluded in the study. Coronary artery disease requiring revascularization, poor echo window, critically ill patients were not enrolled. Echocardiography was performed by single operator to avoid inter observer bias, using Philips HD 7 instrument in left lateral position with 3.5 MHz transducer and is capable of M-Mode,2 D and Doppler study. Echocardiographic examinations carried out prior and 72 hours after PTMC. For all patients in sinus rhythm three measurements and in patients with atrial fibrillation minimum of five measurements were taken in 2 D and Doppler methods.

In order to avoid confounding factors influence, the patients with wall movement abnormalities were excluded for calculating stroke volume. The stroke volume was measured using product of cross sectional area and velocity time integral of left ventricular outflow tract in apical 5- Chamber view. Left atrial diameter with maximum value was taken in para sternal long axis view. Mitral valve area by planimetry was measured in para sternal short axis view with adjusted gain settings. Mitral valve area by pressure half time was calculated using continuous Doppler with optimum velocity spectral contour. In case of bimodal spectrum, we measured from mid systole. We specifically avoided concave shaped slopes in mitral jets for the estimation of pressure half time. We have measured both mean and peak gradients across the mitral valve using continuous wave doppler and diastolic filling period with pulse wave Doppler. Pulmonary artery systolic pressure was estimated by using tricuspid regurgitation jet and right ventricular systolic pressure was calculated using Bernoulli's equation.

Mitral valve resistance Index was calculated as explained previously using the formula **MVR=TMMG/QX1333**, where MVR-Mitral valve resistance index, TMMG-Trans mitral mean gradient, Q-Trans mitral flow rate,1333 is a constant for conversion to Dynes .cm-5. Trans mitral flow rate was derived by using formula **stroke volume/Diastolic filling period.** All these parameters were calculated before and after 72 hrs of Balloon mitral commissurotomy.

Results and analysis : The following baseline variables were analysed in our study.

Table-1:- Baseline variables before PTMC.

S.No	Variables	Minimum	Maximum	Mean	Std Deviation
1	Age	25	45	32.6	6.021
2	MVA(P) in mmHg	0.70	1.40	1.020	0.2015
3	MVA(PHT) in cm2	0.70	1.50	1.065	0.23680
4	Mean gradient(mmHg)	8.9	21.0	14.97	3.352
5	LVOT VTI[cm]	17.700	28.200	20.940	3.3443
6	LVOT diameter[mm]	16	21	17.80	1.673
7	Stroke volume[ml/s]	35.5	96.0	52.175	14.1340
8	DFP[msec]	282	556	440.00	62.790
9	PASP[mmHg]	39	96	58.75	15.099
10	VRI [Dynes.cm-^{5}]	34.5	331.0	182.475	68.5138

MVA(P): Mitral valve area by planimetry, MVA(PHT):Mitral valve area by pressure half time, LVOT: Left venricular outflow tract, VTI: Velocity time integral, DFP: Diastolic filling period, PASP: Pulmonary artery systolic pressure. VRI: Valve resistance index.

Finally 20 patients of mitral stenosis who were eligible for balloon valvotomy have undergone routine echocardiogram. Examined patients were aged from25-45 yrs with mean age of32.6 as observed in table -1. Female patients out numbered male patients.

Table 2: Descriptive status of ECHO parameters after PTMC.

S.No	Variables	Minimum	Maximum	Mean	Standard deviation
1	Left atrial diameter	2.5000	4.8000	3.975000	0.59725
2	MVA(P)	1.2	2.0	1.590	0.2315
3	MVA(PHT)	0.600	2.500	1.6500	0.44662
4	Mean gradient(mmHg)	3.2	11.0	7.3	1.7
5	LVOT VTI (cm)	18.7	29.0	23.485	3.3700
6	LVOT Diameter(mm)	16.0	22.0	18.515	2.0035
7	Stroke volume(ml/sec)	41.0	111.0	64.240	15.9042
8	DFP(msec)	267	580	432.55	80.401
9	PASP(mmHg)	36	71	49.40	10.323
10	MVR(dynes.cm-5)	14.000	172.000	74.04500	35.3463

MVA(P): Mitral valve area by planimetry, MVA(PHT): Mitral valve area by pressure half time, LVOT: Left ventricular outflow tract, VTI: Velocity time integral, DFP: Diastolic filling period, PASP: Pulmonary artery systolic pressure.MVR: Mitral Valve resistance index.

The mean left atrial diameter measured in para sternal long axis in patients before and after PTMC were 4.8±0.61 and 3.9± 0.59 respectively. The mean mitral valve area measured by planimetry before and after valvotomy were 1.02±0.2 and 1.5±0.23 respectively. Similarly the mean mitral valve area by pressure half time before and after PTMC was 1.06±0.23 and 1.65±0.64 respectively. The mean gradient declined from baseline value of 14.9±3.3 to 7.3±1.7 which denotes 50% drop in gradient across mitral valve.

The stroke volume calculated by continuity equation before and after commissurotomy have shown significant differences such as, the mean value of stroke volume were 52±14 ml/sec and 62±16 ml/sec nearing 20% increase. Pulmonary artery systolic pressure estimated by tricuspid regurgitation jet had a mean value of 58.75±15 which subsequently after valvotomy decreased to 49±10.3.

Table 3: ECHO Characteristics of mitral stenosis before and after PTMC.

S.No	Variables	Pre PTMC (mean)	Post PTMC (mean)	P value
1	Left atrial diameter(cm)	4.8	3.9	0.17
2	MVA(P) in cm^{2}	1.02	1.59	0.001
3	MVA (PHT) in cm^{2}	1.06	1.65	0.001
4	TMMG in mmHg	14.9	7.3	0.000
5	Stroke volume (ml/s)	52	64	0.001
6	PASP (mmHg)	58.7	49.4	0.002
7	MVR(dynes.cm-^{5})	182	74	0.001

Mitral valve resistance index declined after valvotomy from 182 to 74 dynes.cm-5 which is significant as suggested by p-value of 0.001.

Table-4: Correllation of systolic Pulmonary artery pressure and other echo variables. r- Pearson co -efficient and p-denotes significance before PTMC.

S.No.	Variables	r	p
1	Stroke volume (ml/sec)	-0.273	0.001
2	Left atrial diameter	-0.008	0.973
3	MVA(P)	-0.602	0.001
4	MVA(PHT)	-o.697	0.005
5	TMMG(mmHg)	0.607	0.013
6	MVR(dynes.cm-5)	0.647	0.001

Table-5: Correlation of systolic Pulmonary arterial pressure and other echo parameters after PTMC.

r- Pearson co- efficient and p- denotes significance before PTMC

S.No	Variables	r	p
1	Stroke volume(ml/s)	-0.418	0.140
2	Left atrial diameter	-0.154	0.518
3	Mitral valve area(planimetry)	-0.613	0.004
4	Mitral valve area(Presure half time)	-0.519	0.019
5	TMMG(mmHg)	0.519	0.019
6	MVR(dynes.cm-5	0.553	0.014

Using spearman's analysis, pulmonary systolic pressure was analysed with mitral valve resistance index, there is independent correlation between pulmonary artery systolic pressure and mitral valve resistance as evidenced by highest r value 0f 0.553 and a P value of 0.014. Hence it independently correlates with mitral valve resistance.

Independent association of severity of Pulmonary artery systolic pressure (PASP) and Mitral valve resistance index is well established by multivariate analysis done before and after balloon mitral valvotomy.

Table 6: Multivariate analysis of valve resistance with PASP as dependant variable before PTMC.

Model	Un standardized co - efficients		Standardized co - efficients	t	Sig
	B	Std error	Beta		
Constant	36.758	8.450		4.350	0.000
VR	0.121	0.043	0.547	2.771	0.013

Dependant variable - PASP. VR - Valve resistance.

Table-7: Multivariate analysis of valve resistance with PASP as dependant variable, after PTMC.

Model	Un standardized Co- efficients	Standardised Co -efficients	t	Sig	
	B	Std.Error	Beta		
Constant	37.444	4.685		7.993	0.000
VR	0.161	0.057	0.0553	2.815	0.011

Dependant variable- PASP. VR- Valve resistance.

As shown in table 6 and 7, it enable us to understand the mitral valve resistance as the independent determinant of pulmonary artery pressure as the β value 0.547 and 0.553 before and after balloon commissurotomy respectively.

Discussion:
This study demonstrates that mitral valve resistance is the most important and independent predictor of PASP in patients with mitral stenosis both before and after balloon mitral valvotomy. Elevated PASP is the major hemodynamic consequence of mitral valve obstruction causing the debilitating symptoms, dyspnea and poor exercise tolerance. The major trigger factor for increased PASP, in mitral stenosis is the retrograde transmission of increased left atrial pressure to the pulmonary circulation, resulting in passive pulmonary hypertension [1,2]. The results of this study demonstrate that the functional or physiological severity of mitral valve obstruction is better reflected by mitral valve resistance rather than mitral valve area by planimetry or pressure half time method.

Our study demonstrates that the valve resistance is an indep endent determinant of pulmonary artery pressure as evidenced by multivariate analysis with β value of 0.547 and 0.553 and p- value of 0.001 and 0.014 before and after mitral valvotomy respectively. As the hemodynamic consequences of mitral stenosis are primarily determined by severity of pulmonary hypertension, valve resistance can be an important adjunct to routine echo evaluation of stenosis.

It is well known that as valve narrowing worsens, pressure gradient increases but pressure gradient also depends on both the amount of blood flow through the valve and the heart rate. Hence taking into account both the factors mentioned above, valve resistance can estimate severity of stenosis with accuracy. It is a expression of the relation of trans valvular gradient to trans valvular flow across a stenotic valve[3]. Valve resistance had been suggested and validated as index of stenosis , long years back[4,5],but it did not gain much importance. Later studies, however clearly demonstrated that valve resistance was in fact flow dependant[6]. But Ford et al [3] considered valve resistance as a stenotic index due to its accuracy in expressing hemodynamics and the impact of stenosis than valve area, despite being flow dependant. The result of this study validates the suggestion of Ford et al in respect to mitral stenosis. Particularly, mitral valve resistance index was more accurately reflecting the hemodynamic burden of mitral stenosis than mitral valve area and transmitral gradient, because of its correlation with resting and stress pulmonary artery pressure. Similar results were also observed by Weitzel et al[7] who also determined mitral valve resistance index as the important independent predictor of resting PASP in large group of patients with mitral stenosis. They also have established that mitral valve resistance was independently affected by degree of structural damage of valve, which is potentially a contributor to obstructive effect of stenotic valve other than its area.

Mitral valve area by planimetry and pressure half time and the mean trans mitral gradient are commonly employed for assessment of severity of mitral stenosis8.Different methods used for MVA evaluation have their own well established intrinsic and technical disadvantages [9,10,11,12]. Mean gradient is considered as a good tool for estimation of severity of mitral stenosis but hampered by flow dependency and diastolic filling period. In case of severe pulmonary hypertension with severe narrowing, mean gradient may not increase due to reduction in flow through the valve. In our study it is clearly evident, that there is strong correlation between valve resistance index and systolic pulmonary artery pressure after 72 hrs of balloon mitral valvotomy as indicated by pearson's r was 0.547 with significant p value. Correlation between mitral valve stenotic severity and valve resistance also established in our study.

Limitations :
Small sample size and atrio ventricular compliance was not addressed in this study as it may also affect resting systolic Pulmonary artery pressure.

Conclusion:
Mitral valve resistance correlates with severity of stenosis. Mitral valve resistance index inversely proportional to mitral valve area. It is an independent predictor of systolic pulmonary artery pressure both before and after mitral valvotomy. Because of the inherent limitations of conventional echo parameters in evaluation of mitral stenosis, valve resistance can be an adjunctive tool in assessment of severity. Among the other conventional echo indices, trans mitral mean gradient better correlates with hemodynamic status than mitral valve area.

Conflict of interest .Nil.

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