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Assessment of Mitral Regurgitation, Multimodality Imaging and Review of Literature

Altaf Rashad Ashour
MBBCh , MS cardiology, Egypt
Email - altafrashad@hotmail.com

1. INTRODUCTION:

Mitral regurgitation is a valvular common cardiac disease and is the 2nd most common indication for valvular heart surgery among countries of the west. About '9'% of the population aged over 75 years old within the United states have mitral regurgitation. Heart imaging is significant for making diagnosis, determining the disease's cause, monitoring progression of the disease, as well as planning the definitive treatment modality for mitral regurgitation.

Mitral regurgitation is subdivided classically to primary mitral regurgitation, because of structural or degenerative mitral valve abnormalities, or secondary mitral regurgitation that takes place as a result of cardiac other diseases, as dysfunction of left ventricle but, firstly, with no structural abnormalities of mitral leaflet. Because of the more prevalence of cardiac ischemic disease, the secondary mitral regurgitation is more common than primary valvular diseases, it takes place among about 1/4 of the patients after myocardial infarction, and reaching ½ the patients having heart failure, dysfunction of left ventricle, as well as cardiomyopathy. (1)

Occurrence of secondary mitral regurgitation makes the prognosis worse and had only few treatment options, as repair or replacement of mitral valve, are present in context of symptomatic and severe mitral regurgitation. But, it's still unclear which choice offers the ideal outcomes among that population, particularly due to that repair of mitral valve is related to a greater rate of post-surgery recurrence of significant mitral regurgitation.

A full hemodynamic and anatomical evaluation of the mitral valve and left ventricle is significant for improving management as well as making of decisions among that population. Our review examines the manner by which the multi-modality imaging method could be used and affect the management as well as making of decisions among patients having mitral regurgitation. The valuableness and current advances within echocardiography, cardiac magnetic resonance imaging, in addition to cardiac computed tomography as well as positron emission tomography scan will be discussed.

2. LITERATURE REVIEW:

Assessment of severity of Mitral Regurgitation:

The significant relation between severity of mitral regurgitation and its outcomes concerns on the evaluation of severity of mitral regurgitation as a main part for clinical work as well as making of decisions among patients having mitral regurgitation. The updated current guidelines from the 'American Echocardiography Society' suggest an integrated method involving semi-quantitative quantitative, as well as qualitative techniques for determining the extent of secondary mitral regurgitation, eventually classified as severe, moderate, and mild. (2)

The methods of color Doppler are the commonly most used for quantifying mitral regurgitation and involve the evaluation of the jet area to area of the left atrium ratio of the distal mitral regurgitation, the width of the vena contracta as well as the isovolumetric proximal surface area for deriving effective regurgitant orifice area, volume, and fraction.

In accordance to the updates of 2017 of the 'American Echocardiography Society' and American Heart Association /American College of Cardiology guidelines, the used cut-offs for determining severe mitral regurgitation among patient having secondary mitral regurgitation are recently the same to the used ones for primary mitral regurgitation, mitral regurgitation jet area/left atrium area ratio more than 50%, width of vena contracta equals to or more than '0.7' cm, effective regurgitant orifice area equals to or more than '0.40' cm^2, regurgitant volume equals to or more than '60' mL, as well as regurgitant fraction equals to or more than '50'%. But, many factors are capable of limiting the assessment reliability of mitral regurgitation severity, utilizing the methods of color Doppler, as loading circumstances, multiple or eccentric non-holosystolic jet of mitral regurgitation, non-hemispherical isovelocity proximal surface area, as well as regurgitant non-circular orifice. (3)

All the universal guidelines suggest quantitative approaches, that assess the regurgitant volume, fraction, as well as the effective regurgitant orifice area, as those seem to possess more accuracy. Quantitation depends on hydro-dynamic values that depend on the blood non-compressibility and the mass principle's conservation. Flow could be assessed as 'flow = (area of the vessel) multiplies (mean blood velocity)'.

Geometrical assumption principles are utilized for measuring 3 indicative parameters of severity of mitral regurgitation, which are effective regurgitant orifice area, that is the mean systolic regurgitant orifice's area, an estimate of severity of the lesion, in addition to mitral regurgitant volume, that is the regurgitated volume in every systole, an estimate of overload absolute volume, besides to mitral regurgitant fraction, which is the % of the overall left ventricular stroke volume presented by the regurgitant volume, an estimate of overload relative volume. (4)

3. For deriving the quantitative parameters of severity of mitral regurgitation, echocardiography utilities those validated 3 methods:

- In pulsed wave Doppler, regurgitant volume is assessed as the difference between aortic and mitral stroke volume, regurgitant fraction is observed as the regurgitant volume ratio to stroke volume mitral valve, and effective regurgitant orifice area as the regurgitant volume ratio to the regurgitant index of jet velocity time.
  In the stroke volume assessment, both annular area of mitral valve and left ventricular outflow tract are expected to be geometrically circular. Incorrect measurements of diameter will lead to significant errors because the value have to be squared for generating the cross-sectional area. (5)
- Within the volumetric technique, regurgitant volume is assessed as the difference between stroke volume of left ventricle as well as stroke volume of aorta. The possible pitfall of that technique is underestimation of true volume of the left ventricle, so in turn underestimating severity of regurgitation. The usage of 3-Dimensional echocardiography may enhance the accuracy of determinations of volume of the left ventricle. (6)
- Within proximal isovelocity surface area, that method concerns on the convergence of flow proximal to regurgitant orifice as stated with color-flow imaging, in which radius of proximal isovelocity surface area of the zone of convergence could be derived. Flow within the zone of convergence is believed to be equal to the flow within regurgitant orifice. The usage of continuous wave Doppler of the mitral regurgitation jet enables assessment of the effective regurgitant orifice area as well as the regurgitant volume. (7)

➢ **Echocardiography:**

Echocardiography is the primary method for evaluation and diagnosis of patients having mitral regurgitation, transthoracic as well as transesophageal echocardiography have complementary actions. Transthoracic echocardiography is used mainly for hemodynamic assessment as regurgitations of valves, pressure of the pulmonary artery, and stroke volume, etc., besides to assessment of atrial and ventricular function and geometry, while transthoracic echocardiography is used mostly for anatomical evaluation of the mitral valve. The integration of 2-Dimensional multi-planar, as well as 3-Dimensional imaging from transthoracic as well as transesophageal echocardiography is needed for providing full hemodynamic and anatomical evaluation of patients having mitral regurgitation. That method is beneficial for guiding percutaneous or surgical intervention as well as determining the ideal option for patients having severe secondary symptomatic mitral regurgitation. (8)

➢ **Trans-thoracic Echocardiography:**

Precise grading of severity of mitral regurgitation is significant, as recent guidelines recommend only surgical intervention when mitral regurgitation is observed as severe by the standardized criteria. The guidelines of 'American Echocardiography Society' as well as 'European Cardiology Society' suggest using multiple semi-quantitative, qualitative, as well as quantitative echocardiographic parameters during assessing severity of mitral regurgitation, despite that each of them own their specific limitations.

➢ **Trans-esophageal Echocardiography:**

In asymptomatic severe mitral regurgitation, ideal outcomes are fulfilled in healthcare centers where rates of repair of mitral valve are more than '95'%, and the mortality is less than '1'%. Measuring the feasibility of surgical successful repair is consequently significant. Transesophageal echocardiography is capable of providing beneficial information regarding the likelihood of repair of mitral valve when transthoracic echocardiography has poor quality or when calcified, complex, or endocardial lesions are expected. Transesophageal echocardiography is recommended within intraoperative setting for more diagnostic re-finement, beside to it's an indispensable tool for imaging to guide

percutaneous procedures of mitral valve. Separately from delineating lesions anatomy and guiding device deployment, it offers information on its hemodynamic dysfunction post- and pre-repair as well. (9)

3-Dimensional transesophageal echocardiography provides significant role in localizing prolapse of valve and in simulating valve's view of surgeon, through orientating the images for exhibiting the aortic valve at the position of 11 a clock. However, it's significant noting that transesophageal echocardiography is semi-invasive and so it's not suitable for the serial studies. (10)

- **Color-Flow Doppler:**

Despite that a mild mitral regurgitation could be diagnosed easily with color-flow method, qualitative evaluation of bigger jets is difficult. Size of the atrium is associated with the pressure within it as well as compliance, both of them may influence the jet area.

That technique must not be utilized to grade severity of mitral regurgitation. If over a central small jet is noted, vena contracta assessment and the method of convergence of flow, the isovelocity proximal surface area is recommended. (11)

- **Continuous-wave Doppler:**

The envelope of continuous wave Doppler of the signal of mitral regurgitation may offer clues to severity of the lesion. As the Doppler signal intensity is in proportion to the scatterers number within the beam, severe mitral regurgitation with high regurgitant volumes generally generate Doppler envelopes of large intensity.

A dense signal of continuous wave Doppler of the jet of mitral regurgitation is in consistency with severe mitral regurgitation. However, there are numerous limitations to that technique, including that there aren't particular criteria for moderate mitral regurgitation designation, besides to the lack of findings that is consistent with either severe or mild mitral regurgitation. In addition to, interpretation of patterns color flow is individualized, so in turn blurring differentiation between severe and moderate. (4)

As density of signal is based on jet spectral recording, a central jet that is well-aligned with the beam of ultrasound may seem more dense than eccentric jet of more severity, as well as despite that particular signs possess positive high predictive value, they aren't sensitive for detecting severe mitral regurgitation. (6)

- **Cardiac Magnetic Resonance Imaging:**

Cardiac Magnetic Resonance Imaging is the advanced gold standard used to define the myocardial structure and architecture of tissue, and is largely used for study and management of athletes. Cardiac Magnetic Resonance Imaging enables detailed evaluation of cardiac functions, function and morphology of valves, origin of coronary artery as well as its proximal course, besides to the great vessels anatomy.

Cardiac Magnetic Resonance Imaging is an evolving, non-invasive method which can offer full evaluation of the mitral valve as well as mitral regurgitation. Also, Cardiac Magnetic Resonance Imaging offers unique reproducibility and accuracy in assessment of atrial and ventricular function and size, enabling full longitudinal as well as post-operative evaluation of left ventricular reverse remodeling. (12)

A detailed assessment with usage of cine Cardiac Magnetic Resonance Imaging enables a systematic anatomic inspection of the mitral valve as well as characterizes the mitral regurgitation, both of them share in determining the mitral regurgitation etiology. The mitral regurgitation severity could be assessed by utilizing numerous quantitative methods based on Cardiac Magnetic Resonance Imaging. Moreover, Cardiac Magnetic Resonance Imaging offer information regarding the mitral regurgitation mechanism through identifying morphologic mitral valve abnormalities. (13)

The existence of flail or billowing segments could be determined through cine dedicated imaging concerning on the various mitral valve scallops. Within secondary mitral regurgitation, Cardiac Magnetic Resonance Imaging can offer a precise assessment of dysfunction and dilatation of left ventricle, besides to identification of formation of scars within cardiac and papillary muscles.

During a multicenter prospective study by Myerson & his colleagues, asymptomatic patients having severe or moderate primary mitral regurgitation identified by echocardiography, undergone baseline Cardiac Magnetic Resonance Imaging, and then followed up for about '8' years. Cardiac Magnetic Resonance Imaging quantification of mitral

regurgitation identified the patients accurately who developed symptoms or other who needed surgeries, '91'% of these participants had regurgitant volumes less than or equal to '55' ml, survived nearly 5 years with no surgery in comparison with '21'% only of the participants who had regurgitant volumes more than '55' ml. (14)

The same findings were noted in another dual-center prospective study by Penicka & his colleagues where asymptomatic patients having severe or moderate primary mitral regurgitation identified by echocardiography, undergone baseline Cardiac Magnetic Resonance Imaging, and then followed up for about '5' years. Within that study, the authors showed that volume of mitral regurgitation which was derived from Cardiac Magnetic Resonance Imaging was the ideal mortality predictor. Besides to, when volume of mitral regurgitation was integrated with the indication for surgery of mitral valve as an outcome, there was an increase in the predictive value. The other significant finding of that study was that, the consistence between echocardiography as well as Cardiac Magnetic Resonance Imaging for categorizing primary mitral regurgitation was poor for patients having late systolic or multiple jets mitral regurgitation. (15)

A multicenter prospective study among patients having secondary or primary mitral regurgitation indicated substantial discordance within the mitral regurgitation severity as evaluated with either echocardiography or Cardiac Magnetic Resonance Imaging on basis of the integrated technique of 'American Echocardiography Society' or the regurgitant volume that is based on isovelocity proximal surface area. (16)

- **Cardiac Computed Tomography:**

Cardiac Multi-slice Computed Tomography could be useful particularly preoperatively as it offers complementary required information on safety and feasibility of replacement or repair of mitral valve. Besides to assessing the extent of calcification of mitral valve annulus, cardiac Computed Tomography can offer detailed estimates of the geometry of mitral valve, as well as measures the angle between the anterior mitral valve and left ventricle outflow track for aiding pre-procedural planning, so in turn reducing the risk of obstruction of left ventricle tract for outflow within advanced transcatheter methods of replacements of mitral valve. (17)

Also, the usage of cardiac Computed Tomography enables the simultaneous cardiac venous and arterial systems visualization, as well as anatomy that can help in planning of percutaneous repair of mitral valve. Despite that cardiac cine Computed Tomography imaging can detect as well as localize segmental prolapse reliably, that's not performed routinely because of the required radiation high dose. (18)

- **Positron Emission Tomography:**

The positron emission tomography scan, has the largest sensitivity for identifying myocardial viability, regardless its status of contractility. Utilizing '18-fluorin-deoxyglucose', which is a tracer that reflects usage of glucose, myocardial uptake quantification of the '18-fluorin-deoxyglucose' is utilized as a viability marker of the myocardium. That viability is related to significant reverse left ventricle remodeling, and improvement of its function, as well as improvement of the functional class and capacity for exercise, besides to better results, and can so be utilized for stratifying risks of patients having secondary mitral regurgitation where transcatheter or surgical intervention is organized. (19, 20)

4. CONCLUSION:

Through integrating mainly transthoracic as well as transesophageal Echocardiography, Cardiac Magnetic Resonance Imaging, Cardiac Multi-slice Computed Tomography, and positron emission tomography scan, a full assessment of patients having mitral regurgitation could be done, enabling assessment of the mitral regurgitation severity as well as the anatomy of the mitral valve and the left ventricle, besides to detecting fibrosis as well as myocardial viability. A multi-modality imaging method for evaluating patients having mitral regurgitation has the clinical capability of improving management as well as making of decisions among that population.

REFERENCES:

1. Koelling TM, Aaronson KD, Cody RJ, et al. Prognostic significance of mitral regurgitation and tricuspid regurgitation in patients with left ventricular systolic dysfunction. Am Heart J 2002;144:524-9.
2. Vahanian A, Alfieri O, Andreotti F, et al. Guidelines on the management of valvular heart disease (version 2012). Joint task force on the management of valvular heart disease of the European Society of Cardiology (ESC); European Association for Cardio-Thoracic Surgery (EACTS). Eur Heart J 2012;33:2451-96.

3. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/ American Heart Association Task Force on Clinical Practice Guidelines. J Am Coll Cardiol 2017.
4. O'Gara P, Sugeng L, Lang R, Sarano M, Hung J, Raman S, Fischer G, Carabello B, Adams D, Vannan M. The Role of Imaging in Chronic Degenerative Mitral Regurgitation. JACC Cardiovasc Imaging 2008;1:221-37.
5. Irvine T, Li XK, Sahn DJ, Kenny A.. Assessment of mitral regurgitation. Heart 2002;88 Suppl 4:iv11-9.
6. Zoghbi WA, Adams D, Bonow RO, Enriquez-Sarano M, Foster E, Grayburn PA, Hahn RT, Han Y, Hung J, Lang RM, Little SH, Shah DJ, Shernan S, Thavendiranathan P, Thomas JD, Weissman NJ. Recommendations for noninvasive evaluation of native valvular regurgitation. J Am Soc Echocardiogr 2017;30:303-71.
7. Van de Heyning CM, Magne J, Vrints CJ, Piérard L, Lancellotti P. The role of multi-imaging modality in primary mitral regurgitation. Eur Heart J Cardiovasc Imaging 2012;13:139-51.
8. Mahmood F, Knio ZO, Yeh L, et al. Regional Heterogeneity in the Mitral Valve Apparatus in Patients With Ischemic Mitral Regurgitation. Ann Thorac Surg 2017;103:1171-7.
9. De Bonis M, Maisano F, Canna G La, Alfieri O. Treatment and management of mitral regurgitation. Nat Rev Cardiol 2011;9:133-46.
10. Shah PM. Current concepts in mitral valve prolapseDiagnosis and management. J Cardiol 2010;56:125-33.
11. Lancellotti P, Moura L, Pierard LA, Agricola E, Popescu BA, Tribouilloy C, Hagendorff A, Monin JL, Badano L, Zamorano JL; European Association of Echocardiography. European association of echocardiography recommendations for the assessment of valvular regurgitation. Part 2: Mitral and tricuspid regurgitation (native valve disease). Eur J Echocardiogr 2010;11:307-32.
12. Suinesiaputra, A. et al. Quantification of LV function and mass by cardiovascular magnetic resonance: multi-center variability and consensus contours. J. Cardiovasc. Magn. Reson., 2015, 17, 63.
13. Sturla, F. et al. Dynamic and quantitative evaluation of degenerative mitral valve disease: a dedicated framework based on cardiac magnetic resonance imaging. J. Thorac. Dis. 2017, 9, 225-238.
14. Myerson, S. G. et al. Determination of clinical outcome in mitral regurgitation with cardiovascular magnetic resonance quantification. Circulation, 2016, 133, 2287–2296.
15. Penicka, M. et al. Prognostic implications of magnetic resonance-derived quantification in asymptomatic patients with organic mitral regurgitation. Circulation, 2018, 137, 1349–1360.
16. Uretsky, S. et al. Discordance between echocardiography and MRI in the assessment of mitral regurgitation severity. J. Am. Coll. Cardiol., 2015, 65, 1078–1088.
17. Thavendiranathan P, Phelan D, Thomas JD, Flamm SD, Marwick TH. Quantitative assessment of mitral regurgitation: Validation of new methods. J Am Coll Cardiol 2012;60:1470-83.
18. Alkadhi H, Wildermuth S, Bettex DA, Plass A, Baumert B, Leschka S, Desbiolles LM, Marincek B, Boehm T. Mitral regurgitation: quantification with 16-detector row CT-- initial experience. Radiology 2006;238:454-63.
19. Beanlands RSB, Nichol G, Huszti E, et al. F-18- fluorodeoxyglucose positron emission tomography imaging-assisted management of patients with severe left ventricular dysfunction and suspected coronary disease: A randomized controlled trial (PARR-2). J Am Coll Cardiol 2007;50:2002-12.
20. Velazquez EJ, Lee KL, Deja MA, et al. Coronary-artery bypass surgery in patients with left ventricular dysfunction. N Engl J Med 2011;364:1607-16.