Value of Doppler Echocardiography for Quantifying Valvular Stenosis or Regurgitation

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During the past 2 decades there has been considerable enthusiasm for the development and use of noninvasive techniques for the initial and serial evaluation of patients with valvular heart disease. The results obtained with noninvasive methods often have altered the decision-making process, particularly when the physician is unsure of the severity of valvular stenosis and regurgitation after a routine clinical evaluation or when the results of noninvasive testing are applied to subgroups of patients in whom the history, physical examination, electrocardiogram, and other routine tests provide less precise positive or negative data. An important example is the elderly patient with vague symptoms of heart disease, with systolic hypertension, and with physical findings that may represent severe valvular aortic stenosis. Considering the increasing number of elderly patients, most of whom have a basal midsystolic murmur and considering the poor short-term prognosis without surgery of patients with severe symptomatic aortic stenosis and considering the excellent results of aortic valve replacement in all age groups, an accurate noninvasive method for quantifying the severity of aortic valve stenosis is highly desirable.

An accurate, reproducible, noninvasive method that quantifies the severity of valvular stenosis or regurgitation may indicate the absence of valvular disease and the need for no further testing, mild-to-moderate valvular heart disease requiring serial follow-up by noninvasive studies, or severe disease necessitating cardiac surgery. Cardiac catheterization may not be required, particularly in young patients without symptoms or risk factors for coincident coronary artery disease.

Until recently, the available noninvasive techniques, with few exceptions,1 have provided only indirect information about the severity of valvular stenosis or regurgitation and have focused on such consequences of the valvular disease as ventricular hypertrophy or dilatation, atrial dilatation, pulmonary venous hypertension, impaired ventricular performance, or a reduced stroke volume. In the past, the accurate quantification of the severity of valvular stenosis or regurgitation has generally required cardiac catheterization often with contrast cineangiography.2-4

With the advent of Doppler echocardiography in the middle 1970s and its refined application to many patients with valvular heart disease in the subsequent decade, a noninvasive method has become available for determining accurately the extent of valvular stenosis or regurgitation, often providing quantitative data for making patient-related decisions. The transvalvular pressure gradient can be calculated directly from blood velocity data by a modification of Bernoulli’s equation to calculate the convective energy loss as blood passes through the stenotic orifice.5 Stroke volume, valve area, and regurgitant fraction are calculated by combining velocity and anatomic information.6

In several clinical studies, the severity of aortic or mitral valve narrowing has correlated well with the extent of aortic or mitral stenosis determined at cardiac catheterization.7,8 As a result, Doppler measurements of transaortic valve pressure gradient and calculated aortic valve area are being made in many patients with suspected aortic valve stenosis. These have been particularly useful when applied to elderly patients in whom the exclusion of severe aortic stenosis on clinical grounds is often difficult. Also, Doppler velocity recordings have provided important quantitative information on many patients with mitral stenosis in whom percutaneous balloon mitral valvulotomy is an important new therapeutic option with early results similar to those in patients undergoing mitral commissurotomy.

The accuracy of Doppler echocardiography for quantifying aortic or mitral valve regurgitation is less well documented although the results of several clinical studies are promising.9,10 Qualitatively, the Doppler technique is usually able to distinguish severe from mild or no valvular regurgitation, but “false positive” evidence of mild valvular regurgitation is commonly reported in patients with no other clinical evidence of cardiac disease. Further-

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more, quantitative measurement of the regurgitant fraction as determined by the Doppler technique cannot be assessed accurately in all patients, and its determination by Doppler compared with its measurement by cardiac catheterization with cineangiography needs further investigation in larger numbers of patients.

In this month's Circulation, Jaffe and associates11 report an interesting prospective comparison of clinical evaluation and Doppler echocardiography results in 75 patients (146 valve lesions), all of whom underwent cardiac catheterization. Entry criteria included a clinical suspicion of significant valvular disease. Fifty-two percent of the patients had isolated single-valve disease, and 31% had multi-valve disease. The authors conclude that "Doppler echocardiography is more accurate than the clinical evaluation, and the need for assessment of valve function at cardiac catheterization can be avoided in many patients." The conclusions are justified by the data presented, but they must be considered with caution when making judgments concerning specific patients.

As with most clinical studies, there are certain limitations to the report by Jaffe et al. Each valve lesion was characterized only as absent, insignificant, or significant, and the definition of significant valvular stenosis or regurgitation is necessarily arbitrary. Many patients with an aortic valve area of 0.75–1.1 cm² or a mitral valve area of 1.0–1.5 cm², defined by Jaffe as significant and an indication for operation in symptomatic patients, would not necessarily be sent for valve surgery in many other institutions. When such patients are symptomatic, the symptoms are often due to noncardiac or associated coronary artery disease. Also, patients in this study with no valve lesion by any of the three methods were "excluded from the final analysis." If patients with suspected but no subsequent evidence of valve disease had been included, the clinical assessment would have shown a higher degree of accuracy. Nevertheless, in most situations where a "clinical error" might have been made, the examining cardiologist was unsure enough to have recommended further quantification of the severity of disease by cardiac catheterization.

The results by Doppler echocardiography for aortic and mitral valve stenoses by Jaffe and coworkers are consistent with other clinical reports.12,13 Applying the continuity equation to continuous-wave Doppler data, the correlation between aortic valve area by Doppler and cardiac catheterization was excellent (r = 0.95), but no confidence limits are provided. Also, the Doppler-determined mitral valve area (pressure half-time method) correlated well (r = 0.89) with the valve area calculated from catheterization data.

The accuracy of Doppler echocardiography for precise measurements of aortic or mitral regurgitation is less well established by the study of Jaffe et al. The regurgitation fraction could not be determined by Doppler in two thirds of the patients with mitral regurgitation, and a semiquantitative Doppler flow-mapping technique was substituted to assess the severity of regurgitation. Also, Doppler measurements of the regurgitant fraction could not be obtained in 30% of the patients with aortic regurgitation, and flow mapping was again substituted to estimate the severity of the regurgitation. Furthermore, in patients with aortic or mitral regurgitation, the severity of regurgitation by Doppler was compared only with a semiquantitative estimate of aortic or mitral regurgitation by single-plane cineangiography rather than with the quantified cineangiographic regurgitant fraction. An appropriate comparison of regurgitant fractions measured by Doppler and angiography was not made in the small subgroup of patients in whom it could be applied. Thus, the quantitative accuracy of the Doppler echocardiographic assessment of valvular regurgitation in this study remains undefined.

Doppler echocardiography is an important, relatively new technique that provides additional information about the severity of valvular stenoses or regurgitation that cannot be obtained by M-mode and two-dimensional echocardiography. M-mode echocardiography provides important data about wall thickness and valve leaflet motion, and two-dimensional echocardiography yields more precise information about chamber size and ventricular function. The three techniques are additive and are usually performed together. The importance of any diagnostic technique, including Doppler echocardiography, depends on its accuracy in the laboratory in which it is applied. Unfortunately, the additional value of Doppler echocardiography is highly dependent on obtaining high-quality recordings and on critical interpretation of the data.

There are several diagnostic options for the physician evaluating patients with suspected or definite valvular heart disease. If the clinical assessment reveals insignificant or no valvular heart disease with a high degree of certitude, no further noninvasive or invasive testing may be needed. If the clinical evaluation does not exclude significant valvular stenoses or regurgitation, additional testing is usually necessary. For the patient with no symptoms suggestive of ischemic heart disease, M-mode, two-dimensional, and Doppler echocardiography as a combined noninvasive examination is likely to yield the most information, and if insignificant or no valve disease is determined by a properly performed and interpreted echocardiographic study, no cardiac catheterization is necessary. If the study indicates severe valve disease in a patient unlikely to have significant coronary artery stenosis, surgery often can be recommended without subsequent cardiac catheterization. However, if the patient is at increased risk for
coronary artery disease, considering recently proposed criteria for coronary angiography based on the patient's age, sex, and type of valve lesion, or has symptoms compatible with myocardial ischemia, cardiac catheterization with coronary angiography is usually necessary. Finally, although the study by Jaffe et al is promising, it does not yet seem to establish whether or not Doppler echocardiographic estimates of valvular regurgitation by the semiquantitative or regurgitant fraction techniques are sufficiently reliable to make a recommendation for operation based primarily on the degree of regurgitation by Doppler echocardiography.

References

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