Comparison between 2D and 3D Echocardiography for Quantitative Assessment of Mitral Regurgitation: Current Status

Lovhale PS, *et al.*[1] compared various quantitative parameters using two- and three-dimensional echocardiography for patients with mitral regurgitation (MR) and it was a prospective observational study from a single center, and all the parameters were measured in the intra-operative period. To find out the most useful parameter for the quantification of MR, authors from index article compared effective regurgitant orifice area (EROA) and regurgitation volume (RV) by 3D vena contracta (VC) with other parameters such as 2D-VC, 2D-proximal isovolumetric surface area (PISA), 3D-PISA with assumption of hemispherical (HS), or hemi-elliptical (HE) shapes. In addition, the authors evaluated shapes of regurgitant orifice in relation to underlying pathological conditions causing MR. Overall the authors observed a good correlation between EROA by 3D-VC with other parameters; however, the best agreement was with 3D-HS method. Moreover, the correlation was better in organic than functional MR (*et al.*).

Mitral valve is a complex structure and unable to analyze completely with 2D echocardiography alone. Understanding mitral valve apparatus (MVA) is vital with the growing demand of various surgical and percutaneous procedures involving MV. 3D echo has several advantages over 2D and able of visualize MV leaflets, commissures, annulus calcifications, and subvalvular structures in different and unique planes, both from the atrium or ventricle, with access to "en face" views.[2] With advancement of software, RT3D can depict the actual saddle shape of the MV and provides data of several other parameters such as annular diameters and area, annular height and planarity, leaflet size, and coaptation geometry.[3] Moreover, dynamic nature of MV leaflets in various pathological conditions best assessed with 3D in order to differentiate between normal mobility and tethered leaflets secondary to alteration in left ventricular geometry.[4] With advancement of technology, various 3D-color doppler measurements are feasible, reproducible, and accurate in quantifying severity of MR.

Several studies have shown superiority of 3D over 2D in the detailed assessment of MR as well as defining various patho-mechanism of MR.[5,6] As described in the index article, the severity of MR is often quantified by the size of 3D-VCA and has shown superior to other echo parameters.[7] Since VCA is often not circular, and in fact ellipsoidal when viewed en face, direct visualization of VCA is more accurate to calculate EROA and to grade severity of MR severity.[8] Moreover, 3D determines exact location of regurgitant orifice by the size and location of the flow convergence zone or PISA, and this information is critical for selection of certain treatment protocol for MR (percutaneous versus surgical).[9] Authors from the index article emphasized the importance of determining the actual shape of the regurgitant orifice to minimize the errors in grading MR severity and representing EROAs from all systolic frames instead of single frame. Even with automated features using 3D unable to avoid errors in the measurements in certain pathological conditions causing MR.

Choi *et al.* in their prospective comparative study (n = 221) demonstrated that 2D-PISA method significantly underestimated RVol compared with the 3D-PISA method (55.3 ± 19.6 vs 67.4 ± 29.1 mL) and the difference was more significant in patients with severe MR, eccentric regurgitant jet, and asymmetrical regurgitant orifice. Authors from index article specifically excluded MR with eccentric jets and reported importance of knowing the nature of jets to determine the EROA more accurately.[10] There have been reports of overestimates of MR due to mitral valve prolapse and nonoptimal flow convergence by 2D and 3D PISA.

The greatest challenge in assessing severity of MR due to functional MR as many of the 2D methods assumed shape of the regurgitant orifice as either HS or HE; however, majority of them have either crescentic or asymmetrical.[11] 3D PISA underestimates EROA by 24% in functional MR due to elongated geometry of regurgitant orifice compared to 2D quantitative methods, but EROA measurements are accurate in majority of patients with MV prolapse patients.[12] On contrary, Marsan *et al.* in quantifying functional MR with reference to velocity encoded cardiac magnetic resonance (CMR), reported higher EROA by

direct measurements using 3D than by 2D methods.[13] Overall determining the shape of regurgitant orifice takes priority in quantifying functional MR.

Data from metanalysis of assessing MR severity (n-1187) by 2D and 3D echo parameters showed moderate agreement and overestimation comparing with CMR. 3D-PISA and 3D-volumetric methods showed the better agreement with an underestimation of - 3.20 (- 12.33, 5.92) ml, and overestimation of 3.73 (- 9.17, 16.61) ml, respectively. 2D-volumetric method showed the poorest agreement and incorrectly estimated severity in severe MR in 38% compared to 14% by 3D.[14] Several studies showed benefits of CMR over echocardiography should be considered as gold standard in severe MVR where uncertainties arise with other parameters.[15]

RT-3D has improved features including captures entire heart movement in a single beat that overcomes limitations in multi-beat mode however suffers deteriorations in spatiotemporal resolution. To conclude 3D echo parameters are vital to avoid errors in various measurements for quantifying MR; however, one should clearly document the size and shape of the acquired regurgitant orifice to interpret in a meaningful way. Future studies are warranting to find out whether these 3D echo measurements provide incremental information to standard 2D echo measures for predicting outcome after treatment.

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REFERENCES

1. Lovhale PS, Gadhinglajkar S, Sreedhar R, Sukesan S, Pillai V. Intraoperative comparison of 2D versus 3D transesophageal echocardiography for quantitative assessment of mitral regurgitation. Ann Card Anaesth 2021;24:163-71.
2. Dal-Bianco JP, Levine RA. Anatomy of the mitral valve apparatus: Role of 2D and 3D echocardiography. Cardiol Clin 2013;31:151-64.
3. Shiota T. Role of modern 3D echocardiography in valvular heart disease. Korean J Intern Med 2014;29:685-702.
4. Otsuji Y, Handschumacher MD, Schwammenthal E, Jiang L, Song JK, Guerrero JL, *et al.* Insights from three-dimensional echocardiography into the mechanism of functional mitral regurgitation: Direct *in vivo* demonstration of altered leaflet tethering geometry. Circulation 1997;96:1999-2008.
5. Buck T, Plicht B, Kahlert P, Schenk IM, Hunold P, Erbel R. Effect of dynamic flow rate and orifice area on mitral regurgitant stroke volume quantification using the proximal isovelocity surface area method. J Am Coll Cardiol 2008;52:767-78.
6. Chew PG, Bounford K, Plein S, Schlosshan D, Greenwood JP. Multimodality imaging for the quantitative assessment of mitral regurgitation. Quant Imaging Med Surg 2018;8:342-59.
7. Yosefy C, Hung J, Chua S, Vaturi M, Ton-Nu TT, Handschumacher MD, *et al.* Direct measurement of vena contracta area by real-time 3-dimensional echocardiography for assessing severity of mitral regurgitation. Am J Cardiol 2009;104:978-83.
8. de Agustín JA, Marcos-Alberca P, Fernandez-Golfin C, Gonçalves A, Feltes G, Nuñez-Gil IJ, *et al.* Direct measurement of proximal isovelocity surface area by single-beat three-dimensional color Doppler echocardiography in mitral regurgitation: A validation study. J Am Soc Echocardiogr 2012;25:815-23.
9. Chikwe J, Adams DH, Su KN, Anyanwu AC, Lin HM, Goldstone AB, *et al.* Can three-dimensional echocardiography accurately predict complexity of mitral valve repair? Eur J Cardiothorac Surg 2012;41:518-24.
10. Choi J, Heo R, Hong GR, Chang HJ, Sung JM, Shin SH, *et al.* Differential effect of 3-dimensional color Doppler echocardiography for the quantification of mitral regurgitation according to the severity and characteristics. Circ Cardiovasc Imaging 2014;7:535-44.
11. Ashikhmina E, Shook D, Cobey F, Bollen B, Fox J, Liu X, *et al.* Three-dimensional versus two-dimensional echocardiographic assessment of functional mitral regurgitation proximal isovelocity surface area. Anesth Analg 2015;120:534-42.
12. Matsumura Y, Fukuda S, Tran H, Greenberg NL, Agler DA, Wada N, *et al.* Geometry of the proximal isovelocity surface area in mitral regurgitation by 3-dimensional color Doppler echocardiography: Difference between functional mitral regurgitation and prolapse regurgitation. Am Heart J 2008;155:231-8.
13. Marsan NA, Westenberg JJ, Ypenburg C, Delgado V, van Bommel RJ, Roes SD, *et al.* Quantification of functional mitral regurgitation by real-time 3D echocardiography: Comparison with 3D velocity-encoded cardiac magnetic resonance. JACC Cardiovasc Imaging 2009;2:1245-52.
14. Sköldborg V, Madsen PL, Dalsgaard M, Abdulla J. Quantification of mitral valve regurgitation by 2D and 3D echocardiography compared with cardiac magnetic resonance a systematic review and meta-analysis. Int J Cardiovasc Imaging 2020;36:279-89.
15. Myerson SG, d'Arcy J, Christiansen JP, Dobson LE, Mohiaddin R, Francis JM, *et al.* Determination of clinical outcome in mitral regurgitation with cardiovascular magnetic resonance quantification. Circulation 2016;133:2287-96.

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