JACC Vol. 15, No. 4
March 15, 1990:825–6

Editorial Comment

Doppler Echocardiographic Evaluation of Stenotic Bioprosthetic Aortic Valves*

CATHERINE M. OTTO, MD, FACC,
ALAN S. PEARLMAN, MD, FACC
Seattle, Washington

Noninvasive evaluation of native aortic valve stenosis by two-dimensional and Doppler echocardiography is feasible, accurate and cost-effective for clinical decision making (1,2). The etiology of valve disease and left ventricular systolic function can be assessed with transthoracic two-dimensional imaging, whereas the severity of stenosis can be quantitated by the Bernoulli equation to calculate maximal and mean transaortic pressure gradients and the continuity equation to calculate valve areas. In addition, the degree of coexisting aortic regurgitation can be estimated with pulsed, continuous wave and color flow imaging Doppler techniques.

Echocardiographic assessment of prosthetic aortic valves has been more difficult. Two-dimensional imaging is limited by reverberations and shadowing by the valve sewing ring and stents, and for mechanical valves, by the occluders as well. Although the fluid dynamics of different mechanical valves are variable and quite complex (3), a central-flow bioprosthetic valve has fluid dynamics similar to those of a native valve. Thus, it is reasonable to assume that Doppler methods for quantitating the severity of native aortic valve stenoses should also be applicable to aortic bioprostheses. It is important to remember that a "normally functioning" bioprosthetic valve is inherently stenotic, so that the systolic pressure gradient will be higher and valve area smaller compared with those of a normal native aortic valve.

The present study. In this issue of the Journal, Rothbart et al. (4) present data comparing Doppler echocardiographic and invasively determined valve areas in a series of patients with an aortic bioprosthetic valve. Earlier studies (5–8) have defined the normal range of anterograde velocities across prosthetic valves (5,6), demonstrated the accuracy of aortic bioprosthetic valve pressure gradient measurement (5) and used continuity equation valve areas to compare groups of patients with bioprosthetic valves (7,8). However, the present study of Rothbart et al. (4) is the first comparison between Doppler continuity equation aortic valve areas and invasively determined valve areas.

Despite the potential technical difficulty of the Doppler method, adequate data for calculating continuity equation valve area could be recorded in nearly all patients, demonstrating the feasibility of this approach. The validity of continuity equation valve areas is supported by the reasonable correlation with invasively measured valve areas in the subgroup with both studies. Given recent studies (9–11) documenting the limitations of the Gorlin equation for determining bioprosthetic valve areas, it is unclear whether the discrepancies between the two methods in this study are due to the Doppler approach or to the standard of reference. On the other hand, an alternative standard for bioprosthetic valve area determination in vivo does not exist; thus, the data presented here represent the only feasible validation of this diagnostic method in patients.

Technical aspects. An important technical aspect of this approach is choice of the optimal site for measuring left ventricular outflow tract diameter and flow velocity. Both should be measured at the same anatomic site, because these data must yield an accurate volume flow measurement. Difficulties arise because diameter must be measured from a parasternal window (for optimal endocardial definition), whereas the velocity curve is recorded from an apical window (to be parallel to flow). Diameter is measured immediately below the aortic valve and the velocity curve is recorded immediately proximal to the region of acceleration into the aortic jet. We attempt to record the aortic valve closing (but not opening) click on the outflow velocity curve to ensure that the velocity recording is, as nearly as possible, from the same site as the diameter measurement. A more proximal sample volume location would result in a lower outflow velocity and potential underestimation of valve area.

As noted by Rothbart et al. (4), it is not surprising that outflow tract diameter was of little importance in determining valve area *in their patients* given the small range of valve sizes (and effective outflow tract areas). However, in other patient groups, outflow tract diameter may be of more importance and should be used in the continuity equation whenever possible. Use of prosthetic sewing ring size in the continuity equation or sole use of the outflow tract to aortic jet velocity ratio should be reserved for patients in whom suboptimal image quality prevents accurate outflow tract diameter measurement.

Diagnostic accuracy. The proposed diagnostic criteria for differentiating a stenotic from a normally functioning aortic

*Editorials published in *Journal of the American College of Cardiology* reflect the views of the authors and do not necessarily represent the views of JACC or the American College of Cardiology.

From the Division of Cardiology, Department of Medicine, University of Washington, Seattle, Washington.

Address for reprints: Catherine M. Otto, MD, Division of Cardiology, RG-22, Department of Medicine, University of Washington, Seattle, Washington 98195.

0735-1097/90/$3.50

JACC Vol. 15, No. 4
March 15, 1990:825-6

bioprosthesis will be valuable clinical aids in evaluating patients with this type of prosthesis. Of course, because the breakpoints were defined in the patient group of interest, prospective validation of these criteria in a separate group of patients is needed before they are applied widely (12), as Rothbart et al. (4) emphasized. Such validation is important not only because predictive accuracy depends on the prevalence of the disease (e.g., stenotic bioprosthesis) in the group studied, but also because groups that include more patients with a smaller bioprosthetic valve will show more overlap in valve area measurement between the patients with normal and abnormal prosthetic valve function.

Conclusions. Rothbart et al. (4) provide convincing data to support the validity of applying the Doppler continuity equation to bioprosthetic aortic valves. Prospective validation of the proposed diagnostic criteria to identify patients with a stenotic bioprosthesis is needed. Meanwhile, a practical approach is to perform a quantitative Doppler echocardiographic examination soon after aortic valve replacement for use as each patient's own baseline for future studies. Extension of these data to the evaluation of mechanical aortic valves should be made cautiously given their more complex fluid dynamics.

References

1. Otto CM, Pearlman AS. Doppler echocardiography in adults with symptomatic aortic stenosis: diagnostic utility and cost-effectiveness. Arch Intern Med 1988;148:2553-60.
2. Oh JK, Taliercio CP, Holmes DR Jr, et al. Prediction of the severity of aortic stenosis by Doppler aortic valve area determination: prospective Doppler-catheterization correlation in 100 patients. J Am Coll Cardiol 1988;11:1227-34.
3. Jones M, McMillan ST, Eidbo EE, Woo Y-R, Yoganathan AP. Evaluation of prosthetic heart valves by Doppler flow imaging. Echocardiography 1986;3:513-25.
4. Rothbart RM, Castriz JL, Harding LV, Russo CD, Teague SM. Determination of aortic valve area by two-dimensional and Doppler echocardiography in patients with normal and stenotic bioprosthetic valves. J Am Coll Cardiol 1990;15:817-24.
5. Reisner SA, Meltzer RS. Normal values of prosthetic valve Doppler echocardiographic parameters: a review. J Am Soc Echo 1988;1:201-10.
6. Miller FA Jr, Callahan JA, Taylor CL, Larson-Keller JJ, Seward JB. Normal aortic valve prosthesis hemodynamics: 609 prospective Doppler examinations (abstr). Circulation 1989;80(suppl II):II-169.
7. Teoh KH, Fulop JC, Weisel RD, et al. Aortic valve replacement with a small prosthesis. Circulation 1987;76(suppl III):III-123-31.
8. Jaffe WM, Coverdale HA, Roche AHG, Brandt PWT, Ormiston JA, Barratt-Boyes BG. Doppler echocardiography in the assessment of the homograft aortic valve. Am J Cardiol 1989;63:1466-70.
9. Cannon SR, Richards KL, Crawford MH, et al. Inadequacy of the Gorlin formula for predicting prosthetic valve area. Am J Cardiol 1988;62:113-6.
10. Carabello BA. Advances in the hemodynamic assessment of stenotic cardiac valves. J Am Coll Cardiol 1987;10:912-9.
11. Gorlin R. Calculations of cardiac valve stenosis: restoring an old concept for advanced applications. J Am Coll Cardiol 1987;10:920-2.
12. Wasson JH, Sox HC, Neff RK, Goldman L. Clinical prediction rules: applications and methodological standards. N Engl J Med 1985;313:793-9.