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The Role of Transcatheter Aortic Valve Implantation in Patients With Bicuspid Valves in 2023

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Introduction

Bicuspid aortic valve (BAV) is the most common congenital heart defect, occurring in 1% to 2% of the general population.[1] Compared with individuals having normal tricuspid aortic valves, those with BAVs are more likely to develop calcification on valve leaflets and raphe and dilation of the ascending aorta (aortopathy)—and at a much earlier age. For highly select patients with severe BAV stenosis, transcatheter aortic valve implantation (TAVI) may be a feasible alternative to surgical repair or replacement.[2-4] Newer-generation replacement valves, such as the balloon-expandable SAPIEN-3 (Edwards Lifesciences) and the self-expanding Evolut R/Pro (Medtronic, Inc) valves, are approved by the US Food and Drug Administration for all surgical indications regardless of valve anatomy, including BAV.[5,6]

Pivotal randomized controlled trials for TAVI in tricuspid aortic valve stenosis[2-4] have excluded BAV stenosis; nonetheless, studies of real-world registry data suggest comparable outcomes and similar short-term (30-day) mortality for TAVI in patients with BAV stenosis,[7,8] although patients with BAV stenosis who underwent TAVI had a higher 30-day stroke rate (2.5% vs 1.6%; hazard ratio, 1.57 [95% CI, 1.06-2.33]).[7] These studies are limited by their observational nature and did not account for various BAV morphologies. Moreover, future randomized clinical trials of BAV and TAVI are unlikely, given that TAVI is now an approved, widely used procedure.

The optimal sizing methodology for BAV has not been resolved. The Sievers classification[9] is the most widespread proposal for BAV morphology and is based on 3 characteristics: the number of raphes, the spatial position of cusps or raphes, and the functional status of the valve. Although the Sievers classification has historically been used to guide surgical BAV replacement, its utility in TAVI is limited.

Current Limitations

Within the traditional Sievers classification scheme, BAV phenotypes are categorized according to the number of raphes (0, 1, or 2). However, this scheme does not account for several unfavorable features of BAV anatomy that warrant special consideration before TAVI. Such features in BAV include a frequently encountered more elliptical annulus, asymmetric and more extensive calcium distribution, calcification extending into the left ventricular outflow tract (LVOT), closer proximity to the coronary ostia (with potential coronary artery occlusion), and more common ascending aorta dilatation (more frequently found in patients with 2 raphes[10]). Overall calcium burden, particularly in the presence of calcified raphes, may hinder optimal valve expansion and promote perivalvular leak.

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Recent Developments

Yoon et al[10] proposed a novel classification scheme that may provide better risk stratification of patients with BAV stenosis who are being considered for TAVI. In their scheme, the Sievers classification is initially used to describe the presence, number, and spatial position of raphes. Then, in patients with raphes, calcification in the leaflets, raphe, and LVOT are assessed and graded, and patients can be categorized into 1 of 3 groups: no calcified raphe and no excess leaflet calcification, calcified raphe or excess leaflet calcification, or calcified raphe plus excess leaflet calcification.

Using this new classification scheme, the authors evaluated the association of BAV morphology and outcomes of TAVI with the new-generation Evolut R/Pro and SAPIEN 3 devices. Multivariate analysis identified calcified raphe and excess leaflet calcification as independent predictors of 2-year all-cause mortality in patients with BAV undergoing TAVI, compared with patients having 1 or none of these features (25.7% vs 9.5% vs 5.9%, respectively; $P < .001$; see Fig. 1).[10] Furthermore, patients with both morphologic features had higher rates of aortic root injury, moderate to severe paravalvular regurgitation, need for reintervention, and 30-day mortality.[10]

Other recent studies further corroborate these findings, suggesting that TAVI is feasible in patients with low-risk BAV stenosis. The Low-Risk Bicuspid Study found that the Evolut R/Pro system was both safe and feasible in 150 patients with BAV without aortopathy or LVOT calcification.[3] An analysis of the PARTNER 3 trial bicuspid registry found similar outcomes with the SAPIEN 3 valve between 148 patients with BAV without extensive raphe or subannular calcification and a propensity-matched cohort of patients with tricuspid aortic valve stenosis.[11]

The present consensus is that patients aged 65 years or younger and patients with an aortic diameter greater than 45 mm are better candidates for surgery than TAVI.[12]

Future Directions

More data are needed to elucidate the role of TAVI for patients with BAV and problematic anatomical features. Further modifications in endoprosthesis design are needed to reduce the incidence of complications such as perivalvular aortic insufficiency, annulus rupture, and coronary ostial obstruction for patients with BAV who undergo TAVI. It is hoped that, in the future, the information gathered through registries will further elucidate the best strategy for TAVI for patients with BAV. The implementation of artificial intelligence in preprocedural planning can assist with visualizing areas of potential risk and has been of significant help in device selection and preventing some of the most common complications for patients undergoing TAVI.[13]

Abbreviations and Acronyms

BAV bicuspid aortic valve
LVOT left ventricular outflow tract
TAVI transcatheter aortic valve implantation

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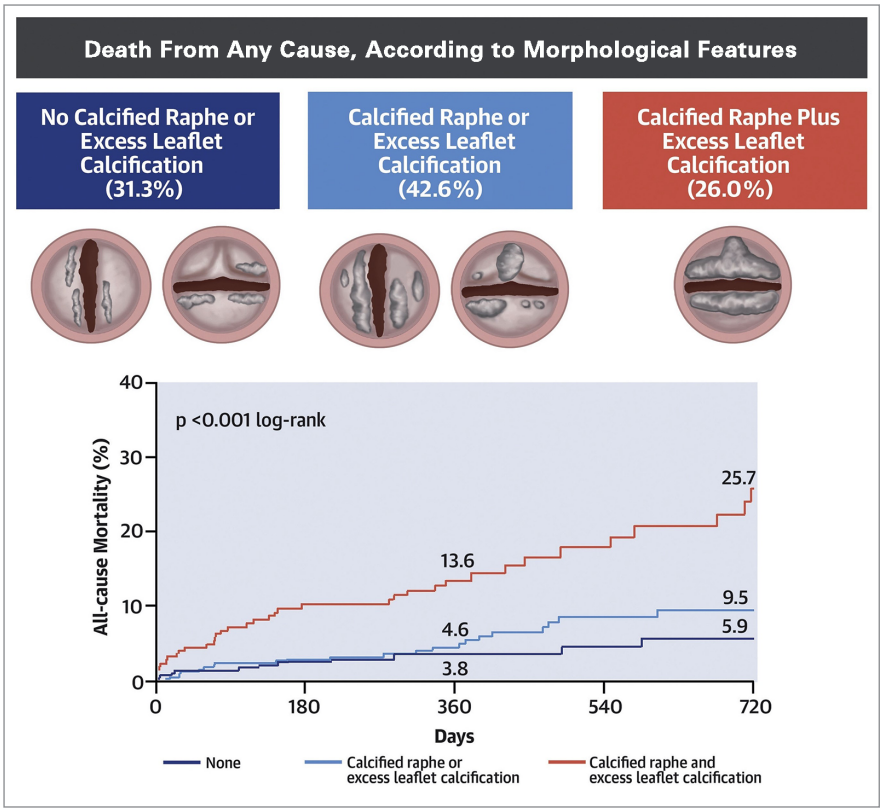

Fig. 1 Illustrations comparing bicuspid and tricuspid morphology and outcomes after transcatheter aortic valve implantation. Top, schematic representation of different types of aortic valve morphology. Bottom, all-cause mortality after transcatheter aortic valve implantation according to morphological features. Event rates were calculated using Kaplan–Meier methods and were compared using the log-rank test.

Adapted from *Journal of the American College of Cardiology*, 76(9), Yoon SH, Kim WK, Dhoble A, et al. Bicuspid aortic valve morphology and outcomes after transcatheter aortic valve replacement, 1018-1030, Copyright (2020), with permission from Elsevier.

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