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An Overview on Echocardiographic Assessment of Mitral Regurge

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Abstract:

Mitral regurgitation (MR) is common, clinically important, and mechanistically complex. Its assessment by echocardiography can be challenging, and particular care is needed in the quantification of severity. Echocardiographers need to be aware of the potential limitations of flow convergence and vena contracta methods in assessing severity and alert to the prognostic importance of even moderate MR. Three-dimensional echocardiography has the potential to improve both the understanding of the mechanisms of MR and the accuracy of its quantification.

Keywords: Echocardiography, Mitral Regurge, 3D Color Doppler.

Introduction:

Echocardiography is noninvasive and the most accessible imaging tool that can be useful for the evaluation of MR or other various conditions and diseases. echocardiography, along with physical examinations, will remain the first line and routine evaluation tool for valvular heart disease because of its repeatability and accessibility **(1).**

The strengths of echocardiography in evaluation of MR also include its capability of comprehensive evaluation of anatomical, physiological, and functional aspects in real time, enabling it to be an extension of physical examinations and an intra-procedural guidance. However, inter-and intra-observer variability and moderate reproducibility/accuracy in grading MR severity should be acknowledged. The purpose of this review document is to provide a comprehensive summary of current standards of echocardiographic assessment of MR **(2).**

1) Color Doppler jet area:

Color Doppler jet area is one of the most commonly used approaches for grading MR severity in routine clinical practice. Using the apical 4-chamber view, with tilting of the plane to capture the largest jet, MR jet area and LA area should be measured on the same plane, and the ratio of MR jet area to LA area was evaluated (Fig.1a). This approach is commonly used as a first screening of the presence of MR. On the other hand, this is not essentially a flow image but rather an image of the spatial distribution of velocities within the image plane. This approach is easy and visually intuitive, but it is imprecise for grading MR severity compared with other approaches **(3).**

In cases of acute MR, eccentric jet, and significantly enlarged LA, in particular, the MR jet area tends to be underestimated. Accordingly, when moderate or more MR is suspected, other approaches should be employed to grade MR severity together in conjunction with this **(4).**

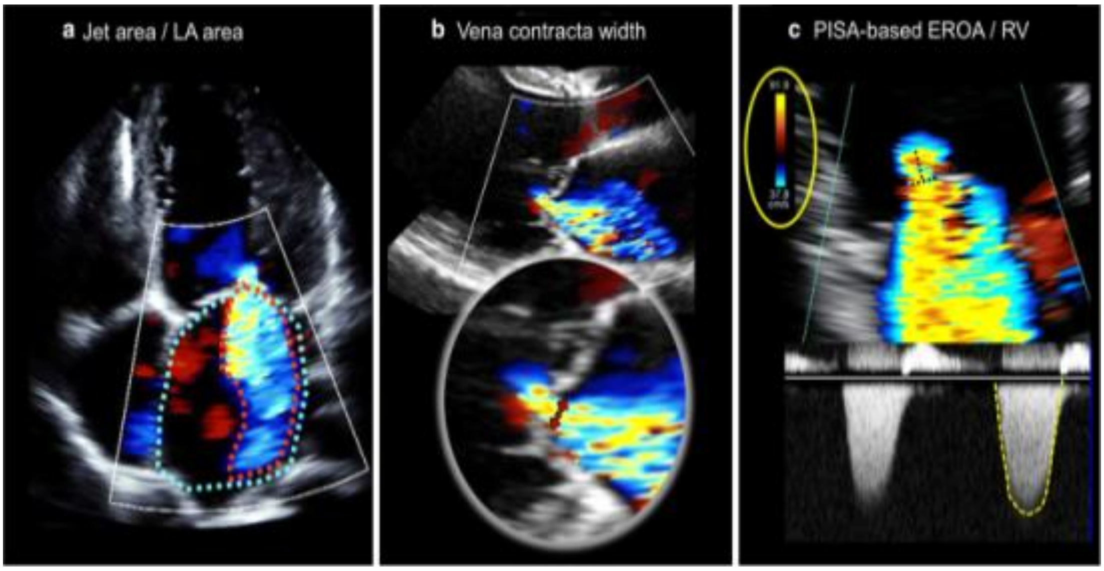

Figure 1: Grading methods of MR. **a** Ratio of color Doppler jet area to left atrium area. **b** Vena contracta width. **c** Proximal isovelocity surface area method **(5).**

2) Vena contracta width:

Vena contracta width is a relatively easy and objective method that provides semiquantitative grading of MR severity. Vena contracta width is the width at the narrowest part of the MR jet (Fig. 1b). It is measured on the parasternal long axis view as other views, e.g., the 2-chamber view, can cause significant over/underestimation of the severity. Vena contracta < 0.3 cm and ≥ 0.7 cm is relatively specific to mild and severe MR, respectively, whereas there is an overlap of mild, moderate, and severe MR in vena contracta of 0.3–0.7 cm. Vena contracta is also reported to be accurate in evaluating eccentric jet **(6)**

Furthermore, a previous study demonstrated that vena contracta width reflected orifice size and was resistant with changes in the flow. However, it is significantly influenced by the orifice shape, i.e., it underestimates MR when the orifice is elliptical and it cannot be applied to multiple jets **(7).**

3) Proximal isovelocity surface area method:

The proximal isovelocity surface area (PISA) method is one of the most commonly used quantitative approaches for MR grading.

Previous studies have reported that MR quantification using the PISA method is associated with the prognosis **(8).**

Using an apical view, the size of the proximal flow convergence radius is measured with the color Doppler baseline shifted in the direction of the jet (= change the Nyquist limit: often to 30–40 cm/s). Then, MR in continuous wave Doppler is traced to obtain the time velocity integral (TVI) and maximum velocity (Fig.1c).

The effective regurgitant orifice area (EROA) and regurgitant volume (RV) can both be calculated using these measurements. The biggest pitfall is in measuring the size of the proximal flow convergence radius, which is sometimes difficult, mainly due to unclear location of the orifice. As small errors in the size of the radius result in a big difference in the estimated value, it should be measured carefully using a zoomed image with accurate detection of orifice location. For an eccentric jet or elliptical orifice, this approach can underestimate MR severity as well as vena contracta **(9).**

4)Volumetric method:

In the volumetric method, MR volume is derived as the difference between the stroke volume (SV) calculated at the LV outflow tract and the volume of LV inflow (10).

Alternatively, MR volume can be obtained as the difference between the SV calculated at LV outflow and the SV measured by tracing the LV endocardium (2D disc method or ideally 3D method) **(11).**

In the former method, the LV inflow volume is calculated using TVI of mitral inflow measured at the mitral annular level and mitral annular diameters. This approach is resistant to multiple jets, elliptical orifice shape, eccentric jet, and duration of MR (non-holosystolic MR), in contrast to other quantitative/semiquantitative approaches. However, there are many steps in the calculation process and small errors in each measurement can accentuate error in the final results**(3).**

Other supporting findings:

Other than the quantitative/semiquantitative approaches, several simple approaches are sometimes helpful for differentiating severe MR (**11).**

For example, if clear proximal convergence flow is observed, the severity of MR should be more than moderate.

Flail leaflet, with a clear gap between the diseased and adjacent leaflet tip, is mostly related to severe MR.

Reversal Doppler wave pattern of pulmonary vein flow is an additional metric indicating severe MR. Also, it is sometimes useful to check the continuous wave Doppler pattern and the shape of MR.

In severe MR, the pattern is dense, and the shape can become triangular since the flow velocity drops fast due to a rapid increase in LA pressure. The mitral inflow pattern is usually E wave dominant with a high peak velocity in severe MR (> 1.2 m/s) **(3).**

Lastly, hyperdynamic LV motion without any other cause may indicate compensation effort against severe MR. These metrics can help to make a quick assessment of the severity and can also help when other quantitative metrics are inconsistent **(3).**

MRI has recently been reported as more accurate tool for quantification of MR (**12).**

3D Echocardiography:

3D echocardiography, especially with transesophageal echocardiography, has already become a routine tool for presurgical assessment of MR.

Compared with 2D echocardiography, which requires some experience to visualize the 3D morphology, 3D echocardiography provides much more intuitive images, improving the accuracy of localization of the mitral valve pathology even by novice readers (Fig.2) **(13)**, and making it easier to communicate with surgeons and other medical staff who are not experts in echocardiography.

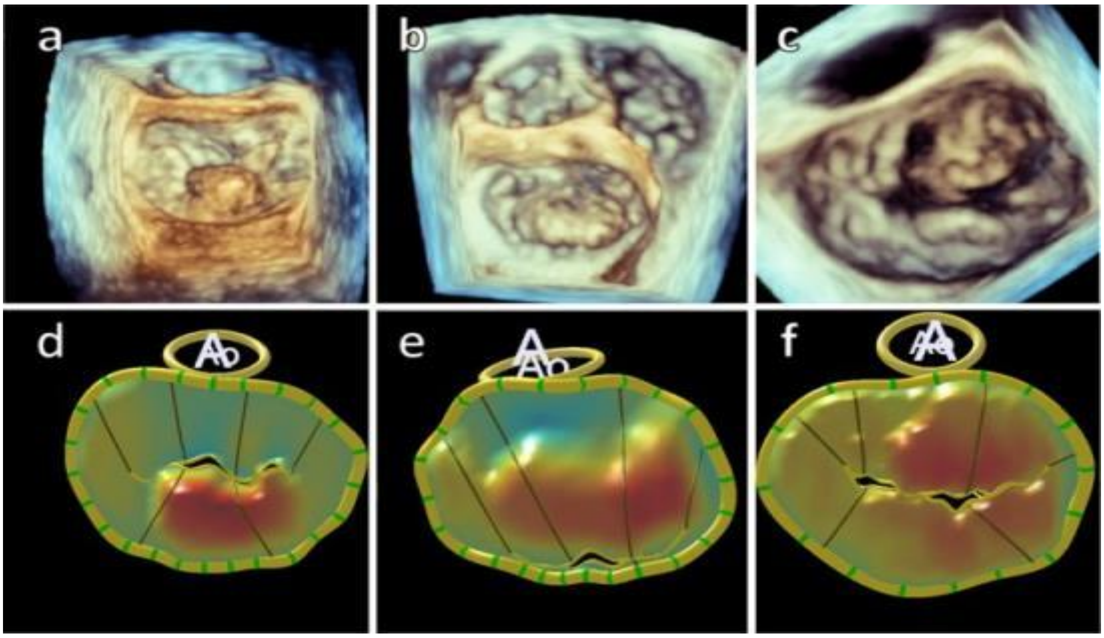

Figure 2: Localization of mitral valve prolapse. Panels **a**, **c**, and **e** show 3D echocardiographic images, and **b**, **d**, and **f** are their 3D modeling. Panels **a** and **b** are posterior, **c** and **d** are anterior, and **e** and **f** are bileaflet prolapse, respectively **(5).**

Furthermore, 3D echocardiography allows not only visual assessment but also quantitative approaches that may be more accurate than 2D methodologies.

For example, 3D quantitative assessment including prolapse volume and its ratio to height allows accurate differentiation of fibroelastic deficiency from Barlow's disease, which requires more complex repair (**14)**.

Recently, such quantitative approaches have become easier and faster because of advances in technologies (**15)**.

Vena contracta area is an area of vena contracta measured by 3D color Doppler (**16)**. Although the principle of vena contracta area is the same as vena contracta width, i.e., assessment of the narrowest part of MR flow, vena contracta area can be applied to any form of MR orifice because of its 3D nature.

Similarly, 3D PISA methods can assess the morphology and size of PISA without shape assumption, with a previous study reporting its superiority over 2D PISA (**17)**.

Currently, these 3D color Doppler-based techniques require manual processing of multiplanar reconstruction and have limited evidence in clinical settings, although they seem to be promising in assessment of MR severity.

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