Editorial:
Crossing the Aortic Valve in Severe Aortic Stenosis: No Longer Acceptable?

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In the past, left ventricular catheterization was needed to confirm the grade of aortic stenosis before surgery, but today echocardiography allows an accurate and completely non-invasive assessment that provides the same information. Although many centers now accept echocardiographic measures of pressure difference and orifice area as the 'gold standard', this situation is not universal, and clinical practice has not moved uniformly with the times. This places patients at unnecessary risk.

Risks from crossing the aortic valve

The surface of the stenotic aortic valve in a patient with calcific degenerative disease may be layered with atheroma, calcific deposits, or secondary thrombus (1). Anecdotal or retrospective accounts exist of calcific or platelet emboli to the brain and kidneys following cardiac catheterization (2). A recent prospective study (3) showed a 3% incidence of clinical stroke and a 22% incidence of new defects on magnetic resonance imaging after retrograde left ventricular catheterization for aortic stenosis. By contrast, there were no strokes or defects on magnetic resonance imaging in patients who only had coronary angiography. Other potential complications of cardiac catheterization include pulmonary edema, cardiogenic shock and death, cardiac arrhythmia, and ventricular perforation. The risk of a potentially fatal complication is about 7% - double that of coronary angiography alone (4,5).

What information does echocardiography provide?

Echocardiography provides detailed information about the appearance and function of the aortic valve. An initial assessment of the grade of stenosis is made with the peak velocity, and usually the estimated peak pressure difference derived from the transaortic continuous-wave Doppler signal. The peak pressure difference is maintained for only a short time, and may not always be representative of the grade of stenosis, particularly if the flow is high. Mean pressure difference is calculated over the whole wave-form and is more representative (Fig. 1). Effective orifice area using the continuity equation provides a relatively flow-independent measure when the left ventricular ejection fraction is reduced, or if the raw velocity information is close to the arbitrary threshold between two grades. If necessary, a wide range of ancillary measures are available, including transaortic resistance, peak-to-mean pressure ratio, relative prolongation of the ejection time, or the velocity integral ratio.

The non-invasive nature of echocardiography allows serial measurements to be made in large populations, and this has improved our understanding of the fre-

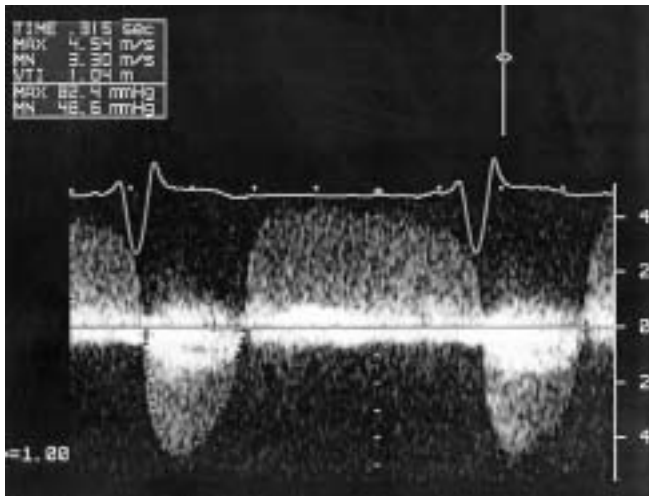

Figure 1: Continuous-wave Doppler signal in aortic valve disease. This shows a waveform recorded from the apex in a patient with dominant aortic stenosis. The forward signal is below the line, and the regurgitant jet above the line. The on-line software calculates pressure difference semi-automatically from the velocity data. The ejection time and systolic velocity integral are also displayed, and can be used for calculating other quantities including resistance or effective orifice area using the continuity equation.

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quency of aortic valve disease (6) and its natural history (7,8). The criteria for surgery are now established using echocardiography (9), and the technique can also aid the planning of surgery - for example, from the size of the annulus or the presence of excessive calcification. Echocardiography also describes the left ventricle, aorta, right ventricle, and the other valves. This information may also be important in planning surgery, for example to determine whether coexistent mitral valve surgery is necessary

How do catheter and echocardiographic hemodynamic data differ?

There is excellent agreement between mean or peak instantaneous pressure difference obtained using the two techniques with transducer-tipped catheters (10). Differences between echocardiographically and invasively derived 'gradients' are largely caused by temporal and spatial differences in what is actually measured. Peak instantaneous pressure difference on echocardiography and 'peak-to-peak' pressure difference on pull-back at catheterization are measured at different times. Doppler measures the maximum pressure difference at the vena contracta, and cardiac catheterization the recovered net pressure difference between the left ventricle and the aorta downstream from the valve (11). In addition, fluid-filled catheter systems give a poor frequency response of about 20 Hz compared with about 50 Hz for transducer-tipped catheters (Fig. 2). This can introduce significant errors in measurement.

Is catheterization ever necessary?

Cardiac catheterization remains necessary for coronary angiography. On occasion, it is difficult to estimate right-sided pressures with echocardiography; catheterization is also better at measuring pulmonary resistance should it be necessary to know this. Otherwise, echocardiography should suffice (12).

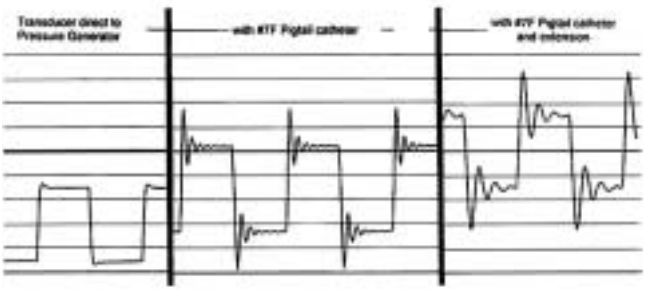

Figure 2: The effect of fluid-filled lines on pressure recording. A square-wave is generated and recorded directly by the transducer (a). Progressive damping and overshoot occur with interpolation of the fluid-filled 'pig tail' catheter (b) and manometer line (c). Reproduced by permission of Mr. G. Leech.

Occasionally, the echocardiographic data may be incomplete (5,13), or there may be a perceived discrepancy between the clinical impression and echocardiography (5). This is uncommon however, and should usually be resolved by the involvement of a more experienced echocardiographer.

In an individual patient with aortic stenosis of uncertain degree on echocardiography, the properly measured catheter net gradient may provide useful complementary information. However, there are usually other ways of obtaining information non-invasively to guide decision making. This may involve the use of dobutamine stress echocardiography to determine pressure drop flow slopes (14) or the effect of flow on pressure difference, effective orifice area or left ventricular function (15). Sometimes, a non-valve-related investigation such as an exercise test or lung function testing is more appropriate.

When both catheterization and echocardiography are performed, the catheter data about the aortic stenosis rarely lead to modifications of management (16-19). However, the relative authority given to either technique is subjective, and this makes comparative studies difficult to interpret. Using the independent standard of clinical events, decisions made putting the catheter above echocardiography have tended to be proved incorrect (17,19).

Why has practice not changed?

In at least two centers in the USA, a decline in the use of retrograde catheterization has been documented, from 64% in 1986 to 54% in 1990 and to 23-30% in 1994 (5,13). In some individual laboratories, routine catheterization has been banned, while in others it remains routine.

One major reason for the discrepancy in practice appears to be variable familiarity with echocardiography. One comparative study (20) reported that echocardiographic information was deficient in as many as 21% of cases, and catheterization was needed to provide information about left ventricular function, cardiac output, right-heart pressures and the aortic root. All of these parameters are usually routinely obtainable by echocardiography, and it is likely that the clinicians involved were either relatively untrained in echocardiography or more trusting of catheterization. Other studies have also shown that the use of cardiac catheterization is more likely if the operator is inexperienced echocardiographically (5,13).

In the past, echocardiography was sometimes limited by poor 'windows' as a result of body habitus or chronic lung disease, but this is uncommon with modern instruments. Echocardiography is criticized as being dependent on the skill of the user, and although this is true it is also true of cardiac catheterization.

Furthermore, if a center is perceived as being deficient echocardiographically, this should not be regarded as a criticism of the technique but rather of the center, and the solution must be to improve the echocardiography service.

Conclusion

Echocardiography is the 'gold-standard' for grading aortic stenosis. The natural history and criteria for surgery are now established using echocardiography. Crossing the aortic valve in severe aortic stenosis is dangerous, and should rarely be necessary. If judged essential in an individual case, we suggest that the rationale and alternative strategies should be discussed and the patient consented appropriately. If echocardiography at an individual center is not trusted, the response should be to develop the non-invasive laboratory rather than to resort to routine retrograde left ventricular catheterization.

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