JACC: CARDIOVASCULAR INTERVENTIONS
VOL. 10, NO. 8, 2017

ISSN 1936-8798/$36.00
PUBLISHED BY ELSEVIER
http://dx.doi.org/10.1016/j.jcin.2017.03.003

EDITORIAL COMMENT

Toward Precision in Balloon-Expandable TAVR

Oversizing Tight Versus Just Right*

Mohamad Alkhouli, MD, Partho Sengupta, MD, Vinay Badhwar, MD

Artificial heart valve sizing in patients undergoing aortic valve replacement has traditionally been achieved intraoperatively using a variety of heart valve sizers. Issues related to sizing inaccuracy of the aortic annulus were first raised by Rahimtoola (1) in 1978 while describing prosthesis-patient mismatch. Outside of discussions of prosthesis-patient mismatch, the topic of valve sizing was rarely alluded to until the introduction of transcatheter aortic valve replacement (TAVR) (2). Early in the transcatheter experience, a strong association was found between inappropriately oversized or undersized transcatheter heart valves (THVs) and major complications, including paravalvular regurgitation (PAR), annular rupture, device embolization, and coronary occlusion (3-5). This has led to a surge in clinical investigations aiming to optimize TAVR sizing.

Compared with surgical valves in which sizing is performed under direct vision, sizing THVs relies entirely on indirect imaging modalities. Therefore, an early major challenge with THVs was to identify the best imaging modality that would provide the most accurate measurement of the aortic annulus. After a decade-long competition among various imaging modalities, multidetector computed tomography became the method of choice for annular measurements pre-TAVR. Also, in contrast to surgical valves, the lower intra-annular prosthetic profile and sutureless aspect of TAVR mandate deliberate oversizing to ensure adequate anchoring and to minimize the risk for PAR. Therefore, the next challenge was to establish the appropriate degrees of oversizing for specific sizes. Initially, large degrees of oversizing (>15% to 20%) were proposed to mitigate the risk for PAR. However, the enthusiasm about aggressive oversizing was tempered by the associated risk for annular rupture (6,7). Therefore, more modest oversizing algorithms to balance the risk for PAR against the risk for annular injury were developed for both SAPIEN and SAPIEN XT balloon-expandable devices (Edwards Lifesciences, Irvine, California) (7). However, because they are device specific, these algorithms require continuous refinements for newer TAVR designs.

SEE PAGE 810

In this issue of *JACC: Cardiovascular Interventions*, Blanke et al. (8) report a study in which they aimed to identify the "sweet spot" for oversizing of the latest generation SAPIEN S3 valve, which is associated with very low rates of PAR and annular rupture. The investigators used data from 835 patients enrolled in the PARTNER (Placement of AoRTic TraNscathetER Valves Trial II) SAPIEN 3 intermediate-risk cohort to investigate the influence of the extent of computed tomography-based area and perimeter oversizing on the incidence and severity of PAR at 30 days. This study highlights several findings that have important implications.

First, using multidetector computed tomographic sizing algorithms, low rates of moderate to severe PAR can be achieved with very little area oversizing (0% to 5%) of the SAPIEN S3 valve. This degree of oversizing is significantly less than the >10% oversizing required to achieve comparably low rates of

*Editorials published in *JACC: Cardiovascular Interventions* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Interventions* or the American College of Cardiology.

From the WVU Heart & Vascular Institute, West Virginia University, Morgantown, West Virginia. The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

PAR with the earlier generation SAPIEN XT valve. This is likely due to distinctive features of the newer generation S3 valve: 1) new frame design—the S3 valve consists of a cobalt-chromium frame with large cells, wider strut angles, and no commissural posts, a design iteration that has been linked to a higher radial strength and a more flared inflow compared with the XT valve (9); and 2) addition of an outer polyethylene terephthalate sealing cuff—these data bring good news for patients with borderline anatomy (annular measurements on the borderline between 2 sizes), in whom device selection can be a dilemma. A larger device would reduce the risk for PAR but increase the risk for annular rupture, whereas a smaller device would do the opposite. Alternative strategies have been previously proposed to overcome these issues, including selecting a larger device with balloon underfilling and post-dilatation as necessary and selecting a smaller device with balloon overfilling (10,11). Although these strategies have been shown to be effective in TAVR, the impact of under- and over-expansion on leaflet function and valve hemodynamic status and possibly the higher rates of cerebrovascular event with post-dilatation remain a concern (12).

Second, area and perimeter-based oversizing algorithms confer similar predictive value of PAR occurrence after SAPIEN 3 THV implantation, with an optimal cutoff for predicting mild to moderate or greater PAR of 4.1% for area oversizing and 0.25% for perimeter oversizing. Traditionally, most operators follow the manufacturer's recommendation and use the annular area for balloon-expandable sizing. However, this study suggests a potential utility for annular perimeter in the size selection of the SAPIEN S3 valve. This is particularly useful in patients with significant annular eccentricity, in whom the relationship between percentage oversizing on the basis of annular area and perimeter is not linear. The investigators suggest the use of perimeter sizing as an adjunct tool to area sizing to predict PAR when no more than nominal area sizing is planned.

Third, the presence of annular and subannular calcification was only modestly associated with PAR. This is in contrast to other studies suggesting a strong independent role for landing zone calcification on the incidence and severity of PAR (13,14). A likely explanation for this finding is perhaps the enhanced paravalvular sealing in the SAPIEN S3 design due to the addition of an outer cuff. However, a stronger correlation between landing zone calcification and PAR could have been concealed because of the small overall number of events in this study. Further longitudinal study of the SAPIEN S3 is required to validate this observation.

The present study serves to narrow the knowledge gap on the very important issue of PAR after TAVR with the contemporary SAPIEN S3 valve. However, it does also raise several intriguing questions.

First, paravalvular regurgitation following TAVR is a complex entity, and several anatomic, procedural, and device-specific factors are implicated in its etiology. What is the impact of other factors not investigated in this study on the occurrence of PAR? For example, what is the impact of the implantation depth on the development and the severity of PAR? There is a trending preference for higher implantation of the SAPIEN S3 valve because of the increased rates of conduction disturbances with the traditional implantation depth targets (15). Would a higher implantation of the SAPIEN S3 valve affect the degree of oversizing required to keep PAR at its minimum?

Second, are there other advantages to the minimal oversizing needed for the SAPIEN S3 valve besides minimizing the risk for PAR while maintaining low rates of PAR? Does it affect valve hemodynamic status, subclinical leaflet thrombosis, and long-term durability? Is it associated with less post-deployment central valve regurgitation? Does it lead to less embolic events?

Third, does the advantage of the lower degrees of oversizing extend to challenging subgroups of patients such as those with high eccentricity index and those with congenital bicuspid aortic valves?

Fourth, the SAPIEN S3 valve frame foreshortens more when it is overexpanded. Are there implications for valve positioning if nominal or minimal oversizing is undertaken?

Nevertheless, the minimal required oversizing and the historically low incidence of PAR with the SAPIEN S3 valve are symbolic of engineering advances in valve designs that continue to progressively improve TAVR outcomes. This study confirms that the few remaining issues with TAVR are slowly but surely being resolved, boosting the momentum of this transformative therapy.

ADDRESS FOR CORRESPONDENCE: Dr. Mohamad Alkhouli, West Virginia University Heart & Vascular Institute, 1 Medical Drive, Morgantown, West Virginia 26505. E-mail: mohamad.alkhouli@wvumedicine.org.

REFERENCES

1. Rahimtoola SH. The problem of valve prosthesis-patient mismatch. Circulation 1978;58:20–4.

2. Bartels C, Leyh RG, Matthias Bechtel JF, Joubert-Hubner E, Sievers HH. Discrepancies between size and valve dimensions: implications for small aortic root. Ann Thorac Surg 1998;65:1631–3.

3. Binder RK, Webb JG, Willson AB, et al. The impact of integration of a multidetector computed tomography annulus area sizing algorithm on outcomes of transcatheter aortic valve replacement: a prospective, multicenter, controlled trial. J Am Coll Cardiol 2013;62:431–8.

4. Gurvitch R, Tay EL, Wijesinghe N, et al. Transcatheter aortic valve implantation: lessons from the learning curve of the first 270 high-risk patients. Catheter Cardiovasc Interv 2011;78:977–84.

5. Yang TH, Webb JG, Blanke P, et al. Incidence and severity of paravalvular aortic regurgitation with multidetector computed tomography nominal area oversizing or undersizing after transcatheter heart valve replacement with the SAPIEN 3: a comparison with the SAPIEN XT. J Am Coll Cardiol Intv 2015;8:462–71.

6. Barbanti M, Yang TH, Rodes Cabau J, et al. Anatomical and procedural features associated with aortic root rupture during balloon-expandable transcatheter aortic valve replacement. Circulation 2013;128:244–53.

7. Blanke P, Reinohl J, Schlensak C, et al. Prosthesis oversizing in balloon-expandable transcatheter aortic valve implantation is associated with contained rupture of the aortic root. Circ Cardiovasc Interv 2012;5:540–8.

8. Blanke P, Pibarot P, Hahn R, et al. Computed tomography-based oversizing degrees and incidence of paravalvular regurgitation of a new generation transcatheter heart valve. J Am Coll Cardiol Intv 2017;10:810–20.

9. Kazuno Y, Maeno Y, Kawamori H, et al. Comparison of SAPIEN 3 and SAPIEN XT transcatheter heart valve stent-frame expansion: evaluation using multi-slice computed tomography. Eur Heart J Cardiovasc Imaging 2016;17:1054–62.

10. Tan JS, Leipsic J, Perlman G, et al. A strategy of underexpansion and ad hoc post-dilation of balloon-expandable transcatheter aortic valves in patients at risk of annular injury: favorable mid-term outcomes. J Am Coll Cardiol Intv 2015;8:1727–32.

11. Shivaraju A, Kodali S, Thilo C, et al. Overexpansion of the SAPIEN 3 transcatheter heart valve: a feasibility study. J Am Coll Cardiol Intv 2015;8:2041–3.

12. Nombela-Franco L, Rodes-Cabau J, DeLarochelliere R, et al. Predictive factors, efficacy, and safety of balloon post-dilation after transcatheter aortic valve implantation with a balloon-expandable valve. J Am Coll Cardiol Intv 2012;5:499–512.

13. Buellesfeld L, Stortecky S, Heg D, et al. Extent and distribution of calcification of both the aortic annulus and the left ventricular outflow tract predict aortic regurgitation after transcatheter aortic valve replacement. EuroIntervention 2014;10:732–8.

14. Maeno Y, Abramowitz Y, Jilaihawi H, et al. Optimal sizing for SAPIEN 3 transcatheter aortic valve replacement in patients with or without left ventricular outflow tract calcification. EuroIntervention 2017 Jan 25 [E-pub ahead of print].

15. Tarantini G, Mojoli M, Purita P, et al. Unravelling the (arte)fact of increased pacemaker rate with the Edwards SAPIEN 3 valve. EuroIntervention 2015;11:343–50.

KEY WORDS balloon-expandable valve, computed tomography, paravalvular leak, transcatheter aortic valve replacement, valve sizing