Transcatheter Mitral Valve Implantation in Degenerated Bioprosthetic Valves

Sunil V. Mankad, MD, Gabriel S. Aldea, MD, Natalie M. Ho, MD, Rekha Mankad, MD, Sorin Pislaru, MD, PhD, L. Leonardo Rodriguez, MD, Brian Whisenant, MD, and Karen Zimmerman, BS, ACS, RDCS, RVT,
Rochester, Minnesota; Seattle, Washington; Cleveland, Ohio; Murray, Utah; and Traverse City, Michigan

The use of bioprosthetic valves for mitral valve disease has been increasingly popular with both patients and physicians, and current practice uses these valves for increasingly younger patients. However, these valves are known to degenerate over time. Historically, reoperation was the only recourse for a failing bioprosthetic valve. Today, however, percutaneous options exist with the use of transcatheter valve implantation. Determining candidacy for this less invasive option requires careful evaluation with echocardiography. This review is focused on the echocardiographic evaluation required pre-, intra-, and postprocedurally during transcatheter mitral valve insertion. (J Am Soc Echocardiogr 2018;■:■-■.)

Keywords: Echocardiography, Transcatheter, Mitral, Valve, Replacement, Prosthesis

Patient concerns over lifelong anticoagulation with mechanical valves and the evolving role of valve-in-valve transcatheter interventions for aortic pathology are affecting the discussions and choices regarding mitral valve (MV) replacement in a growing (broader and younger) patient population. Bioprosthetic valves universally degenerate given sufficient time. Surgical MV re-replacement has been the mainstay treatment when repaired or replaced MVs fail with either mitral stenosis (typically with a more chronic presentation) or regurgitation (typically with a more acute or subacute clinical presentation). However, catheter-based therapy with balloon-expandable valve-in-valve implantation is increasingly recognized as an alternative treatment in select patients with recurrent mitral stenosis or insufficiency following replacement with a bioprosthesis. In this report we discuss perspectives of transcatheter MV replacement (TMVR) within failed bioprosthetic MVs, focusing on transthoracic and transesophageal echocardiographic imaging of the original bioprosthetic valve, TMVR, and postprocedural evaluation. Although these interventions were originally conceived for patients with prohibitive risk for open operative reintervention, it is anticipated that with evolution and maturation of these technologies, these techniques and approaches will be increasingly considered for broader and lower risk populations. This would of course require assessment by an experienced heart team with expertise in preprocedural diagnosis and planning assessments as well as significant experience with reoperative open surgical, catheter-based, or hybrid approaches. This would be a multidisciplinary team including interventional cardiologists, cardiothoracic surgeons, noninvasive cardiologists, imaging specialists (echocardiography, computed tomography, magnetic resonance imaging), cardiothoracic anesthesiologists, nurse practitioners, and cardiac rehabilitation specialists with experience in structural heart disease interventions.[1]

BACKGROUND

More than 20,000 MV operations are performed yearly in the United States, of which approximately 60% are repairs and 40% replacements.[2] Bioprostheses have increasingly displaced mechanical valves as the preferred valve in the mitral position. Bioprosthetic heart valves have a finite life span and ultimately fail, with tissue degeneration leading to either stenosis or regurgitation.[3] The 2014 American Heart Association/American College of Cardiology guideline for the management of patients with valvular heart disease recognized the limited longevity of bioprosthetic valves by counseling that the decision between mechanical and bioprosthetic valves should consider the potential need for and risk for reoperation. In recognition of transcatheter options, the 2017 update changed the word *reoperation* to *reintervention*.[4]

Reoperation is associated with acceptable morbidity and mortality for many patients but carries a higher risk than the initial surgery and may be prohibitive for some.[5] As re-replacement rather than repair is often selected for higher risk operative patients, including the elderly and those with functional mitral regurgitation, degenerated mitral bioprostheses are often encountered in patients with increased risk for surgical reoperation.[6] A safe and effective less invasive option has an obvious role in such patients. Bioprosthetic valves demonstrate an even earlier degeneration among younger patients, presumably related to increased contractility and valve stress among those with increased activity.[7,8] Transcatheter valve-in-valve procedures may also have a role in the postponement or prevention of reoperation for low surgical risk patients who may face the prospect of numerous sternotomies if managed exclusively with reoperation.

From the Department of Cardiovascular Disease, Mayo Clinic, Rochester, Minnesota (S.V.M., R.M., S.P.); the Department of Cardiovascular Surgery, University of Washington, Seattle, Washington (G.S.A.); the Department of Cardiovascular Medicine, Cleveland Clinic, Cleveland, Ohio (N.M.H., L.L.R.); the Intermountain Heart Institute of Cardiology, Intermountain Medical Center, Murray, Utah (B.W.); and Webber Heart Center, Munson Medical Center, Traverse City, Michigan (K.Z.).

Conflicts of Interest: None.

Reprint requests: Sunil V. Mankad, MD, Department of Cardiovascular Disease, Mayo Clinic, 200 First Street SW, Rochester, MN 55905 (E-mail: *mankad.sunil@mayo.edu*).

0894-7317/$36.00

https://doi.org/10.1016/j.echo.2018.03.008

Abbreviations
2D = Two-dimensional
3D = Three-dimensional
CT = Computed tomographic
EOA = Effective orifice area
LV = Left ventricular
LVOT = Left ventricular outflow tract
MV = Mitral valve
PLAX = Parasternal long-axis
PSAX = Parasternal short-axis
SHV = Surgical heart valve
TEE = Transesophageal echocardiography
TMVR = Transcatheter mitral valve replacement

It is important to mention that at the present time, the balloon-expandable SAPIEN S3 (Edwards Lifesciences, Irvine, CA) is the only bioprosthesis approved by the US Food and Drug Administration for implantation in degenerated bioprostheses in the aortic and/or mitral position. The balloon-expandable Melody bioprosthesis (bovine jugular venous valve segment with a platinum-iridium stent; Medtronic, Minneapolis, MN) had been used previously but much less so currently. Because of their length, CoreValve and Evolut valves (Medtronic) cannot be used for mitral valve-in-valve procedures for failing bioprostheses. This procedure uses the old failing bioprosthesis to anchor the percutaneously placed valve, similarly to how a calcified native aortic valve (AV) stabilizes the new valve in transcatheter AV implantation.

SURGICAL AND INTERVENTIONAL PERSPECTIVES OF TMVR

Early in transcatheter valve development, transcatheter valve replacement was recognized as an effective alternative for patients with failed mitral and aortic bioprosthetic valves and prohibitive surgical risk.[9] These procedures require careful and detailed preprocedural imaging to understand underlying pathology (including associated paravalvular leak warranting treatment before TMVR) and anatomy (understanding precise pathology of prosthetic and native leaflets) and typically require careful transesophageal echocardiography (TEE) and gated computed tomographic (CT) angiography. These imaging assessments guide the best route of prosthesis delivery (transapical vs transseptal), prosthesis size, depth of insertion, anchoring (avoidance of migration), and avoidance of left ventricular outflow tract (LVOT) obstruction. Initial experience with early-generation technologies demonstrated high technical success, particularly with transapical delivery, and excellent acute hemodynamic results.[10-12] Anchoring (device migration) is only rarely a concern, but potential LVOT obstruction from a displaced prosthetic leaflet in valves with longer posts and in patients with smaller LVOTs continues to be a concern. The LVOT's geometry itself may become altered by placement of the TMVR, termed the "neo-LVOT."

Patient selection for TMVR must balance acute risks and long-term outcomes of both surgery and transcatheter procedures. Transthoracic echocardiography (TTE) plays an essential role in procedural guidance and is essential to predicting procedural outcomes and thereby guiding patient selection. This includes the diagnosis of valve failure, mechanism of valve failure, suitability for TMVR including risk for neo-LVOT obstruction, and risk for prosthesis mismatch. The risk for LVOT obstruction is lower for mitral valve-in-valve implantation for degenerative mitral bioprostheses. Preliminary validation of a CT computer-aided design prediction modeling tool to identify patients at risk for LVOT obstruction in TMVR has now been published, and computed tomography plays a key role in preprocedural planning to assess the geometry of the neo-LVOT.[13] Although early in its adaptation, a small but growing experience enhanced by improved advanced echocardiographic imaging and the evolution from transapical to transfemoral access with transseptal TMVR delivery has streamlined the procedure and improved outcomes. Recent retrospective publications have reported not only excellent hemodynamic results but modest adverse events and short hospital lengths of stay.[14-16]

Finally, there is growing recognition of a limited role for the hybrid use of balloon-expandable valve implantations during an open surgical procedure through a direct transatrial approach in patients with prohibitive circumferential annular calcification (extending into the left ventricle) noted intraoperatively. These can be more carefully assessed before reoperation with a gated CT angiography, which allows careful planning and execution of a contingency multidisciplinary approach. This hybrid approach allows removal of prosthetic leaflets surgically and thus reduces the risk for LVOT obstruction, allows more precise deployment of the transcatheter valve and anchoring (avoiding migration), but still requires sternotomy or thoracotomy, cardiopulmonary bypass, and cardioplegic arrest.

The postprocedural management, durability, and follow-up of these new approaches are currently in their infancy and yet to be defined. Additional prospective, multicenter, longitudinal research is essential to better understand the long-term risks and benefits of transcatheter heart valves in the mitral position. TMVR has been associated with valve thrombosis and requires long-term serial imaging follow-up to identify and attempt to reverse early valve thrombosis (which may be first recognized because of increasing prosthetic gradients on TTE).[17] The need for and duration of antithrombotic medications following TMVR not only warrants further study but must be considered among patients who have options for surgical replacement. There are limited data on the durability of mitral valve-in-valve versus aortic valve-in-valve implantation for failing bioprostheses.[12]

PREPROCEDURAL IMAGING WITH TTE

TTE is an essential first step in the initial workup of all patients with suspected mitral bioprosthetic valve dysfunction, including those being considered for TMVR. Despite its limitations, which include dependence on adequate acoustic windows and susceptibility to shadowing from prosthetic material, TTE plays an important role in assessing candidacy for TMVR, ruling out contraindications and contributing to preprocedural planning. The echocardiographic assessment of a patient with a failing bioprosthetic MV should be aimed at determining the likely cause and severity of valve failure. Structural failure of a surgical valve refers to stenosis, regurgitation, or both and in most cases can be reliably assessed using TTE. However, there are certainly limitations of TTE, and one should have a very low threshold for performing preprocedural TEE; in fact, we recommend routinely performing preprocedural TEE so that there are no surprises when the patient arrives for the procedure. Knowledge of the type and size of the existing surgical heart valve (SHV) is helpful for this assessment. For a detailed description of the echocardiographic assessment of mitral prosthetic valves, one should refer to published guidelines.[18]