Conclusion

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The role of 3D Echocardiography in Ischemic MR:-

The recent development of a fully sampled matrix array transducer has enabled real-time volumetric imaging of the mitral valve from the transthoracic approach. ***(Sugeng et al. 2006)***

Three-dimensional echocardiography has been instrumental in demonstrating the *nonplanar* nature of the mitral annulus and the implications of this complex geometry for the diagnosis of mitral valve prolapse as well as for the design of therapeutic interventions such as mitral annuloplasty rings. Depicts the normal non planar anatomy of the mitral annulus and its relationship to mitral leaflet closure patterns. ***(Feigenbaum et al. 2005)***

3D imaging is superior to the traditional 2D techniques and should be routinely used in 2 clinical scenarios: ***{1}*** Quantification of LV volume, EF, and LV mass, ***{2}*** Quantification of the mitral valve area. ***(Roberto et al. 2006)***

The anterior mitral valve leaflet was more readily visualized compared with the posterior leaflet, probably because of its larger size. The mitral leaflets, commissures, and mitral valve orifice were also easily viewed. The posterior leaflet is best visualized from the parasternal window, whereas the anterior mitral leaflet was equally well seen from either the parasternal or the apical window. ***(Roberto et al. 2006)***

The main advantage of 3D echocardiography is the ability to achieve a perpendicular ***en-face*** cut plane of the mitral valve orifice, enabling accurate mitral valve area measurements. These measurements have been found more accurate when performed from the ventricular orientation. ***(Roberto et al. 2006)***

When compared with traditional 2D and Doppler measurements, such as 2D planimetry, pressure half-time, and flow convergence, 3D echocardiography best agreed with mitral orifice area calculations derived using the ***Gorlin formula*** during cardiac catheterization. Importantly, the 3D measurements had the additional advantage of having lower intraobserver and interobserver variability. ***(Zamorano et al. 2004), (Sugeng et al. 2003), (Binder et al. 2000).***

Characterization of the mitral valve apparatus using 3D echocardiography has shed new light on the pathophysiology of mitral regurgitation in patients with non ischemic and ischemic MR.

It has been shown that functional mitral regurgitation is associated with annular dilatation and reduced cyclic variations in annular shape and area. ***(Kaplan et al. 2000)***

Further investigations showed differences in patients with ischemic mitral regurgitation compared with normal subjects in mitral annular shape with increased intercommissural and anteroposterior diameters and increased leaflet tenting, indicating chordal tethering. ***(Watanabe, Kawamoto et al. 2005)***

Patients with anterior wall myocardial infarction have flattened mitral annulus, which is more pronounced than with posterior myocardial infarction. ***(Watanabe et al. 2006)***

Three-dimensional echocardiography has also been used to evaluate the differences in the shape and dynamics of **2** types of mitral rings: although the Duran ring seemed nonplanar and showed changes in annular area throughout the cardiac cycle, the ***Carpentier ring*** was planar and did not effectively change its area. ***(Yamaura et al. 1997)***

Several studies have reported that MR caused by ischemia occurs in conjunction with remodeling of the ischemic region, leading to LV dilatation with subsequent papillary muscle displacement. ***(Aikawa et al. 2002), (Liel et al. 2000)***

Interestingly, an animal 3D echocardiographic study showed that MR resolved after plication of the infarct region ***(Liel et al. 2000)*** Hence, the insights provided by 3D echocardiography have shown that the presence of MR in patients with dilated or ischemic cardiomyopathy is a disease of the remodeled myocardium rather than being caused by a true valvular abnormality. ***(Roberto et al. 2006)***

Advantages of 3D Echocardiography:-

Three-dimensional echocardiography is uniquely qualified because images are tomographic, are acquired at a relatively high rate, can be triggered to an appropriate phase of the electrocardiogram, and can be acquired from any angle. ***(Thomas et al. 2008)***

Improvement in the accuracy of the echocardiographic evaluation of cardiac chamber volumes, which is achieved by eliminating the need for geometric modeling and the errors caused by foreshortened views.

The realistic and unique comprehensive views of cardiac valves and congenital abnormalities.

3D imaging is extremely useful in the intra-operative and postoperative settings because it allows immediate feedback on the effectiveness of surgical interventions. ***(Roberto et al. 2006)***

The auto crop function suppresses the front half of the 3D images, which can be a starting point of further cropping. The 3D images can be rotated to any direction for viewing. These capabilities provide optimal perspective for visualizing structural abnormalities and allow anatomically correct views for quantitative measurements. ***(Jae et al. 2006)***

Comparison between 2D, 3D echocardiographic study in IMR:-

Three-dimensional echocardiography has now been shown to have several advantages over 2D echocardiography, particularly for:-

(a) Whole-valve evaluation.

(b) Volume measurements.

(c) Visualization of septal defects.

Given these data, it is clear that 3D echocardiography is here to stay and soon will become part of routine echocardiographic examinations. ***(Solís et al. 2009)***

The principal advantage of RT3DE over 2D echocardiography is that it enables us to see the MV from any angle and map the MV from a single image without the need for mentally reconstruction. ***(Solís et al. 2009)***

The severity of complex mitral regurgitant flows is usually underestimated by 2DE. ***(De Simone et al.1999)***.While full volume imaging during Seven heart beats acquires a full-volume image which is able to demonstrate the entire flow of interest. ***(Solís et al. 2009)***

3DE has enabled us to demonstrate mitral annular displacement by calculating displacement area. ***(Ahmad et al.2004)***. In healthy individuals, caudal displacement occurs, which is more accentuated in the posterior region. In patients with FMR, this displacement is reduced, most notably in the posterior region. ***(Solís et al. 2009)***

With 3DE, the capability to trace the mitral leaflets and measure their area using specialized computer software exists. In addition, the tenting volume (the volume in the space between the mitral annulus and the {tented} mitral leaflets) can easily be measured thus giving an idea of the amount of tethering on the leaflets. ***(Solís et al. 2009)***

2DE has been used exclusively to calculate the mitral valve tenting area as an estimate of how left ventricular remodeling and geometrical changes have affected mitral annular geometry ***(Calafiore et al. 2005)***. But the presence of asymmetry of this tenting area and the existence of patterns that differ with the etiology of FMR, making single plane studies less than optimal. ***(Daimon et al. 2005)***

In contrast, 3DE enables the measurement of tenting volume, the maximal diameter between the mitral annulus and mitral leaflet surface, and the visualization of leaflet deformation from any angle. ***(Watanabe et al. 2006)***

Compared with 3D echocardiography, 2D echocardiography using the PISA method overestimates the MR volumes. While 3D echocardiography being based on formulae, which allow a more accurate estimation of the PISA surface according to its shape. Thus, this non-spherical surface is smaller because it integrates the smallest diameter of the PISA in the transversal plane, where as 2D echocardiography PISA is based only on the PISA radius in the longitudinal plane. ***(Abd-el-Kader et al. 2009)***

3DE has demonstrated superiority over 2DE in measuring left ventricular volumes, especially in patients with dilated cavities and distorted ventricular geometry. ***(Jacobs et al. 2006)*** because the obliquely-acquired planes or 2D images with inadequate visualization of the apex may easily be corrected using the slice plane through the volume of data can be manipulated in any direction to obtain adequate visualization of the area of interest. ***(Solís et al. 2009)***

Unlike 2DE, 3DE makes no geometric assumptions in order to calculate volumes. ***(Solís et al. 2009)***

Limitation of Current 3D Technology:-

Although RT3DE has succeeded in eliminating some of the limitations that prevented the application of other 3D techniques in clinical practice, significant limitations remain. The technique relies on image quality and there is a long learning curve to optimal image acquisition. Compared with conventional 2DE, RT3DE suffers from low spatial resolution which, for example, prevents automatic endocardial border detection for volume quantification.

The lower frame rate can also be a significant limitation when quantifying regurgitant flow. Full volume imaging acquires the data over 4-7 heartbeats and thus is prone to ECG-related and respiratory motion artifacts. Finally, real-time *(live)* imaging, although it requires no reconstruction, is limited by the small volume acquired. ***(Solís et al.2009)***

Despite its unquestionable role in the diagnosis of heart disease and in the management of cardiac patients, 3D echocardiography does have some limitations, both in the morphologic visualization as well as in the functional assessment of the heart, such as blood flow, quantification of intracardiac volumes, etc. The prolonged acquisition time and tedious post-processing are important limiting factors that currently restrict routine clinical applications. ***(Binder et al. 2000)***

One must also remember that the quality of 3D images is greatly dependent on the quality of 2D images, and thus the ability to obtain a motion- and artifact-free 3D dataset is critical. Possible inherent errors may be introduced by the off-line reconstruction technique, including spatial discordance due to movement of the heart, transducer, or patient during the acquisition process, and temporal discordance due to multiple beats needed for the rendered image. Although the newer RT3D machines utilize only {1 – 4} cardiac cycles to acquire and render images, the quality and accuracy of these images can still be affected by factors like irregular heart rhythms, tachycardia, and irregular breathing. If the acquisition is obtained via the trans-esophageal route, sedation of the patient is often necessary for this unpleasant procedure, with increased potential risks to the patient. It must likewise be remembered that the basic image source for 3D echocardiography is the ultrasound wave. It is thus limited by the fundamentals of ultrasound waves. Since ultrasound waves are affected by signal loss from reflection, refraction, and attenuation, the image dataset obtained can be limited by these confounding factors, which can lead to areas of drop-out in the rendered images. ***(Binder et al. 2000)***

In addition, certain structures which are highly echo reflective, such as metallic prostheses, can cause acoustic shadowing which affects image quality. The acquisition angle of the transducer may not contain the entire structure of interest within the dataset, particularly in cases with dilated cardiac chambers. During the image reconstruction, the original gray value might be partially lost. On the other hand, operator-dependent changes in threshold settings, which define the tissue–blood interface on the 3D rendered display, can affect the apparent anatomic measurements. Measurements on reconstructed images should be made with caution, and the entire image post-reconstruction and interpretation thus requires a high degree of operator experience. ***(Binder et al. 2000)***