EXPERT REVIEW

John G.T. Augoustides, MD, FASE, FAHA
Section Editor

Moderate Aortic Stenosis and Coronary Artery Bypass Grafting: Clinical Update for the Perioperative Echocardiographer

Yasdet Maldonado, MD,* Saket Singh, MD,* John G. Augoustides, MD, FASE, FAHA,† Brenda MacKnight, MD,* Elizabeth Zhou, MD,† Jacob T. Gutsche, MD,† and Harish Ramakrishna, MD, FASE‡

Incidental aortic stenosis in the setting of coronary artery bypass surgery may be a perioperative challenge. The accurate assessment of the degree of aortic stenosis remains an important determinant. Although severe aortic stenosis is an indication for valve replacement, current guidelines advise a balanced approach to the management of moderate aortic stenosis in this setting. Multiple factors should be considered in a team discussion to balance risks versus benefits for the various management options in the given patient. The rapid progress in aortic valve technologies also offer alternatives for definitive management of moderate aortic stenosis in this setting that will likely become even safer in the near future.

PATIENTS REQUIRING coronary artery bypass grafting (CABG) often may undergo comprehensive intraoperative transesophageal echocardiography (TEE) as part of perioperative management.[1,2] In this setting, TEE may reveal associated cardiac pathology that may require incidental cardiac conditions that may require surgical intervention at the time of CABG.[2–5] A retrospective analysis of patients undergoing isolated CABG from 1990 to 2005 (N = 12,566) revealed that intraoperative TEE influenced surgical decisions in 5.4% of procedures.[6] Furthermore, in this large analysis, 3.3% of study subjects had an additional mitral or aortic valve procedure added to their CABG procedure as a result of incidental findings from intraoperative TEE.[6] Even though recent CABG guidelines recommend that aortic intervention is reasonable for moderate aortic stenosis (AS), the perioperative decision as to whether to intervene is complicated by factors such as patient age, associated comorbidities, expanding surgical and percutaneous options, and advances in imaging techniques.[7] The purpose of this expert review is to ev1aluate these important questions to both provide a guide for decision making and a clinical update for the perioperative echocardiographer.

*From the *Department of Anesthesiology, Allegheny Health Network, Temple University School of Medicine, Pittsburgh, PA; †Department of Anesthesiology and Critical Care, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA; and ‡Department of Anesthesiology, Mayo Clinic, Scottsdale, AZ.*

Address reprint requests to John G. Augoustides, MD, FASE, FAHA, Cardiothoracic Section, Anesthesiology and Critical Care, Dulles 680, HUP, 3400 Spruce Street, Philadelphia, PA, 19104-4283. E-mail: yiandoc@hotmail.com

1053-0770/2601-0001$36.00/0

http://dx.doi.org/10.1053/j.jvca.2015.04.007

Key Words: aortic stenosis, coronary artery bypass grafting, risk stratification, transesophageal echocardiography, aortic valve area, minimally invasive, port access, sutureless, transcatheter aortic valve replacement, three-dimensional imaging, ellipse, pressure recovery, continuity equation, geometric orifice area, effective orifice area, Gorlin area

INCIDENTAL MODERATE AORTIC STENOSIS AT THE TIME OF CABG

Although there have been dramatic advances in the medical and percutaneous management of coronary artery disease, recent trials have highlighted the therapeutic value of CABG in scenarios such as left main or 3-vessel coronary artery disease, especially in the setting of diabetes mellitus.[8–10] Besides the enduring clinical indications for CABG, the prevalence of significant aortic stenosis requiring surgical intervention is increasing steadily due to factors such as an aging population, advances in aortic intervention such as transcatheter aortic valve replacement, and advances in cardiac imaging such as 3-dimensional TEE.[11–15] The incidence of incidental AS in contemporary patients presenting for CABG recently has been estimated at about 2.5%.[13]

Although recent guidelines recommend severe AS as a Class-I indication for severe surgical aortic valve replacement (AVR), lesser grades of AS present a complex clinical dilemma at the time of CABG since it is unclear at which threshold untreated AS impacts long-term outcome.[15,16] A recent Mayo Clinic analysis (N = 624) evaluated the outcome effects of mild or moderate AS (defined as aortic valve area from 1.0-2.0 cm^2) in patients who underwent isolated CABG.[16] Although mild/moderate AS did not affect perioperative mortality ($p = 0.1$), it did result in an increased risk for future aortic valve intervention (as high as 21% for patients with moderate AS, defined as an aortic valve area from 1.0-1.5 cm^2).[16] Furthermore, in the Mayo analysis, moderate AS was an independent risk factor for late mortality ($p = 0.001$) following isolated CABG.[16] This mortality risk also was inversely related to aortic valve area. Patients with aortic valve areas of 1.0 cm^2 to 1.25 cm^2 had 2.5-fold increase in mortality (hazard ratio 2.45; 95% confidence interval 1.57-3.82; $p < 0.001$) as compared to patients with aortic valve areas of 1.25 cm^2 to 1.50 cm^2 who had a 1.8-fold increase in mortality (hazard ratio 1.83; 95% confidence interval 1.28-2.61; $p = 0.001$).[16] The investigators concluded that untreated moderate AS independently predicts excess late mortality after CABG, with the greatest risk in

patients with moderate-to-severe AS (defined as aortic valve area 1.0-1.25 cm^2).[16] Future trials are indicated to test whether or not aortic valve intervention mitigates this identified mortality risk.

The estimated average progression of AS is a decline of aortic valve area of approximately 0.1 cm^2/year.[17] Hence, patients with aortic valve areas of 1 cm^2 to 1.25 cm^2 at time of diagnosis can be expected to develop severe AS within 5 years. According to the 2014 ACC/AHA valvular heart disease guidelines, expert opinion has recommended AVR as reasonable for patients with moderate AS (defined as an aortic velocity of 3.0 m/s to 3.9 m/s or an aortic mean pressure gradient of 20-30 mmHg) who are undergoing cardiac surgery (Class-IIa Recommendation IIA; Level of Evidence C).[15] In a recent thoracic aortic guideline, the Society of Thoracic Surgeons also has supported performing an AVR in patients with moderate AS undergoing CABG (Class-IIa Recommendation IIA; Level of Evidence B).[18]

Since AS is a progressive disease, symptom onset is likely within 5 years once moderate AS is present. It is also important in patients with both coronary artery disease and AS for the clinician to be able to differentiate the origin of the symptomatology since symptomatic AS has a poor prognosis. Individuals with AS are relatively symptom-free until late in the disease. However, once symptoms manifest, the interval from onset of symptoms to time of death is approximately 2 years for individuals with dyspnea, 3 years for those with syncope, and 5 years for those with angina.[19]

The rate of progression of AS often is a function of etiology, age, and comorbidities. Rheumatic AS has a slower progression than degenerative AS. The rate of progression is intermediate in patients with bicuspid aortic valves.[20] Aortic stenosis with morphologic features such as advanced leaflet calcification and/or leaflet motion restriction typically has a rapid progression.[21] Comorbidities such as smoking, hypercholesterolemia, and renal dysfunction can accelerate the progression of AS.[22,23] The rate of progression also may be more rapid in patients older than 80 years.[24] Patients with incidental AS presenting for CABG with these risk factors may merit special consideration given their higher risk of rapidly progressive AS. Further studies are required to investigate the factors that govern the progression of AS so that therapeutic interventions can be designed to further improve the prognosis for this disease.[25]

There currently are no proven medical interventions that delay the progression of AS, although statins have shown some promise in this regard.[26,27] Medical treatment for AS typically is directed in treating concurrent cardiovascular conditions. The maintenance of sinus rhythm remains an important consideration in these high-risk patients, given the excessive dependence of atrial kick for preservation of left ventricular end-diastolic volume in AS. Patients with medically treated AS have mortality rates of 25% at 1 year and 50% at 2 years after the onset of symptoms, highlighting that medical therapy is not definitive management in this disease.[28] Recent multi-society guidelines from 2012 also have supported timely intervention in patients with symptomatic AS.[29]

The decision-making process in the geriatric population is complicated by the question as to whether the elderly patient will outlive the rate of disease progression in aortic stenosis. Early surgical management exposes the patient to operative and prosthetic valve-related risks, whereas a delay in management may subject the patient to higher risk secondary to disease progression and/or late re-operation.[30] A recent prospective analysis (N = 236: age >70 years) in patients with moderate AS who underwent CABG demonstrated that AVR should be performed with CABG in patients with minimal comorbidities and aortic gradients greater than 26/15 mmHg.[30] The data analysis in this clinical trial identified a peak gradient of 26 mmHg and a mean gradient of 15 mmHg as risk factors for AVR downstream after CABG.[30] In their opinion, patients with multiple comorbidities such as renal failure and pulmonary disease only should have a CABG performed due to their increased perioperative risk and limited lifespan.[30]

The risk-benefit ratio of AVR for the patient with incidental moderate AS first encountered during CABG should be individualized. The operative risks include prolonged cardiopulmonary bypass and cross-clamp times, a repeat sternotomy, and the long-term valve-related complications such as embolism, endocarditis, and/or anticoagulation-related bleeding. With conservative medical management, there are risks from significant AS, such as angina, left heart failure, and sudden death. The advent and rapid progress of transcatheter AVR (TAVR) will affect significantly the risk profile for high-risk surgical patients.[31]

AORTIC VALVE REPLACEMENT AFTER PRIOR CABG

According to compiled data from important trials published in the past decade, the rate of progression to AVR in patients with asymptomatic AS is approximately 25% in the first year after diagnosis and 12% every year thereafter.[32] In those patients who require AVR after CABG, this redo procedure can be performed with acceptable outcomes, including a perioperative mortality of 4.4% in patients with patent grafts, as demonstrated in a recent multicenter clinical registry (N = 113).[33] This clinical registry analysis also reported the following morbidity rates: Prolonged tracheal intubation: 20.8%; intensive care unit stay longer than 5 days: 19.5%; low-cardiac-output syndrome: 14.1%; and stroke: 8.0%.[33] Furthermore, in a large study (N = 1,400), the type of aortic valve prosthesis (mechanical, stented, or stentless) was not an independent risk factor for perioperative mortality (within 30 days).[34] Due to these favorable outcomes, a history of a prior CABG is not necessarily a contraindication to surgical AVR, although the clinical shift to lower-risk patient cohorts currently in progress with TAVR may challenge this perspective in the near future.[35]

Furthermore, besides TAVR, there are refined approaches for AVR, including minimally invasive AVR, port-access AVR, and sutureless AVR.[36] A large systematic review (N = 4,586) demonstrated that compared to conventional AVR, minimally invasive AVR via ministernotomy was associated with shorter intensive care unit and hospital stays, shorter ventilation times, and less blood loss.[37] Although not as common, port-access AVR procedures also have been shown to be effective.[38] In this technique, the patient undergoes peripheral endovascular catheter placement for cardiopulmonary bypass, and surgical access to the aortic valve is via right