

Assessment of Left Ventricular Function by Doppler Velocity Tissue Imaging of the Mitral Annulus in Patients with Mitral Stenosis before and after Percutaneous Transvenous Mitral Commissurotomy

Neil D. Erguiza, MD; Edwin S. Tucay, MD; Viannely Berwyn Flores, MD; Romeo J. Santos, MD; Raul D. Jara, MD.

Background --- Several methods of assessing the post-PTMC cross-sectional area of the mitral valve by echocardiography in patients with rheumatic mitral stenosis are limited by several factors. Tissue Doppler imaging, a new echocardiographic technique that is being used for to evaluate LV function, eliminates some of the limitations that are encountered with the conventional methods. This study is aimed to determine if there is significant improvement in the mitral annular peak velocity after PTMC and if the change(s) is/are correlated with the planimeterized mitral valve area (MVA).

Methods --- Patients with mitral stenosis (MS) in Sinus Rhythm who underwent PTMC from June 01, 2006 to January 15, 2007 were included in the study. Transthoracic Echocardiogram (TTE) and Transesophageal Echocardiogram (TEE) were performed within 24 hours before PTMC. Repeat TTE were performed within 48 hours after the procedure. Tissue Doppler velocities were taken from the lateral and septal annuli during ejection, early diastole and late diastole. Changes between the pre-PTMC values and post- PTMC values were then correlated.

Results --- A total of 14 patients who underwent PTMC were included in the study. There is attenuation of all the echocardiographic parameters after PTMC. Among the annular velocities measured, significant improvement is observed only in lateral Sm and Em post PTMC, (p-value 0.011, 0.025). Also, no significant correlation was noted between pre- and post PTMC annular velocities with MVA by planimetry, (ejection: $r=0.30$; $p=0.285$; early diastole: $r=0.28$; $p=0.329$).

Conclusion --- There is a significant improvement in lateral Sm and Em post PTMC. There is a trend towards good correlation between the noted improvement in the peak velocities and the change in mitral valve area (MVA) by planimetry. *Phil Heart Center J* 2007; 13(2):89-91.

Key Words: Mitral Valve Area ■ Percutaneous Transvenous Mitral Commissurotomy ■ Doppler Tissue Imaging

Mitral stenosis, a known sequela of Rheumatic Heart Disease, is brought about by structural changes in the mitral valve apparatus consisting of the valve itself and its associated structures such as the annuli, chordae, papillary muscles and the subvalvular apparatus.

Previous studies have shown that pure MS impairs left ventricular performance.⁵ In approximately 15% of patients with isolated MS, the left ventricular end diastolic volume is reduced while the ejection fraction and other ejection indices of systolic performance is below normal in 25%.⁹ This deterioration of LV performance may be a result of functional factors. Functional factors result from restriction due to adhesion of the thickened and immobile mitral valve apparatus to the ventricle. In a study done by Lee et al, the majority of patients with deteriorated LV ejection fraction recovered after PTMC. The improvement of LVEF indicates that the deterioration of performance

is primarily a result of functional restriction which was attenuated after the PTMC. Tissue Doppler imaging (DTI), a new echocardiographic technique that is now being used to evaluate the LV function,³ measures myocardial velocities. Because of this, limitations such as unsatisfactory imaging quality are eliminated. One of its applications is the evaluation of LV function by measuring the mitral annular velocity along its long axis. The major advantage of pulsed wave annular velocity measurements is the ultrasound beam being parallel to the ventricular contraction. It is also non-invasive and repeatable.⁶

The first study using DTI in the evaluation of LV functions in patients with severe MS were done by Ozdemir et al. Their study had shown that myocardial velocities obtained from LV wall annuli were found to be significantly lower in patients with MS.

PTMC is an established technique for managing

Accepted paper for PHC 15th Annual research Paper Competition 2007 and for 38th PHA Annual Convention held on May 16-18, 2007 at Edsa Shangrila Hotel, Philippines

Correspondence to Neil D. Erquiza, M.D. Division of Adult Cardiology, Philippine Heart Center, East Avenue, Quezon City, Philippines 1100 Available at <http://www.phc.gov.ph/journal/publication> copyright by Philippine Heart Center and H.E.A.R.T Foundation, Inc., 2007 ISSN 0018-9034

MS.⁷ Several methods of assessing the procedural outcome are being used. These include the measurement of cross-sectional area by two dimensional planimetry and/or using the flow dependent parameters such as pressure half time, continuity equation and PISA. Since the flow dependent parameters are relatively inaccurate after PTMC, 2D planimetry is used as the non-invasive standard. However, this method also has technical limitations because it requires optimal image quality and that the operator must have a certain level of expertise tracking the mitral orifice, especially after PTMC when the orifice has assumed an unpredictable geometry. Aside from this, the change in the area of the orifice does not reflect the changes in the entire mitral valve apparatus' geometry and function. In the only study of patients with MS pre- and post-PTMC done by Sengupta et al, evaluation of changes in mitral annular velocities by Doppler tissues imaging aids clinical assessment of immediate improvement in left ventricular function after PTMC.¹ In the Philippine Heart Center where 50 to 60 PTMC procedures are done yearly,⁴ DTI could help in the assessment of LV function in patients with MS after PTMC. Improvement in the myocardial velocities immediately after PTMC could explain the role of functional factors. This study was done to determine if there is significant improvement in the mitral peak annular velocity after PTMC and whether this improvement correlates well with the changes in planimeterized mitral valve orifice area. This is the first descriptive study that was done in this institution.

Methods

This is an observational study involving patients 18 years of age or older with pure MS in sinus rhythm who underwent PTMC at the Philippine Heart Center from June 01, 2006 to January 15, 2007. Excluded were patients with past interventions of the mitral valve such as close or open valvotomy and past PTMC, presence of co-morbidities such as hypertension, diabetes mellitus, coronary artery disease, pericardial disease and reactivation.

Echocardiographic evaluations were performed 1 to 24 hours before PTMC and 48 to 72 hours after the PTMC. The studies were performed by two operators. The following echocardiographic Tissue Doppler Imaging (DTI) protocol was used. The mitral annular velocities in the lateral and septal corners of mitral annulus were measured during ejection time, early diastole and late diastole. The procedure was performed using standard apical views with a sector angle of <60 degrees. The spectral Doppler signal filters were adjusted to obtain Nyquist limits of -60 and +60 cm/sec, with the lowest wall filter settings and the minimal optimal gain, to eliminate the signals produced by transmitral flow. The peak annular velocities were averaged over 2- 3 heartbeats.

Statistical Analysis

Data was reported as mean and standard deviation. Student t-test was used to compare echocardiographic variables before and after PTMC. $P < 0.5$ was considered significant. Correlation study between the changes in peak mitral velocities and MVA by planimetry was done.

Results

The table below shows that there is attenuation of all the echocardiographic parameters after PTMC. However, on statistical analysis, the ejection fraction (EF), Pulmonary Artery Pressure (PAP), all of the peak annular velocities taken from the septal annulus and the peak annular velocity from the lateral annulus during late diastole did not show significant improvement. Among the annular velocities measured, only the change in the peak annular velocities from the lateral annulus during ejection and early diastole are statistically significant. When the difference in mitral peak velocities from the lateral wall in ejection and early diastole pre- and post- PTMC was compared with the difference between the pre and post- PTMC MVA by planimetry, no significant correlation was noted. (ejection: $r=.30$; $p=0.285$; early diastole: $r=0.28$; $p=0.329$).

Table 1. M-mode, 2-Dimensional and Doppler tissue Echocardiography findings in patients with mitral stenosis before and after PTMC

Features	Pre PTMC (n=14)	Post PTMC (n=14)	P value
MVA-2D PLN (cm ²)	0.801 ± .18	1.63 ± .22	0.000 *S
MVA by PHT	0.839 ± .14	1.78 ± .63	0.000 *S
Mean MVG	12.977 ± 5.49	4.84 ± 1.69	0.000 *S
PAP	50.778 ± 36.53	35.44 ± 18.80	0.067
Ejection Fraction	62.727 ± 5.76	66.00 ± 4.96	0.139
Lateral Wall			
Sm* (m/sec)	0.114 ± .026	0.13 ± 0.33	0.011 *S
Em†	0.133 ± .037	0.15 ± 0.04	0.025 *S
Am‡	0.111 ± .034	0.13 ± .041	>.05
Septal Wall			
Sm* (m/sec)	0.119 ± .029	0.13 ± .030	0.221
Em†	0.124 ± .026	0.14 ± .052	0.256
Am‡	0.094 ± .019	0.11 ± .030	0.058

*Sm= peak annular velocity of systolic excursion in ejection

†Em= peak annular velocity in early diastole

‡Am= peak annular velocity in late diastole

Discussion

Previous studies have shown that in about ¼ of patients with pure MS, the systolic performance is under a normal level. This deterioration in LV performance may be a result of functional and myocardial changes.¹ Functional factors result from extension of the scarring process from the mitral valve into adjacent mitral valve apparatus. Myocardial factors may result from rheumatic changes in the myocardium itself and from structural adaptations like cellular atrophy in response to hemodynamic derangements such as decrease in preload. Tissue Doppler imaging is a relatively new

method used for quantification of systolic and diastolic myocardial function. The first study where pure MS was evaluated by DTI had shown that the myocardial velocities of the left ventricle were found to be significantly lower in patients with pure MS as compared to the healthy individuals.² Later, a study was done by Sengupta et al in patients who underwent PTMC had shown that evaluation of changes in mitral annular velocities by Doppler Tissue Imaging aids in clinical assessment of immediate improvement in left ventricular after PTMC.¹ In our study, we found improvement in most of the peak annular velocities. On statistical analysis, we noted significant improvement of the peak annular velocities of the lateral annulus in ejection and early diastole. This increase in mitral annular velocities could be explained by the rapid reversal of the increased myocardial stiffness and improved motion and function of the subvalvular structures and myocardial segments brought about by mobilization of the mitral valve apparatus after PTMC.⁸ The more prominent changes in the lateral annulus as compared to that in septal annulus can be explained by abnormal right and left sided heart interaction, which are likely to be more pronounced in the septum.

When the difference in mitral peak velocities from the lateral wall in ejection and early diastole pre- and post-PTMC was compared with the difference between the pre and post- PTMC MVA by planimetry, no significant correlation was noted.(ejection: $r=0.30$; $p=0.285$; early diastole: $r=0.28$; $p=0.329$). The study done by Sengupta MD et al showed significant correlation between the improvement in peak annular velocity in early diastole and the MVA by planimetry.¹ That study however included more number of patients. The paucity of sample population in our study possibly could have affected the correlative study.

Conclusion

There is a significant improvement in lateral Sm and Em post PTMC. This has confirmed that the functional change in LV myocardium is partly reversible.. Its use in the assessment of outcome of PTMC could be helpful especially in cases where limitations of the conventional echocardiographic methods are apparent. There is a trend towards good correlation between the noted improvement in the peak velocities and the change in mitral

valve area (MVA) by planimetry. Additional sample population should be included for further evaluation of the correlation between the changes.

Acknowledgement

The author would like to thank Mrs. Mercy Parazo and Mrs. Celia Aliño of the Division of Preventive Cardiology of the Philippine Heart Center for the assistance in the statistical analysis of the paper as well as Ms. Ayin Senga, RMT and Mrs. Ethel May de Vera, RMT of the Department of the Non- invasive laboratory of the Philippine Heart center for the assistance in gathering the echocardiographic parameters needed.

References

1. Sengupta PP, Jagdish C, et al. Effects of Percutaneous Mitral Commissurotomy on Longitudinal Left Ventricular Dynamics in Mitral Stenosis: Quantitative Assessment by Tissue Velocity Imaging. *J Am Soc Echocardiogr* 2004;17:824-8.
2. Ozdemir K, Altunkeser BB, Gok H, Icli A., Temzhan A. Analysis of Myocardial Velocities in patients with Mitral Stenosis. *J Am Soc Echocardiogram* 2002;15: 472-8.
3. Sohn DW, Chai IH, Lee DJ, Kim HC, Kim HS, Oh BH, et al. Assessment of Mitral Annulus Velocity in Doppler Tissue Imaging in the evaluation of left ventricular diastolic function. *Am J Cardiol* 1996; 77:979-84.
4. Dino DA, Fortuno A. The Percutaneous Transvenous Mitral Commissurotomy Registry: The Philippine Heart Center Experience, a 5 year review (1999-2003). Philippine Heart Center Office of Education and Research 2004.
5. Goto S, Hinda S, Akaishi M, Abe S, Ogawa S. Left ventricular ejection performance in mitral Commissurotomy. *Am J Cardiol* 1992; 69: 233-7.
6. Hill J, Palma R., Doppler Tissue Imaging for the Assessment of Left Ventricular Diastolic Function: A Systemic Approach for the Sonographer. *J Am Soc Echocardiogr* 2005;18:80-90.
7. Yap G., Pascual AC, Pineda RM. Long term follow up after Transvenous Mitral Commissurotomy with a high valve score: The HC Experience. Philippine Heart Center Office of Education and Research 2004.
8. Mayer I., et al. Reversal of increased diastolic stiffness in Mitral stenosis after Successful Balloon Valvuloplasty. *J Heart Valve Dis* 1999;8:47-56.
9. Bonow R., Braunwald E. Braunwald's Heart Disease. A textbook of Cardiovascular Medicine. 7th edition. Chapter 57