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EDITORIAL COMMENT

Grading Severity of Mitral Regurgitation by Echocardiography: Science or Art?*

Paul A. Grayburn, MD, Paul Bhella, MD
Dallas, Texas

"Vision is the art of seeing the invisible"
–Jonathan Swift (1)

The current American College of Cardiology/American Heart Association guidelines recommend surgery for asymptomatic severe mitral regurgitation (MR), provided that there is a 90% likelihood of successful valve repair (2). Therefore, it is imperative to accurately distinguish severe from nonsevere MR. In clinical practice, echocardiography has become the standard for assessing mechanism and severity of MR. In this issue of *iJACC*, Biner et al. (3) report surprisingly low interobserver agreement between academic cardiologists reviewing the same set of data obtained in a small group of patients referred for surgical correction of MR. Their findings are a sobering reminder of the limitations of echocardiographic grading of MR. Briefly, images from 16 patients were obtained by a single, experienced sonographer and distributed via the Internet to 11 academic centers worldwide. Eighteen readers then graded MR severity as severe or nonsevere based on 3 parameters: qualitative assessment of the color jet area, vena contracta width (VCW), and the proximal isovelocity surface area (PISA) method. The key finding was that "substantial" interobserver agreement, defined as >80% raw agreement among readers, was observed in only about 40% of cases for each parameter. Stated differently, the investigators found substantial disagreement among readers for MR severity based on color jet area, VCW, and PISA.

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The 3 methods studied all have known limitations. Sole reliance on color jet area to assess MR severity is discouraged because of its dependence on instrument settings, hemodynamics, jet eccentricity, orifice geometry, pulmonary venous counterflow, left atrial compliance, and other factors (4). Unlike color jet area, which is a map of the spatial distribution of velocities in the left atrium, VCW and PISA provide indirect measurements of effective regurgitant orifice area (EROA), which is a fundamental determinant of MR severity (5). VCW should be measured in a long-axis view, which is perpendicular to the coaptation of the mitral leaflets (6). Even mild MR may have a wide VCW in a 2-chamber or commissural view. Thus, a limitation of VCW is that it is a 1-dimensional measurement of an often elliptical EROA. Ultimately, 3-dimensional echocardiography may be able to accurately image EROA (7,8). The PISA method offers a simple way of calculating EROA. However, the PISA method assumes a hemispheric proximal flow convergence region, which often does not occur in MR because of an elliptical regurgitant orifice. A small error in measuring PISA radius can lead to a large error in calculated EROA because the radius is squared. Several years ago, Vandervoort et al. (9) developed a computer algorithm to predict the exact location of the orifice (and hence the true radius) from the velocity profile of the entire proximal convergence region. Such a program could automate PISA calculation and potentially eliminate observer variability, but it has never been implemented in color flow mapping systems. Both VCW and PISA are single-frame measurements that can overestimate MR severity in some circumstances, for example when MR only occurs in late systole due to prolapse. In addition, both

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From the Department of Internal Medicine, Cardiology Division, Baylor University Medical Center, Dallas, Texas. Dr. Grayburn has received grants from Evalve, Inc., GE Ultrasound, and Philips Ultrasound.

VCW and PISA have a fairly narrow range of values that separate mild from severe MR, so small errors in measurement can cause misclassification of MR severity. Because all methods of assessing MR severity have known limitations, the American Society of Echocardiography recommends an integrative approach that includes multiple signs and measurements of MR severity, including left atrial size, left ventricular size and function, leaflet morphology and motion, mitral filling pattern, pulmonary venous flow patterns, and other variables (4). This approach acknowledges that various measurements may be discordant in individual patients and allows the interpreter to discount any parameter that is qualitatively poor. For example, in the Biner et al. study (3), observer variability for VCW was higher when the regurgitant orifice (i.e., VCW) could not be visualized. The integrative approach would ignore VCW in such a patient and emphasize the other findings. Although the integrative approach has been shown to predict outcomes (10), its validation against a reference standard and its observer variability remain to be rigorously tested.

The report by Biner et al. (3) has both strengths and limitations. A particular strength is that all studies were performed by a single, experienced sonographer, who acquired images of the color flow jet, VCW, and PISA using established, recommended methods. Therefore, the observed variability was not a function of technical study quality, but rather a true test of interpreter variability. The high degree of observer variability may in part be due to a selection bias in which patients being considered for surgery were studied. Had they studied a consecutive series of patients undergoing echocardiography, most of whom have no MR or mild MR, variability should have been much lower. On the other hand, they studied exactly those patients in whom the evaluation of MR severity is most clinically relevant. The main limitations of the study are obvious: a small number of patients—8 with degenerative MR and 8 with functional MR—and lack of an independent reference standard. Another potential limitation is that the readers were not given a standard set of rules or a training session by which to attempt to standardize criteria for selecting which frames to measure or for judging severe from nonsevere MR. Even though this could have potentially improved interobserver variability, no accepted standard protocol exists for routine clinical practice.

Despite these limitations, Biner et al. (3) have clearly shown that even objective parameters, such as VCW and PISA, are prone to high interobserver variability. This is a real cause for concern, because, as alluded to previously, the study's design limited the observed variability to just 1 factor, the interpretation differences among highly trained, academic cardiologists. In the real-world practice of cardiology, one might expect interobserver variability to be even higher. Ensuring adequate case volume, training modules, standardized protocols, physician credentialing, and continuing medical education may be requisite to lowering variability in the community. As noted earlier, automated computer image processing methods might also help, provided that they are shown to be accurate.

Optimal image acquisition is also critical in grading MR severity. As detailed previously, VCW and PISA radius are technically demanding measurements, which require careful and thorough interrogation of the mitral valve and regurgitant jet. Factors that limit this interrogation may include patient imaging windows and the level of sonographer training and experience. With the exception of converting a study from transthoracic to transesophageal, little can be done to improve the patient imaging window; however, the quality and variability of sonographer training may greatly influence image quality. Based on industry estimates, only one-half of the 40,000 practicing cardiac sonographers in the U.S. have received some form of certification from a recognized agency (D. Haydon, October, 2009). This fact has caught the attention of state legislatures. Recently, Oregon and New Mexico passed legislation mandating state licensure for all sonographers. There have also been suggestions that insurance companies may only reimburse for echocardiograms performed by credentialed sonographers in accredited laboratories. Regardless of certification and licensure requirements, it is clear that failure to obtain high-quality images with precise and reproducible measurements will result in even greater interobserver variability than reported by Biner et al. (3). Quality improvement initiatives should focus on improving sonographer training, continuing education, and image acquisition skills.

In closing, the ability to accurately distinguish nonsevere from severe MR is of critical importance for cardiologists as guidelines now recommend surgery for asymptomatic patients with severe MR. Biner et al. (3) demonstrated that even among experienced academic echocardiographers, intraobserver variability for common parameters used to grade MR severity is too high, implying that as a

community, we struggle to accurately and reproducibly identify those who would benefit from surgery. Although not directly tested, it seems plausible that a variety of factors likely increase this variability in the day-to-day practice of cardiology, rendering an even greater challenge. As Jonathan Swift's quote implies, the "vision" for correcting this problem may lie in quality improvement initiatives to improve training, continuing education, and credentialing for sonographers and physicians involved in evaluating the increasingly complex patients with MR. It seems that we have a lot of room for improvement, and that current echocardiographic grading of MR severity is more art than science.

Reprint requests and correspondence: Dr. Paul A. Grayburn, Baylor Heart and Vascular Institute, 621 North Hall Street, Suite H030, Dallas, Texas 75226. *E-mail: paulgr@baylorhealth.edu.*

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Key Words: effective regurgitant orifice area ■ mitral regurgitation ■ proximal isovelocity surface area ■ vena contracta width.