

Is prophylactic root replacement needed to prevent future root aneurysm in bicuspid aortic valve patients?



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Feature Editor's Introduction—In deciding when to perform a “prophylactic” aortic root operation, the surgeon must weigh the risk of the procedure with the potential benefit of preventing future adverse events. A variety of patient-specific, surgeon-specific, and institution-specific factors may tip the balance in one direction or the other. In this issue of the Journal, Suzuki and colleagues explore the nuances of this decision making in patients with bicuspid aortic valve (BAV) requiring surgical aortic valve replacement. Although the aortopathy of BAV is heterogeneous, the predominant phenotype involves the ascending aorta only; thus, most patients with BAV undergoing aortic valve surgery will have nonaneurysmal roots. The natural history of the aortic root in patients with this phenotype after combined surgical aortic valve replacement (AVR) and ascending replacement has been studied, and, interestingly, the aortic root dimensions typically remain stable over time. The authors present a framework that can help surgeons identify specific circumstances when prophylactic root replacement should be considered in these patients as well.

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Bicuspid aortic valve (BAV) is the most common congenital heart valve defect, affecting approximately 1% to 2% of the population.¹ Although the incidence of BAV has remained constant, the management of the associated aortopathy of BAV has undergone changes in recent years. There was a trend toward more aggressive replacement of the supracoronary ascending aorta as well as the aortic root in the setting of BAV with associated aortopathy based on the concern for continued growth of the tissue even after valve replacement. A 2010 American Heart Association/American College of Cardiology consensus practice guideline lumped BAV with Marfan syndrome and other genetically mediated disorders, recommending elective replacement of the ascending aorta at small



The authors (left to right): Drs Suzuki, Levy, and DeAnda

CENTRAL MESSAGE

Prophylactic aortic root replacement in the setting of a bicuspid aortic valve can be justified in certain situations.

See Commentary on page 106.

diameters (40-50 mm) to avoid the risk of acute dissection or rupture (class I, level of evidence C).² A subsequent update of these guidelines tempered the approach,³ albeit requiring further clarification,⁴ and the 2018 American Association for Thoracic Surgery consensus guidelines mirrored the updated guidelines.⁵ With all these moving parts and considerations, when assigned the task of writing an expert opinion on whether root replacement of BAV is needed to avoid future root aneurysm, our answer is—maybe.

We can begin with the question of what happens to the root if the ascending aorta and the aortic valve are replaced without addressing the root. A study by Milewski and colleagues⁶ looked at 428 patients undergoing elective aortic valve replacement with the additional procedure of supracoronary aorta replacement. After adjusting for valve morphology (BAV vs trileaflet [TAV]), pathology (ie, stenosis vs insufficiency), and preoperative dimension, there did not appear to be any difference in long-term outcomes, including the need for reintervention on the root. A similar conclusion was reached by Hui and colleagues,⁷ who found that with a mean imaging follow-up of 5.5 ± 5.3 years, there was negligible growth in the postoperative root whether the patient had a BAV or a TAV (Figure 1). Sundt⁸ provided a commentary to Milewski and colleagues noting that to generalize their findings, it would be important to better understand the incremental risk of adding a root replacement to the procedure and to know the risk of late sinus tissue degeneration.

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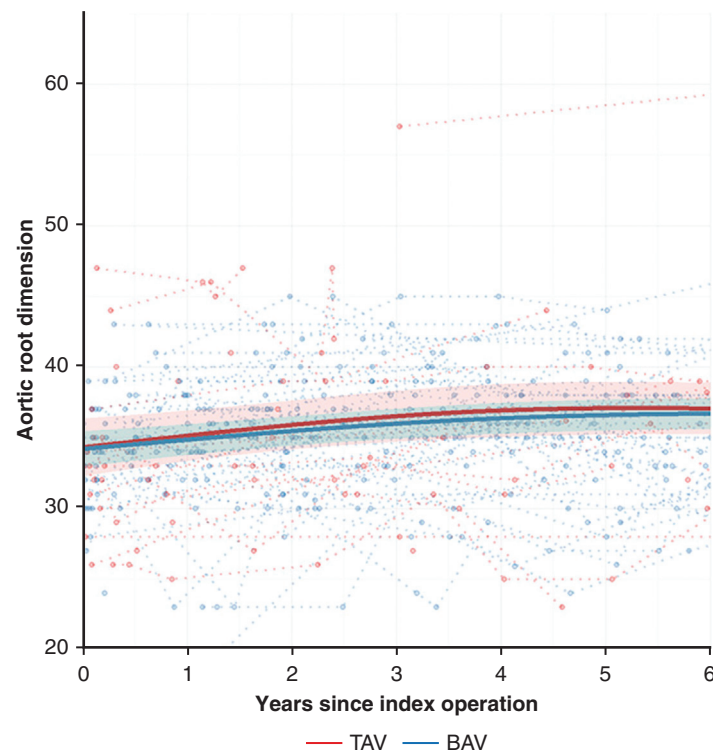


FIGURE 1. Comparison of aortic root diameter over time after aortic valve replacement and ascending aorta replacement. *TAV*, Tricuspid aortic valve; *BAV*, bicuspid aortic valve.

Notwithstanding the findings of Milewski and colleagues⁶ and Hui and colleagues,⁷ when contemplating the added risk of a root replacement in the setting of BAV, we need to balance the risk of replacing the root with the 2 overwhelming risks of not replacing the root: the risk of aortic dissection and the risk of aneurysmal growth (without dissection). Both studies suggested that the latter is not an issue and the former is uncommon, with the caveat that the initial root dimensions in both studies were on the normal side (BAV, 37.4 ± 5 mm and TAV, 37.8 ± 6 mm for Milewski and colleagues⁶; BAV, 33 ± 5 mm and TAV, 32 ± 6 mm for Hui and colleagues⁷), so concerns for dissection with root dimensions <45 mm might still be reasonable. Dissections can (and do) occur at diameters <55 mm. For all comers (ie, BAV and TAV), the entry tear for acute type A aortic dissection (aTAAD) occurs in equal proportion between the sinotubular junction (STJ) and ascending aorta.⁹ With aTAAD, compared with TAV, the primary tear in BAV was more likely to have occurred in the root.¹⁰ The implication is that if the presence of BAV raised concerns for a risk of aTAAD, then the root would be a critical target for early intervention.

Endorsing the argument that the root is as important as the ascending aorta when considering risk reduction for aortic dissection is a study by Gomez and colleagues¹¹ that examined the wall stress distribution in the aneurysmal aorta (≥ 45 mm) of patients with BAV. A computational

model was used to determine the 99th percentile longitudinal and circumferential wall stresses at systole. Stresses were determined at the level of the sinuses, the STJ, and the ascending aorta. The authors found the highest longitudinal wall stress in the root and the highest circumferential wall stress at the level of the STJ.¹¹ This would support the argument that for BAV, if the enlarged ascending aorta is being replaced prophylactically to reduce the risk of aTAAD, then the root should be equally considered, and indeed the current guidelines support prophylactic replacement for either (or both) the root and the ascending aorta with dimensions ≥ 45 mm.

Support for early intervention for a ≥ 4.5 -cm supracoronary aorta included a study by Borger and colleagues¹² that found on long-term follow-up a significant impact on freedom from ascending aorta-related complications (43%, compared to 86% and 81% for aortic diameters ≤ 4 cm and 4.4 cm, respectively) when only the valve was addressed. The same group looked at BAV patients with annuloaortic ectasia (annular size ≥ 27 mm and root diameter 40–50 mm) and aortic insufficiency and found adverse aortic events in 34%, with one-third of those events necessitating surgical intervention. Overall, 13% of the study patients were found to have progressive root enlargement, although not all required reoperation.¹³ Svensson and colleagues¹⁴ reported only 3 of 1449 BAV patients who underwent AVR had a late aortic event when the aortic diameter



FIGURE 2. Factors influencing surgical threshold of bicuspid aortic valve (BAV) aortopathy. BSA, Body surface area; AS, aortic stenosis; AR, aortic regurgitation.

was <4.5 cm at the time of valve surgery. Valve pathology may play a role in the risk for downstream aortic events. In a meta-analysis conducted by Girdeauskas and colleagues,¹⁵ valve replacement for BAV insufficiency compared with stenosis had a higher incidence of subsequent aortic dissection (2.8% vs 0.2%, $P < .01$; odds ratio, 10.0; 95% confidence interval, 6.2-16.2). It is here that the treatment algorithm begins to diverge. The consensus is that the ascending (and root) should be dealt with for diameters ≥ 45 mm, and with these additional pieces of evidence, consideration can be given to intervening on small diameters (<45 mm) in the presence of aortic insufficiency and/or annuloaortic ectasia.

Are there any other considerations that would potentially override the ≥ 45 mm guideline? For the ascending aorta, there is compelling data to argue that the relative size of the aorta, not the absolute size, is critical to decision making. Sievers and colleagues¹⁶ described their institutional threshold for intervening on the ascending aorta at the

time of AVR for BAV. In their group of 1693 patients (697 [41%] for stenosis, 332 for insufficiency, and 664 with a mixed lesion), 577 underwent some type of intervention on the ascending aorta (either replacement or aortoplasty), with a mean diameter of 49.9 ± 7 mm (median, 50 mm; range, 29-84 mm). The decision to operate on the smaller diameters was influenced by the age and z -score of the patient. Patients with insufficiency were more likely to have an intervention on the aorta, and 97 patients who were intervened on had an aortic diameter <45 mm. As also reported by Idrees and colleagues,¹⁷ the addition of a prophylactic aortic procedure does not appear to have a negative impact on operative or hospital mortality. Finally, in a large multi-institutional retrospective review (from 2 large cardiovascular registries) of 2861 BAV patients, 1786 patients had an aortic diameter <45 mm, and in 516 patients (29%) the ascending aorta was intervened on, including 28 (1.6%) who had only the aorta intervened on despite the <45 mm diameter.¹⁸

From these 3 studies,¹⁶⁻¹⁸ the take home message might be that aortic intervention for ascending aortas <45 mm is not a big deal. But the question remains: What to do about the small aortic root? The centers in the 3 studies are all considered proverbial “Centers of Excellence” and high-volume institutions. For the ascending aorta, Gazoni and colleagues found significantly increased mortality in low-volume centers (<40 cases over a 3 year period) compared with high-volume centers (>80 cases in 3 years) for isolated ascending aneurysms (17% vs 3%; $P = .01$).¹⁹ The addition of a root replacement would be more complex than the addition of an ascending aortic replacement and would be dependent on operative volume. Hughes and colleagues²⁰ found a statistically significant impact on mortality for root replacements in centers performing fewer than 30 to 40 procedures annually.²⁰ Missing from the literature are large longitudinal studies comparing prophylactic root replacement with nonreplacement during surgery for BAV.

Putting this together, we return to the original question: In BAV, is prophylactic root replacement needed to avoid future root aneurysm? Braverman’s answer to this question summarizes the necessary considerations: “The surgical threshold for prophylactic aortic aneurysm resection in BAV aortopathy requires complex decision making based on multiple factors including surgical expertise in each institution.”²¹ (Figure 2). In a recent analysis of the Society of Thoracic Surgery database, elective root replacement outcomes for the period 2011 to 2016 was noted to have a mortality rate of 2.2%, a stroke rate of 1.4%, and a reoperation for bleeding rate of 3.6%.²² Institutions proceeding with prophylactic root replacement for BAV could be expected to have superior results. Finally, most studies following growth of the aortic root in BAV purposely exclude patients with Marfan syndrome or other connective tissue disorders, as well as patients in whom the root was spared during intervention for aortic dissection. In both cases, it would be reasonable to intervene on the root for either TAV or BAV at the time of the index operation. Thus, our recommendations are as follows:

- Prophylactic replacement of the aortic root is reasonable at the time of surgery on the aortic valve and/or ascending aorta in patients with connective tissue disorders (eg, Marfan syndrome), owing to the high risk of the need for future interventions as well as the risk for dissection.
- For roots <45 mm, sex and body size can be taken into consideration, especially for younger patients. We further recommend referring to the indexing of aortic dimension as described by Sievers and colleagues^{16,23}
- For roots 40 to 45 mm in the presence of moderate to severe aortic insufficiency, it would be reasonable to consider intervening on the root if this could be done without a significant increase in operative risk to the patient.

In either of these circumstances, the procedure should be performed in a high-volume center by an experienced surgeon. Only in this situation could adding a potential increase in risk for the potential long-term benefit be justified.

Conflict of Interest Statement

The authors reported no conflicts of interest.

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