Options for Incidental Moderate Aortic Stenosis During Concomitant Valve Surgery: A Clinical Update for the Perioperative Echocardiographer

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THE INCIDENCE of valvular heart disease, including aortic stenosis (AS), continues to grow worldwide. Recent data from the American Heart Association indicate that valvular heart disease has an overall prevalence of 2.5% in the United States.[1,2] In the elderly, AS has an incidence of nearly 10% over age 80 years, with eventual progression to severe AS once mild obstruction has developed.[3] Furthermore, adults with congenital heart disease comprise a growing proportion of patients with VHD, with published data pointing to approximately 1 million adult patients in the US alone.[4,5] More than 50% of these patients will need repeat cardiac surgery.[6] Bicuspid aortic valve, a common cause of AS in adults, is the most common congenital valvular defect, with an estimated prevalence of 1% to 2% in the general population.[7] The costs of AS alone as a component of valvular heart disease have been estimated to have an annual direct cost of at least $1 billion.[8] Given that AS is common in patients with valvular heart disease, the clinical scenario of incidental AS in adult cardiac surgical patients presenting for valvular surgery will fall into the practice of the perioperative echocardiographer. This expert review will outline the management options for this scenario in the era of detailed guidelines, 3-dimensional (3D) echocardiography, and transcatheter aortic valve replacement (TAVR).[9]

CURRENT DEFINITION OF MODERATE AORTIC STENOSIS

Recent guidelines from the European Association of Echocardiography (EAE) and the American Society of Echocardiography (ASE) have defined moderate AS by the following criteria: an aortic jet velocity of 3.0 to 4.0 m/s; a mean gradient of 20 mmHg to 40 mmHg; an aortic valve area of 1.0 to 1.5 cm^2; an indexed aortic valve area of 0.6 to 0.85 cm^2/m^2; and a velocity ratio of 0.25 to 0.50.[10] Recent valvular heart disease guidelines from the American Heart Association (AHA) and the American College of Cardiology (ACC) defined the stages of progression of aortic stenosis in the following 4 stages: stage A was defined as patients with risk factors for development of AS; stage B was defined as patients with progressive AS that is of mild-to-moderate severity and that has remained asymptomatic; stage C was defined as asymptomatic severe AS with or without ventricular dysfunction; and stage D was defined as symptomatic severe AS.[11] Therefore, in terms of this AHA/ACC perspective, this expert review concerns patients presenting for valvular heart surgery with incidental stage-B AS.[11] The ACC/AHA guideline has recommended serial transthoracic echocardiography every 1 to 2 years for monitoring of AS severity in patients with stage-B AS of moderate severity, assuming normal left ventricular function and a normal stroke volume.[11] Similar to the EAE/ASE guideline, the ACC/AHA guideline has defined moderate AS by the following criteria: an aortic jet velocity of 3.0 to 4.0 m/s and/or a mean gradient of 20 mmHg to 39 mmHg.[11] These definitions for moderate AS based on transaortic maximum velocity assume that transaortic volume flow rate falls within the normal range.[10,11]

SOURCES OF ERROR IN THE GRADING OF MODERATE AORTIC STENOSIS

Some patients with AS have a low transaortic flow rate that may be due to left ventricular (LV) systolic dysfunction or significant diastolic restriction (small hypertrophied left ventricle). Both categories of low-flow AS have a low stroke volume in common. Therefore, in this low-flow state, transaortic gradient will be low and may thus underestimate the severity of AS.[10,11] In selected cases, dobutamine stress echocardiography may be required to augment transaortic flow in patients with ventricular dysfunction to document the true transaortic maximum velocity and mean gradient for correct grading of AS severity.[10,11] Conversely, in the setting of high transaortic flow, the transaortic maximum velocity and mean gradient will be high even in the setting of moderate AS with a valve area above 1.0 cm^2. Transaortic flow rate typically is high due to co-existent significant aortic regurgitation

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(augmented LV stroke volume) or a high-cardiac-output state (eg, fever; hyperthyroidism).[10,11]

The EAE/ASE guideline for the grading of AS also has recommended that the aortic valve area be indexed to body surface area, especially in the setting of height <135 cm or body surface area <1.5 m^2 (see earlier definition of moderate AS).[10] This AV area index will thus prevent the error of misclassifying the severity of AS based on extremes of adult body size. For example, in an elderly lady with AS and a body surface area of 1.4 m^2, an aortic valve area of 1.4 cm^2 clearly is not consistent with moderate AS when indexed to the small body surface area. In this case, the indexed aortic valve area is 1.0 cm^2/m^2, which lies above the EAE/ASE range for moderate AS of (0.6-0.85) cm^2/m^2.

LOW-FLOW AORTIC STENOSIS

Low-flow AS is characterized by low transaortic flow. There are 2 large subgroups in this AS population, those with reduced LV ejection fraction and those with preserved LV ejection fraction.[10,11] In patients with low-flow AS with preserved LV function, the low transaortic flow is due to a low LV end-diastolic volume typically due to severe LV hypertrophy in the setting of a small LV.[10,11] The natural history of this AS subtype recently has received significant attention since it appears to be distinct.[12] In a recent observational trial (n = 809), patients with severe low-flow AS with a preserved LV ejection fraction had similar outcomes to patients with mild-to-moderate AS (adjusted hazard ratio 0.96; 95% confidence interval 0.58-1.53) and was not influenced favorably by aortic valve replacement (adjusted hazard ratio 0.75; 95% confidence interval 0.14-4.05). Although further trials are indicated to characterize the natural history of low-flow AS with preserved LV function, this entity should be considered in the evaluation of incidental AS in the cardiac surgical patient presenting for a valvular procedure.

In a large TAVR analysis (n = 971), low-flow AS was defined as patients with AS who also had a $<$35-mL/m^2 LV stroke volume index.[13] In this cohort of high-risk AS patients, low-flow AS was common, with a 55% incidence. In this trial, low-flow AS with preserved LV ejection fraction also was called "paradoxical" because the expectation is that with normal LV function, transaortic flow should be normal. The paradox here is that although pump function is intact, there is still low flow due to a low LV end-diastolic volume, as outlined earlier.

In contrast to ejection fraction and transaortic gradient, low-flow AS was an independent predictor of mortality across all patient strata (approximate hazard ratio of 1.5).[13] Furthermore, in patients with low-flow AS and preserved ejection fraction, TAVR reduced mortality at 1 year from 66% to 35% (hazard ratio 0.38; p = 0.02).[13] This important clinical trial has highlighted the importance of including a measure of flow, such as LV stroke volume index, in the complete evaluation of AS. In this analysis, low-flow AS was common, clinically important and was favorably influenced by TAVR.[13] Further trials will likely focus on this important AS subtype, given its incidence and outcome significance.[14,15] The perioperative echocardiographer should include LV function and stroke volume index in the comprehensive assessment of AS since gradient alone often may underestimate the true severity of the incidental AS.

THE CONTRIBUTION OF 3D ECHOCARDIOGRAPHY IN THE GRADING OF AORTIC STENOSIS

The calculation of aortic valve area in the continuity equation assumes not only the preservation of volumetric flow across the aortic valve, but also that the LV outflow tract area is circular in shape.[10] This circular assumption means that the LV outflow tract (LVOT) area is a function of the square of its radius, given that the formula for the area of a circle is $A=\pi r^2$ (where A = area and, r = radius).[10,11] The LVOT diameter is typically measured in the midesophageal long-axis view of the aortic valve during transesopahageal echocardiography (TEE). As can be seen from the formula, small errors in this measurement will be magnified since the radius is squared to result in significant error in the final aortic valve area.[10,11] This is the reason that the accurate measurement of the LVOT radius remains vital for accurate determination of aortic valve area and correct grading of AS severity.

It turns out that this circular assumption for the LVOT area frequently is incorrect.[16] Recent 3D imaging of the LVOT has revealed that it frequently is elliptical rather than circular.[16,17] This ellipse has a major diameter, minor diameter, a circumference, and an area.[16,17] All of these parameters can be measured accurately and directly during 3D multiplanar reconstruction with either 3D echocardiography or 3D computed axial tomography.[16,17] The correct sizing of the aortic annulus in the 3D LVOT has revolutionized the contemporary practice of TAVR within a multidisciplinary heart team model with respect to grading of AS, selection of stent type and size, stent implantation, detection and management of complications, and postoperative management.[18-20] The single 2D LVOT diameter measured in the typical fashion during TEE frequently measures the minor diameter of the ellipse, resulting in underestimation of the true LVOT size, which has important consequences such as underestimation of the AS severity, undersizing of the TAVR prosthesis, and a significant risk for paravalvular regurgitation and stent migration.[21-23] The take-home message here for the perioperative echocardiographer is that 3D multiplanar reconstruction and direct measurement of the LVOT diameter and the anatomic aortic valve area eliminate sources of error due to geometric assumptions that may not be valid in the individual patient.[16-20,24] The impact of 3D imaging of the aortic valve complex in the functional aortic annulus already has resulted in a clinical drift towards routine application of this technology with echocardiography, computed axial tomography, and/or magnetic resonance imaging in the preoperative assessment of patients for both surgical and transcatheter AVR.[16,17,24-26]

THE MANAGEMENT OF INCIDENTAL MODERATE AORTIC STENOSIS

The focus until this point in this expert review has been about the definition and accurate assessment of moderate aortic stenosis as an incidental finding in the patient presenting for cardiac surgery. This section now will discuss the options and guideline recommendations for the management of moderate AS in the adult cardiac surgical patient. The first major modifier is the presence of significant coronary artery disease that may or may not be the primary indication for cardiac surgery. Approximately 40% of patients with valvular heart disease will have concomitant coronary artery disease.[27,28]