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Review Article

Noninvasive Evaluation of Native Valvular Regurgitation: A Review of the 2017 American Society of Echocardiography Guidelines for the Perioperative Echocardiographer

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NATIVE VALVULAR regurgitation accounts for 35% to 45% of all valvular heart disease.[1,2] The effect on society is clear with more than 100,000 cardiac valve surgeries occurring annually in the United States. Cardiac anesthesiologists play a pivotal role in these procedures because the use of intraoperative transesophageal echocardiography (TEE) influences the evaluation and frequently the surgical plan. The American Society of Echocardiography (ASE) recently provided an overdue comprehensive update of its 2003 guidelines on the evaluation of native valvular regurgitation. Within this period, remarkable changes in the understanding of regurgitant lesions, diagnostic modalities, and treatment for these lesions have taken place. This narrative review focuses on the most important principles for cardiac anesthesiologists, considering environmental limitations, in a stepwise fashion for each of the regurgitant lesions. Emphasis is placed first on mechanisms of disease followed by the implications of these mechanisms on both old and new diagnostic modalities. Of note, most assessment recommendations are derived from transthoracic echocardiography (TTE) examinations and have been extrapolated to TEE views. Lastly, newer diagnostic modalities, although discussed, may not have specific quantification values defined. European guidelines may be referenced for these values.[3]

Mitral Regurgitation

The advances made in valvular diagnosis and treatment since the previous guidelines were published have stemmed largely from efforts dedicated to mitral regurgitation (MR). With this in mind, the major diagnostic modalities (ie, vena contracta [VC], proximal isovelocity surface area [PISA], and 3-dimensional [3D] imaging) are detailed in this section. The principals discussed are widely applicable to all regurgitant pathology. Changes from previous guidelines are highlighted.

Mechanism of Mitral Regurgitation

The detailed sonoanatomy of the mitral valve and Carpentier classification of MR have changed very little over the last 25 years and are reviewed in detail elsewhere.[4,5] In his original description, Carpentier described the "pathophysiological triad," in which the etiology, lesion, and dysfunction caused by the lesion are considered individually.[6] It is from this approach that a remarkable understanding of MR has been detailed. These efforts have led to a detailed description of regurgitant mechanisms and resultant flow dynamics.

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An understanding of how these changes affect echocardiographic diagnostic modalities also has increased significantly. With Carpentier's triad in mind, the newest guidelines describe MR mechanisms in much greater detail. Distinguishing an intrinsic abnormality of the leaflets (ie, primary MR) from functional or ischemic MR (ie, secondary MR), although technically easy, has far-reaching implications on diagnosis and treatment. A well-published figure relating MR mechanisms to the Carpentier classification scheme is included in the ASE guidelines.

Primary MR is most commonly due to myxomatous degeneration (ie, type II leaflet motion) and results from a continuum of pathologies such as fibroelastic deficiency to diffuse thickening of leaflets known as Barlow's disease.[6,7] The subsequent mitral valve prolapse (MVP) in primary MR is readily recognizable by novice echocardiographers. Highly variable degrees of insufficiency, however, require a more expert knowledge and examination. Severity of regurgitant lesions is most closely linked to the total regurgitant volume, and many of the current echocardiographic grading techniques are aimed at either directly or indirectly estimating this volume. For example, the use of the effective regurgitant orifice area (EROA) to grade severity is based on the assumption that there is a relative linear relationship between regurgitant areas and volumes. This assumption fails to take into consideration regurgitant time, requiring some integration of time in the evaluation of nonholosystolic lesions. MR of lesser severity in MVP occurs during mid-to-late systole; failure to recognize that MVP is not holosystolic can result in inaccurate assessment of MR severity when using some color Doppler measurements in a single frame.[8] Numerous other pitfalls of grading MR with indirect measures exist and are expanded on in this review.

Another significant change in the newest guidelines is the detailed description of mechanisms related to secondary MR. Major advances have been made in the understanding of left ventricular remodeling and its role in secondary MR. Poor coaptation secondary to apical displacement of the mitral leaflets and outward displacement of the papillary muscles as the left ventricle remodels are now recognized as critical components in both understanding and treating secondary disease. Asymmetric leaflet tethering, preferentially affecting the posterior leaflet (P3 scallop) also is now appreciated.[9] This is particularly important in ischemic cardiomyopathies.[10] The relevance of these discoveries to the perioperative echocardiographer relates to a whole host of new measurements that can be made to guide clinical decision making. The degree of the apical leaflet displacement, described as tenting, of the mitral leaflets can be quantified by various measures and has clinical utility. The simplest of these measures is the coaptation height (or tenting distance) measured from the annular plane to the point of coaptation during midsystole. The tenting area also can be measured by tracing the annular plane and coaptation plane (Fig 1).[11] Imaging software allows for these measurements to be extracted from 3D data sets as well. In addition, tenting volume may be calculated with 3D software. Quantification of tenting as described in the newest guidelines can serve not only to grade the severity of MR but also to identify patients with contraindications to valve repair by either surgical or percutaneous methods. Tenting heights > 1.0 cm have been associated with failure of mitral valve repair and serve as relative contraindications to both surgical repair and percutaneous clipping.[12] Interestingly, although mitral annular dilation contributes to the development of functional MR, annular dilation alone without leaflet tethering is unlikely to cause significant secondary MR.[13]

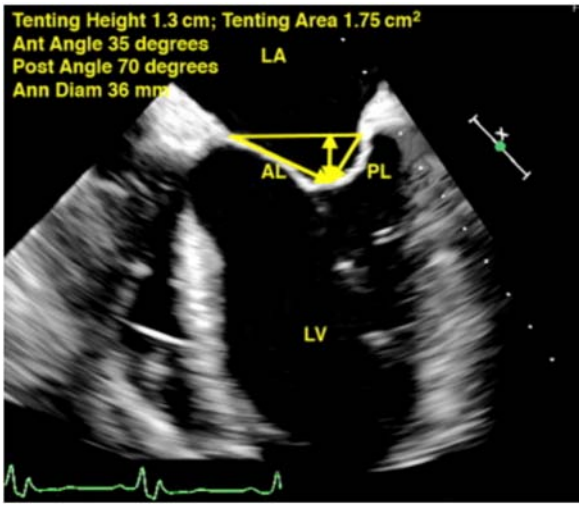

Fig 1. Tenting area. Note the midesophageal 4-chamber view demonstrating the measurement of both tenting height and tenting area. AL, anterior leaflet; LA, left atrium; LV, left ventricle; PL, posterior leaflet.
Reprinted from Maslow.[11]

Echocardiographic Assessment

MVP is diagnosed most accurately with the TTE parasternal long-axis window because systolic displacement of the mitral leaflet into the left atrium of at least 2 mm beyond the annular plane is well-visualized from this view.[14] Apical 4- or 2-chamber windows give false measurements of leaflet displacement into the left atrium.[15] Due to the limitations of TTE, the use of TEE is recommended by the ASE when good quality data cannot be obtained. TEE also has an expanding role in the preprocedural workup for novel therapies, such as clip devices and transcatheter mitral valve replacement, translating into a rapidly expanding role for the perioperative echocardiographer. A commanding knowledge of each of the echocardiographic measurements that are detailed in the following, including their limitations, is imperative for cardiac anesthesiologists collaborating to treat valvular disease. Table 1 highlights the important values for grading MR, as discussed in the following.

Color-flow Doppler

Color Doppler is the primary screening tool for MR. Initial estimations of severity are frequently made using visual inspection of the color jet alone. The physics of color flow