

Valve-in-Valve Transcatheter Aortic and Mitral Replacement

Expert opinions on the United States experience with valve-in-valve transcatheter aortic and mitral valve replacement techniques.

BY JOSE F. CONDADO, MD, MS; BRIAN KAEBNICK, MD; AND VASILIS BABALIAROS, MD

Transcatheter aortic valve replacement (TAVR) has revolutionized the treatment of severe aortic stenosis (AS) in patients at high and very high surgical risk.¹ Simultaneously, this technique has been increasingly used off-label for the treatment of failing aortic or mitral valve bioprostheses, with promising results.^{2,3} The aging United States population, increased implantation of surgical bioprosthetic valves,⁴ and increased risk of redo surgical valve replacement in the elderly population⁵ will inevitably lead to further increased use of this technology in the future.

Currently, there are two transcatheter heart valves (THVs) approved in the United States, the balloon-expandable Sapien valve (Edwards Lifesciences) and the self-expandable CoreValve device (Medtronic). Compared to TAVR in a native valve, valve-in-valve (VIV) TAVR and VIV transcatheter mitral valve replacement (TMVR) have unique challenges that we will further discuss in this article.

VIV TAVR

Valve-in-valve TAVR, with a reported 1-year survival rate of 83.2%,² can be an alternative to surgical aortic valve replacement in selected patients at high surgical risk. However, the observed increase in severe patient-prosthesis mismatch (31.8%), THV malposition (12.8%), coronary obstruction (2.5%–3.5%), and implantation of a second THV (8%–9%)^{2,3,6} during VIV TAVR emphasizes the importance of procedure planning. Learning the specific technical challenges and interaction of current THV technology with the existing surgical bioprosthesis is essential.

Procedure planning must include a comprehensive evaluation of the patient by the heart team, starting

with the determination of surgical risk and indication for bioprosthesis valve replacement. Unlike native valve TAVR, which has mostly been used to treat severe AS,^{7,8} VIV TAVR has been used for treating failing surgical bioprostheses that cause isolated AS (42%), isolated aortic regurgitation (AR; 34%), or a combination of AR and AS (24%).³

The preprocedural echocardiographic evaluation of failing bioprostheses entails special challenges that need to be considered. First, the echogenic material of the bioprosthesis (eg, the sewing ring, calcium, and metal stent) can create “shadows” that prevent adequate imaging of the valve. Second, the severity of eccentric AR jets is often difficult to quantify and differentiate from perivalvular leaks, despite good quality transesophageal echocardiographic imaging. Functional cardiac magnetic resonance imaging and cardiac catheterization can be useful to objectively quantify the severity of AR by calculating a regurgitant fraction and AR index,⁹ respectively (Figure 1), and intracardiac echocardiography can help differentiate valvular from perivalvular leak, which is imperative to deciding treatment. The former can be percutaneously corrected with VIV TAVR and the later with implantation of an Amplatzer vascular plug (St. Jude Medical, Inc.).

Understanding the potential for patient-prosthesis mismatch is another critical step to the preprocedural VIV TAVR workup. Up to one-third of patients who undergo VIV TAVR develop severe patient-prosthesis mismatch.³ This phenomenon results from poor THV size selection (limited by the current THV technology and sizes) and underexpansion of the THV due to the lack of distensibility of the bioprosthetic surgical valve ring. Preventing patient-prosthesis mismatch is important, as increased mortality has been observed

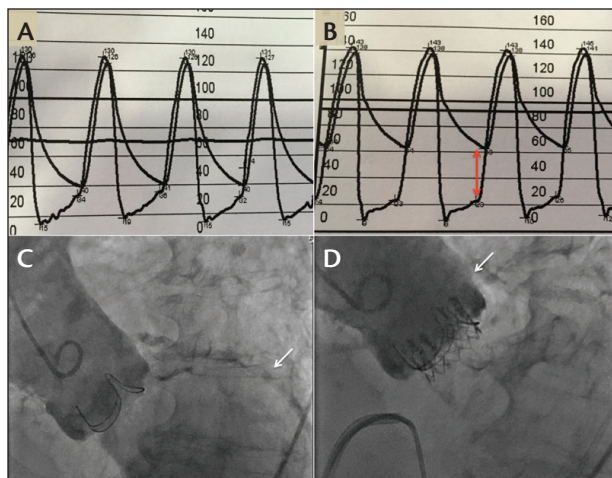


Figure 1. Intraprocedural evaluation of bioprosthesis AR. Aortic and left ventricular pressures were measured and used to calculate the AR index, which improved from 4.6 at baseline (A) to 28.7 after THV deployment; red arrow indicates the difference between diastolic blood pressure and left ventricular end-diastolic pressure, which is used for AR index calculation (B). At the same time, baseline aortography revealed regurgitation of contrast filling the entire left ventricular chamber (C, white arrow). Aortography after THV deployment revealed resolution of AR (D).

in patients undergoing VIV TAVR with a small THV (< 21 mm) and high postprocedure aortic valve mean gradients (> 20 mm Hg).² Knowing the true internal diameter and design of the aortic prosthesis is essential to selecting the appropriate THV size. Fortunately, free mobile apps, such as the Aortic Valve in Valve application (UBQO Ltd.), aid in selecting the proper THV size based on the surgical bioprosthetic valve type and its internal diameters. This application also provides guidance on the fluoroscopic landmarks that are specific to each bioprosthetic valve and can be used for proper valve deployment (Figure 2).

However, fluoroscopic landmarks for THV deployment can be difficult to identify due to the absence of calcification and the “classic” anatomy of the native valve, especially in patients who have undergone aortic root replacement or have received a stentless surgical bioprosthesis (Figure 2). These issues may explain the observed increased incidence of THV malposition, the requirement of a second THV, and coronary obstruction during VIV TAVR. The use of simultaneous power-injected aortography during THV deployment can aid in identifying the anatomy and landing zone location. The lack of calcium on bioprosthetic valves also allows the THV to translate in the ventricular and aortic direction much more freely and can result in a valve placed too high or low. In our

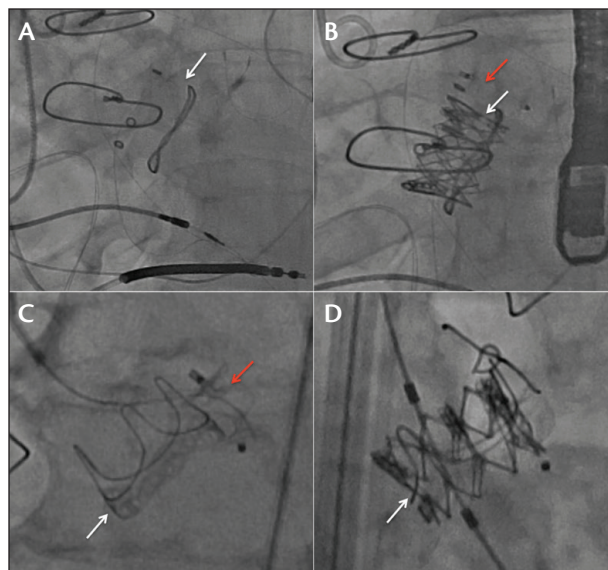


Figure 2. VIV TAVR in two patients with different failing surgical bioprostheses. Patient 1 (A, B) had a prior 25-mm Hancock II bioprosthesis (Medtronic) (A, white arrow) causing severe AR and underwent successful VIV TAVR with a 23-mm Sapien XT device (B, white arrow) and paravalvular leak closure (B, red arrow) using a TF approach. Patient 2 (C, D) had a prior 21-mm Carpentier-Edwards Perimount surgical valve (Edwards Lifesciences) complicated with infective endocarditis causing severe AR from both central and paravalvular leak (C, white arrow). He first underwent paravalvular leak closure with an Amplatzer vascular plug (C, red arrow), with partial hemodynamic and clinical improvement. During a second procedure, he underwent success transfemoral VIV TAVR with a 23-mm Sapien XT valve (D, white arrow). Both patients were discharged with mild/trace AR and marked clinical improvement.

experience, a slow deployment can provide time for the fine positioning adjustment that may be required during deployment to properly position the THV.

Finally, previous surgical aortic valve replacement can distort the normal anatomy of the aortic root, which can lead to an increased risk of coronary obstruction. The use of power-injected aortography, transthoracic echocardiography, transesophageal echocardiography, and gated cardiac CT assists in defining the aortic root anatomy and understanding the spatial relationship of the coronary ostium to the aortic annulus and valve struts. High-risk characteristics for coronary obstruction include a short distance between the coronary ostium and the surgical bioprosthesis (especially if the latter has been implanted in a supra-annular and/or tilted position), a narrow or low-lying sinotubular junction, a reimplanted coronary (ie, Bentall procedure), and a stentless or internally stented surgical bioprosthesis.¹⁰

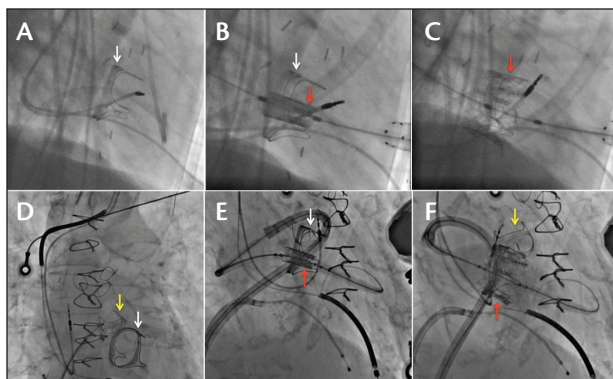


Figure 3. VIV TMVR in two patients with severe mitral regurgitation from failing bioprostheses. Patient 1 (A–C) had prior surgical mitral valve replacement with a 25-mm Perimount Magna valve (Edwards Lifesciences) (A, B; white arrows) and underwent successful transapical VIV TMVR with a 26-mm Sapien XT device (B, C; red arrows). Patient 2 (D–F) had a prior aortic (D, F; yellow arrows) and 33-mm mitral Carpentier-Edwards Perimount surgical valve (D, E; white arrows) and underwent successful transseptal TMVR with a 26-mm Sapien XT valve (E, F; red arrows). Both patients were discharged with no residual mitral regurgitation and clinical improvement.

If there is concern for potential coronary obstruction, careful planning to prevent or react to coronary obstruction must be addressed prior to the procedure. Prewiring the coronary artery with a stent in place has been a useful safety net during TAVR implantation in patients with a low coronary ostium to alleviate obstruction from the calcium or stent frame, if needed.¹⁰ Preventing obstruction, however, is preferred to attempting to treat obstruction after the fact. Making a concerted effort during THV deployment to avoid placing the valve too high or overinflating the THV outside the current bioprosthesis stent frame are important in cases where coronary obstruction is a concern.

VIV TMVR

Although VIV TMVR has been performed with success in selected patients with severe mitral regurgitation and very high surgical risk,¹¹ it is rarely performed due to the lack of mitral valve–specific transcatheter devices, the complex anatomy and disease etiology of the mitral valve, and the current lack of insurance reimbursement for this procedure in the United States.

VIV TMVR is performed via transapical or transseptal access, using the mitral valve surgical bioprosthesis for fluoroscopic guidance (Figure 3). The circular shape of these bioprostheses differs from the saddle-shaped morphology of the native mitral valve and allows the

adaptation of currently available THVs, designed for the aortic position, for use in the surgical mitral valve. Finally, new TMVR valves in development and early stages of clinical trials for native mitral valve disease¹² may be used for VIV TMVR in the near future.

CONCLUSION

VIV TAVR and TMVR are feasible treatment options for well-selected, high-surgical-risk patients with failing bioprostheses, and these applications are likely to increase in number. Operators, however, need to be aware of specific preprocedural planning and intraprocedural technical challenges that are inherent to the off-label use of THVs in VIV TAVR. ■

Jose F. Condado, MD, MS, is with Structural Heart and Valve Center, Division of Cardiology, Emory University School of Medicine in Atlanta, Georgia. He has stated that he has no financial interests related to this article.

Brian Kaebnick, MD, is with Structural Heart and Valve Center, Division of Cardiology, Emory University School of Medicine in Atlanta, Georgia. He has stated that he has no financial interests related to this article.

Vasilis Babaliaros, MD, is with Structural Heart and Valve Center, Division of Cardiology, Emory University School of Medicine in Atlanta, Georgia. He has disclosed that he is a consultant to DirectFlow Medical and St. Jude Medical. Dr. Babaliaros may be reached at (404) 712-7667; vbabali@emory.edu.

1. Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol.* 2014;63:e57-185.
2. Dvir D, Webb J, Brecker S, et al. Transcatheter aortic valve replacement for degenerative bioprosthetic surgical valves: results from the global valve-in-valve registry. *Circulation.* 2012;126:2335-2344.
3. Dvir D, Webb JG, Bleiziffer S, et al. Transcatheter aortic valve implantation in failed bioprosthetic surgical valves. *JAMA.* 2014;312:162-170.
4. Balsam LB, Grossi EA, Greenhouse DG, et al. Reoperative valve surgery in the elderly: predictors of risk and long-term survival. *Ann Thorac Surg.* 2010;90:1195-1200; discussion 201.
5. Brown JM, O'Brien SM, Wu C, et al. Isolated aortic valve replacement in North America comprising 108,687 patients in 10 years: changes in risks, valve types, and outcomes in the Society of Thoracic Surgeons National Database. *J Thorac Cardiovasc Surg.* 2009;137:82-90.
6. Ribeiro HB, Webb JG, Makkar RR, et al. Predictive factors, management, and clinical outcomes of coronary obstruction following transcatheter aortic valve implantation: insights from a large multicenter registry. *J Am Coll Cardiol.* 2013;62:1552-1562.
7. Leon MB, Smith CR, Mack M, et al. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. *N Engl J Med.* 2010;363:1597-1607.
8. Adams DH, Popma JJ, Reardon MJ, et al. Transcatheter aortic-valve replacement with a self-expanding prosthesis. *N Engl J Med.* 2014;370:1790-1798.
9. Sinning JM, Hammerstingl C, Vasa-Nicotera M, et al. Aortic regurgitation index defines severity of periprosthetic regurgitation and predicts outcome in patients after transcatheter aortic valve implantation. *J Am Coll Cardiol.* 2012;59:1134-1141.
10. Dvir D, Leipsic J, Blanke P, et al. Coronary obstruction in transcatheter aortic valve-in-valve implantation: preprocedural evaluation, device selection, protection, and treatment. *Circulation Cardiovasc Interv.* In press.
11. Seiffert M, Conradi L, Baldus S, et al. Transcatheter mitral valve-in-valve implantation in patients with degenerated bioprostheses. *JACC Cardiovasc Interv.* 2012;5:341-349.
12. Cheung A, Webb J, Verhey S, et al. Short-term results of transapical transcatheter mitral valve implantation for mitral regurgitation. *J Am Coll Cardiol.* 2014;64:1814-1819.