JACC: CASE REPORTS VOL. 2, NO. 12, 2020

EDITORIAL COMMENT

Calcium Assessment, Correct Sizing, and Care With Balloons

Three Commandments to Prevent Annular Rupture Post-TAVR*

Gianluca Lucchese, MD, PhD,[a] Omar A. Jarral, MBBS, PhD,[a] Simon Redwood, MD,[b] Bernard Prendergast, MD[b]

In this issue of *JACC: Case Reports*, Kellogg et al. (1) from Boston describe the successful percutaneous management of contained annular rupture following transcatheter aortic valve replacement (TAVR). Following deployment of a self-expandable valve in a fit 70-year-old patient with aortic stenosis, an area of contrast extravasation was noted and was managed conservatively. Post-operative surveillance demonstrated enlargement of the pseudoaneurysm with compromise of the right coronary artery. Since the patient declined surgical correction, they proceeded with percutaneous closure using 4 coils and polymer injection. This case is interesting for a number of reasons. First, the operators showed extreme technical skill in dealing with this difficult situation—one of just a few reported cases where treatment completely sealed the origin of the pseudoaneurysm. Second, the patient had limited calcification in the landing zone, and was theoretically at low risk of complications, demonstrating the importance of vigilance in all cases. Last, as the patient preferred a nonsurgical approach throughout, it demonstrates how difficult navigating patient preference and consent can be in the face of rapidly developing technology.

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

From the [a]Department of Cardiac Surgery, St. Thomas' Hospital, London, United Kingdom; and the [b]Department of Cardiology, St. Thomas' Hospital, London, United Kingdom.

The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the *JACC: Case Reports* author instructions page.

DEFINITION AND INCIDENCE

Annular rupture is a term that refers to a broad and imprecise category of injuries to the TAVR landing zone (2) and can be further categorized based on anatomical location, completeness of injury (contained or uncontained), and subsequent impact (e.g., pericardial effusion, coronary compromise, or fistula). The reported incidence is 0.5% to 1.0%, but is probably higher due to unidentified contained ruptures of little clinical significance. Annular rupture accounts for 15% of patients requiring a bail-out surgical procedure following TAVR, and in-hospital mortality is 50% for contained and >75% when uncontained (3,4).

ANATOMY AND CLASSIFICATION

Anatomically, injuries may be annular, subannular, or supra-annular (5). Detailed knowledge of landing zone anatomy is essential for operators in understanding the mechanism and impact of potential injuries, particularly in the subannular region. Annular injuries are typically localized and may subsequently be sealed by the implanted valve. Supra-annular injuries may traumatize the aortic wall (leading to aortic dissection) or coronary ostia. The consequences of subannular perforation depend on location, since the left ventricular outflow tract (LVOT) has fibrous and muscular parts (6). The fibrous part forms the aorto-mitral continuity, sitting between the right/noncoronary commissure and the mid portion of the left coronary cusp. In the healthy patient, this region is strong and distensible, and damage can typically result in acute mitral regurgitation or a ventricular septal defect, rather than catastrophic bleeding. The muscular part lies under the right coronary sinus and the left

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2020.09.001

JACC: CASE REPORTS, VOL. 2, NO. 12, 2020
OCTOBER 2020:1859–61

portion of the left coronary sinus. The portion under the right sinus is formed by the interventricular septum and anatomically supported by the overriding right ventricular outflow tract, and injuries are therefore less likely to be immediately life threatening. The remainder of the muscular LVOT is less protected, and thus is more likely to lead to bleeding (6). Hematoma in neighboring muscle has potential to spread to the subepicardial fat, and subsequently the pericardial space. Typically, this would occur in the proximal atrioventricular groove behind the main pulmonary artery, and close to the base of the left atrial appendage and proximal circumflex (6). The anatomic heterogeneity of annular injuries understandably means that it can present in a wide variety of ways, including totally silent, unexplained circulatory collapse, coronary ischemia, arrythmias, pericardial effusion, and the presence of periaortic hematoma or abnormal shunts.

RISK FACTORS

Conceptual knowledge regarding this topic is in its infancy: there are just a handful of reviews in the published data, there are no basic science studies, and predictors are based on retrospective and registry data, which may be subject to confounding. However, a number of contributory factors have emerged (7). The risk of annular rupture is significantly higher in the presence of moderate or severe LVOT calcification (8). This makes sense from a biomechanical point of view, since these regions of stiffness have lower yield strength. Calcification may also be a marker of overall patient frailty. Not all LVOT calcification is the same: the highest risk is in the anatomically weakest region of the muscular LVOT, as described in the previous text (6).

Rupture is mainly a complication associated with balloon-expandable TAVR devices and seldom encountered with self-expanding devices unless excessive balloon pre- or post-dilatation is performed. Balloon-expandable valves exert greater radial force and circularize the annulus (9). This risk is significantly exacerbated with aggressive over sizing (>20%) or post-dilatation in the presence of calcification.

Other anatomic risk factors include bicuspid valve, small root diameter (<20 mm), annular asymmetry, and asymmetric LVOT hypertrophy. Institutional/operator risk factors include poor patient selection, low procedural volumes, lack of experience, and incorrect aortic measurements.

TIPS TO AVOID ANNULAR RUPTURE: LESSONS FROM EXPERIENCE

Aortic annular rupture is among the most devastating life-threatening complications of TAVR. Although uncommon, the high associated mortality requires careful procedural planning and execution. We have identified the following golden rules from our own experience:

1. Always perform a detailed quantitative and descriptive assessment of leaflet, annular, and LVOT calcification.
2. Size the device carefully based on annular and LVOT dimensions. Utilize the latest imaging software to obtain measurements in multiple views and at multiple levels.
3. In a high-risk patient, consider using smaller valves, and use balloon-expandable devices with caution. Consider incomplete inflation if a balloon if used (e.g., 2 to 3 ml underfilled) (2). If balloon dilatation is required, do not exceed the mean diameter of the LVOT or sinotubular junction (whichever is smaller). A balloon-to-artery ratio of 1 can be used for semicompliant balloons and <1 for noncompliant balloons (10). Adopting a slow 2-step deployment is an alternative technique to reduce the risk of annular rupture using balloon expandable valves in the presence of adverse anatomical features.
4. Ensure that the valve is deployed in a plane parallel to the annulus. Modify implantation (e.g., higher valve positioning to avoid protruding deposits) if required.
5. The presence of multiple risk factors for annular rupture in low- or intermediate-risk patients should heighten awareness and may favor conventional surgery at the time of heart team discussions.
6. Uncontained rupture requires emergency surgery and carries a very high mortality. Contained ruptures with no evidence of ongoing bleeding or compromise can be managed conservatively, with appropriate surveillance in-hospital and after discharge. This case is an extraordinary example of effective complete transcatheter occlusion of a "benign" contained rupture.

CONCLUSIONS

Annular rupture can be a devastating complication of TAVR. Awareness and avoidance are key, with particular focus on high-risk LVOT calcium, correct valve sizing, and careful use of balloons. Operators implanting in the high-risk setting need advanced percutaneous skills to deal with potential complications, and the judgement to know when to manage rupture using a conservative, percutaneous, or surgical approach. Patient preferences need to be taken into consideration, but ultimately, the heart team should lead the decision-making process in the patient's best interest.

AUTHOR RELATIONSHIP WITH INDUSTRY

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr. Gianluca Lucchese, Department of Cardiac Surgery, St. Thomas' Hospital, Westminster Bridge Road, London SE1 7EH, United Kingdom. E-mail: Gianluca.lucchese@gstt.nhs.uk.

REFERENCES

1. Kellogg MS, Tuttle MK, Sharma R, Mehta SV, Laham RJ. Percutaneous management of a contained annular rupture occurring with self-expanding transcatheter aortic valve replacement. J Am Coll Cardiol Case Rep 2020;2:1852–8.

2. Pasic M, Unbehaun A, Buz S, Drews T, Hetzer R. Annular rupture during transcatheter aortic valve replacement: classification, pathophysiology, diagnostics, treatment approaches, and prevention. J Am Coll Cardiol Intv 2015;8:1–9.

3. Arsalan M, Kim WK, Van Linden A, et al. Predictors and outcome of conversion to cardiac surgery during transcatheter aortic valve implantation. Eur J Cardiothorac Surg 2018;54:267–72.

4. Pineda AM, Harrison JK, Kleiman NS, et al. Incidence and outcomes of surgical bailout during TAVR: insights from the STS/ACC TVT registry. J Am Coll Cardiol Intv 2019;12:1751–64.

5. Aksoy O, Paixao AR, Marmagkiolis K, Mego D, Rollefson WA, Cilingiroglu M. Aortic annular rupture during TAVR: mini review. Cardiovasc Revasc Med 2016;17:199–201.

6. Girdauskas E, Owais T, Fey B, et al. Subannular perforation of left ventricular outflow tract associated with transcatheter valve implantation: pathophysiological background and clinical implications. Eur J Cardiothorac Surg 2017;51:91–6.

7. Yoon SH, Bleiziffer S, De Backer O, et al. Outcomes in transcatheter aortic valve replacement for bicuspid versus tricuspid aortic valve stenosis. J Am Coll Cardiol 2017;69:2579–89.

8. Okuno T, Asami M, Heg D, et al. Impact of left ventricular outflow tract calcification on procedural outcomes after transcatheter aortic valve replacement. J Am Coll Cardiol Intv 2020;13:1789–99.

9. Das R, Puri R. Transcatheter treatment of bicuspid aortic valve disease: imaging and interventional considerations. Front Cardiovasc Med 2018;5:91.

10. Coughlan JJ, Kiernan T, Mylotte D, Arnous S. Annular rupture during transcatheter aortic valve implantation: predictors, management and outcomes. Interv Cardiol 2018;13:140–4.

KEY WORDS annular rupture, aortic stenosis, complications, TAVR