The Intraoperative Quantification of Aortic Stenosis

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In the industrialized world, aortic stenosis (AS) is the most common valvular heart abnormality and is primarily the result of calcific valvular disease.[1] Its prevalence increases with age, reaching 2.8% in individuals older than 75 yr.[2]

When history and clinical examination suggest the diagnosis of AS, transthoracic echocardiography (TTE) is the confirmatory test of choice. The focus then shifts to the quantification of disease severity. Doppler echocardiography is used to calculate the transvalvular pressure gradient and, in combination with the left ventricular outflow tract (LVOT) diameter, allows derivation of aortic valve area (AVA) using the continuity equation.[3]

Valve replacement surgery is indicated when symptomatic AS is severe (valve area <1 cm^2, Doppler velocity$>$ 4 m/s).[4] In asymptomatic patients with severe AS, the benefit of surgery is less clear, but may be considered in patients with left ventricular systolic dysfunction, those who develop symptoms during stress testing, the presence of severe valvular calcification or a rapid rate of peak velocity progression.[4,5] Many patients previously rejected for surgery because of prohibitive risk are now being operated on, including octogenarians and patients with advanced degrees of left ventricular dysfunction.[6,7] Percutaneous aortic valve replacement (endovascular or via the left ventricular apex)[8,9] is being studied as an option for patients with prohibitive surgical risk.

In patients presenting for aortic valve replacement, intraoperative transesophageal echocardiography (TEE) can yield important information on the structure of the aortic root and ascending aorta. It may also help delineate associated abnormalities, such as left ventricular hypertrophy, systolic and diastolic function, and functional characteristics of the other cardiac valves. Baseline findings can be compared to those after cardiopulmonary bypass. Occasionally, a new abnormality, such as the presence of subaortic stenosis, may lead to a change in the surgical plan.[10,11]

In patients presenting for other cardiac surgical procedures, such as coronary artery bypass grafting or mitral valve replacement, the presence of moderate or severe AS should generally be corrected at the time of the primary procedure.[12] In rare instances, intraoperative TEE may yield *de novo* evidence of moderate or severe AS. Intraoperative quantification of AS in the anesthetized patient is problematic; there is no opportunity to obtain a proper history, and symptoms gleaned from the medical record may be a result of the primary indication for cardiac surgery. Initial enthusiasm for the use of planimetry for the determination of AVA by TEE[13] was based on the minimal number of steps needed to arrive at a measurement; the use of planimetry has been dampened by inaccurate measurements obtained in the setting of heavily calcified or bicuspid valves.[14,15]

As noted above, the continuity equation is routinely used to calculate AVA; Doppler measurement of aortic valve and LVOT velocities can be obtained from the deep transgastric or the transgastric long axis imaging planes.[16,17] However, difficulty may be encountered in obtaining parallel Doppler alignment and significant signal attenuation may be seen in the presence of heavily calcified aortic valves.[18]

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Accepted for publication August 28, 2008.

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DOI: 10.1213/ane.0b013e31818db6e1

The reasons for the resurgence in popularity of epicardial (EE)[19] and epiaortic[20] echocardiography as alternatives to TEE during cardiac surgery are the ability to use these techniques in patients with contraindications to TEE, and the recognition that image quality may be superior in certain clinical settings. Specifically, attenuation of the aortic valve Doppler signal will be less than with TEE as the flow is interrogated proximal to the calcified valve.

In this issue of the journal, Hilberath et al.[21] describe the use of EE in the calculation of AVA by the continuity equation. Comparisons are made to values obtained with the continuity equation by TEE, TTE, and by the Gorlin formula[22] used during cardiac catheterization.

The main strength of this paper is the important comparison that was made between EE and TTE, as the latter is the most commonly used preoperative method for measurement of AVA, and is also unencumbered by the problem of pressure recovery.[23] This phenomenon is based on the fact that blood flowing in the LVOT consists of kinetic energy (velocity) and potential energy (pressure). As blood accelerates through the stenotic aortic valve, it is accompanied by a maximal decrease in pressure at the vena contracta, the narrowest diameter of the stream of flow; Doppler echocardiography measures these variables that are then used in calculating AVA. As flow reexpands beyond the valve, the kinetic energy is converted back to pressure (Law of conservation of energy), so that the catheter pullback technique (used during cardiac catherization with the Gorlin formula) measures a smaller pressure gradient and AVA.[24] As AS worsens and the ascending aorta dilates, the turbulence of flow in the aortic root leads to dissipation of energy, less pressure recovery, and less "Doppler-catheter discrepancy."[25,26]

The investigators were able, in most patients, to acquire the requisite data. Intraobserver and interobserver variability of AVA measurements were acceptable, and the values of AVA with EE and TTE were strongly correlated. Data on the 95% limits of agreement (Bland Altman)[27] were included; this technique speaks more clearly to whether the EE and TTE can be used interchangeably in the measurement of AVA.[28] The mean difference between EE and TTE measurement of AVA was -0.06 cm^2 with a standard deviation of 0.11, indicating that for 95% of individuals the difference between EE and TTE measurement of AVA was between 0.16 cm^2 and 0.28 cm^2. The wide scatter at all mean valve areas shows that the interchangeability of the two values may not be clinically acceptable.

The paper's limitations are that, ideally, the authors should have commented *a priori* on what difference in AVA measurement between EE and TTE was clinically acceptable. The study was also limited by its retrospective nature and the fact only 76% of the subjects had a TTE available for comparison. A prospective study comparing matched EE and TTE is in order. That being said, EE can help quantify disease severity in the instance of a "surprise diagnosis" of AS during cardiac surgery, but adequate preoperative workup should keep this occurrence to a minimum.[29]

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