The Role of Preoperative and Intraoperative Imaging in Guiding Transcatheter Aortic Valve Replacement

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KEYWORDS

• TAVR • Transesophageal echocardiography • Computed tomography • Aortic root
• Fusion imaging • Fluoroscopy

KEY POINTS

- With approval and rapid expansion of transcatheter aortic valve replacement (TAVR) in the United States, the use of this procedure continues to increase.
- Multimodality imaging is essential to the proper diagnosis, preprocedural planning, and intraprocedural assessment for TAVR.
- Intraprocedurally, 3-dimensional transesophageal echocardiography and fluoroscopy are the mainstays of imaging to guide valve position and deployment.
- Newer imaging modalities such as intracardiac echocardiography and fusion imaging hold promise in TAVR as the procedure evolves.

INTRODUCTION

It is estimated that with an aging population, the burden of valvular heart disease, particularly aortic stenosis, will increase.[1] The definitive therapy for aortic stenosis is surgical aortic valve replacement. However, it is believed that almost one third of patients with aortic stenosis will be too high risk to undergo traditional open surgery.[2]

With the introduction and approval of transcatheter aortic valve replacement (TAVR), there has been a rapid expansion and penetration of this new technology into clinical practice around the United States.[3] TAVR is currently approved for patients with severe symptomatic aortic stenosis who are considered either inoperable or too high risk for traditional open aortic valve replacement. Furthermore, with the success of TAVR in the high-risk patient population, it is currently being investigated in the United States for intermediate risk patients, with the potential to increase its role in the treatment of patients with severe symptomatic aortic stenosis.

TAVR remains a complex procedure with a relatively steep learning curve. TAVR also requires an understanding and expertise in multimodality imaging techniques, which comprise a vital component of the procedure. Multimodality imaging is necessary for the preprocedural planning stages, intraprocedural guidance and postprocedural assessment for TAVR.

As multimodality implies, there are several imaging tools available and necessary for planning,

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carrying out, and assessing the postdelivery function of a percutaneous aortic valve replacement. An understanding of these imaging modalities, their role, and their limitations is necessary to competently perform TAVR. Regardless of one's role during the procedure, it is paramount to be able to understand and communicate effectively the information obtained from these imaging studies in real time.

Herein, we discuss those imaging modalities that have become vitally important in preprocedural planning and intraoperative imaging for TAVR. The role of annular sizing and imaging is discussed in depth elsewhere.

PREPROCEDURAL IMAGING

Transthoracic Echocardiography

The mainstay of diagnosis of aortic stenosis is transthoracic echocardiography (TTE). With the use of echocardiography and Doppler measurements, aortic valve gradients can be obtained and aortic valve area (AVA) can be calculated, or directly measured by planimetry in a parasternal short axis view (Fig. 1). This is particularly helpful in making a diagnosis of aortic stenosis. TTE also provides useful information regarding ventricular function. An understanding of the limitations of 2-dimensional (2D) TTE must be taken into account when considering AVA calculations. TTE measurement of the left ventricular outflow tract (LVOT) assumes a circular shape of the LVOT and that the measurement made is of the true diameter and not of a chord. Use of Three-dimensional (3D) transesophageal echocardiography (TEE) suggests that the LVOT shape is not circular but rather elliptical and that AVA calculations based on 2D TTE LVOT measurements can often underestimate the true AVA.[4]

In the setting of patients with a low left ventricular ejection fraction, the diagnosis of aortic stenosis is often challenging. With a reduction in left ventricular stroke volume in the setting of left ventricular dysfunction, despite the presence of a heavily calcified aortic valve and an AVA of less than 1.0 cm^2, often the aortic valve peak and mean gradients are much lower than expected owing to the reduction in stroke volume. To definitively establish the diagnosis of severe aortic stenosis in the setting of low left ventricular ejection fraction and to assess myocardial contractile reserve, the use of dobutamine stress echocardiography is an important imaging tool. With the use of dobutamine, an increase in stroke volume should accompany an increase in aortic valve gradients without an increase in AVA to confirm a diagnosis of severe aortic stenosis. In the situation where there is an increase in stroke volume and AVA with dobutamine, the diagnosis of severe aortic stenosis is excluded. Although identifying a potentially higher risk patient population with severe aortic stenosis, there is evidence to suggest that these patients with low-flow low ejection fraction aortic stenosis have shown to derive survival benefit from TAVR as well.[5]

Computed Tomography

As part of the preprocedural workup for TAVR, information needs to be obtained regarding aortic annular sizing, aortic root anatomy, ascending aorta sizing, ostial coronary artery position, and iliofemoral artery size and anatomy. All of this information can be obtained via computed tomography (CT), which has led CT to become an indispensable imaging modality for TAVR. In addition to this information, CT can provide information regarding aortic valve morphology (bicuspid vs

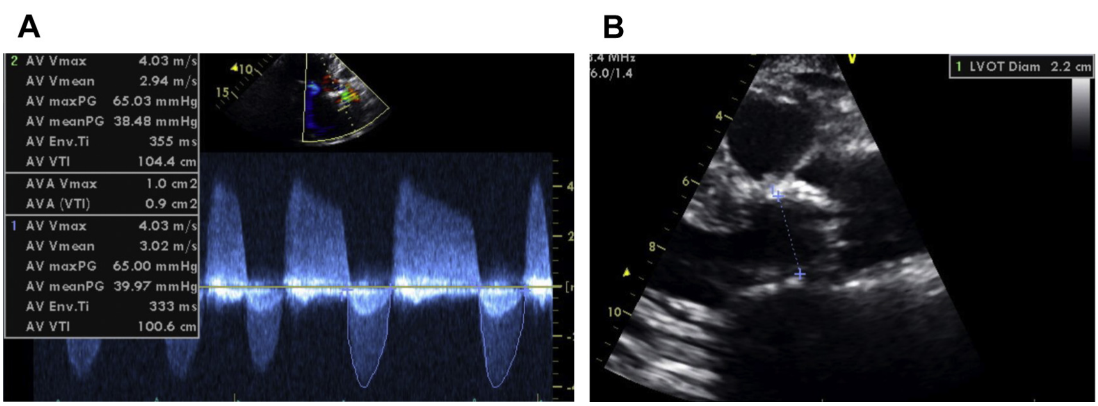

Fig. 1. (*A*) Transthoracic echocardiography (TTE)-based aortic valve gradients and calculated aortic valve area using the continuity equation. (*B*) TTE Parasternal long axis view of the left ventricular outflow tract (LVOT) diameter in a patient with a calcified stenotic aortic valve.