JACC: CASE REPORTS VOL. 1, NO. 3, 2019

EDITORIAL COMMENT

Delayed Coronary Obstruction After Transcatheter Aortic Valve Replacement*

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Transcatheter aortic valve replacement (TAVR) has become the mainstay treatment for patients with severe, symptomatic aortic stenosis who are not candidates for surgical aortic valve replacement due to either intermediate or high risk for perioperative morbidity or mortality; there is evidence of at least equivalent outcomes and possible superiority in the short term in low surgical risk patients (1,2). TAVR has also emerged as a therapeutic option in patients with previous surgical valves who are at high risk for reoperative surgical aortic valve replacement, the valve-in-valve (ViV) approach (3). Coronary obstruction is an infrequent complication of TAVR, with an incidence ranging from 0.35% to 4.0% that increases 3- to 4-fold in ViV TAVR (4,5). This complication is devastating as the mortality rate approaches 50% (6). Typically, the left main coronary artery is implicated more than the right coronary artery (5). Most cases present with severe, persistent hypotension.

Coronary obstruction occurs when a native or bioprosthetic leaflet comes into direct or proximal contact with the coronary ostium or the aortic root at the coronary ostium (4). Acute coronary obstruction is identified at the time of the procedure (7). Delayed coronary obstruction (DCO) occurs after the procedure has concluded. DCO can be classified into 2 groups: early, occurring ≤7 days of TAVR, or late, occurring >7 days after TAVR. Patients who develop DCO within 7 days of TAVR usually present with cardiac arrest or ST-segment elevation myocardial infarction (and a higher subsequent in-hospital mortality rate), whereas patients with DCO occurring after >7 days typically present with stable or unstable angina.

Retrospective data have been used to identify risk factors for coronary obstruction, with female sex, coronary ostial height <10 mm, sinus of Valsalva width <30 mm, leaflet length greater than corresponding coronary height, and a previous aortic prosthetic valve in situ putting patients at highest risk (8). Although the distance between the annulus and the coronary ostium is typically used to determine the risk of coronary obstruction in the setting of native valve TAVR, this measurement is less useful in ViV TAVR (4). Proximity of the coronary ostia to the final position of the existing bioprosthetic leaflets is the most important risk factor for coronary obstruction during ViV TAVR.

In ViV TAVR, unless the sinuses are shallow, coronary obstruction is not necessarily caused by low position of the coronary ostia (4). It occurs more frequently with stenotic and bulky bioprosthetic valves compared with regurgitant valves. Bioprosthetic valve selection (particularly valves with an external sewing ring such as the Mitroflow bioprosthetic valve, Sorin Group USA Inc., Arvada, Colorado) during surgery can have a significant impact on outcomes for patients who undergo ViV TAVR years later. In addition to aortography and coronary angiography, computed tomography imaging has become the mainstay for assessing aortic root dimensions and relative positioning of the surgical valve. Dvir et al. (4) stratified risk for coronary obstruction using virtual transcatheter heart valve (THV)-coronary distances as follows: high risk, <3 mm; intermediate risk, 3 to 6 mm; and low risk, >6 mm.

*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.

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ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2019.08.011

As risk factors for coronary obstruction have been identified in recent years, efforts to reduce its risk have also increased. When choosing the THV, smaller diameter valves or under-filling and under-expansion of the balloon-expandable valves may result in less contact of the surgical valve leaflets with the coronary ostia (4). Use of retrievable THVs can be beneficial during ViV TAVR, especially valves that can be retrieved after full deployment. Surgical valve leaflet dynamics can be simulated by using balloon valvuloplasty; however, aggressive balloon dilation should only be done when TAVR can be completed rapidly due to the high risk of hemodynamic compromise from tearing of degenerated leaflets.

Because these patients are at high risk for surgery at the time of the decision to pursue ViV TAVR, treatment of coronary obstruction in these patients becomes even more troublesome. Their condition is typically unstable, and cannulation of the coronaries with the guidewire and subsequent stent deployment is challenging. This dilemma has led to "protection" of coronaries by placement of guidewires in the coronary ostia during TAVI, with occasional bailout stenting if required (4).

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Building on the aforementioned principle, the "chimney snorkel" technique was developed for prevention of acute coronary obstruction for high-risk ViV TAVR (6), as described in this issue of *JACC: Case Reports* by Nour et al. (8). In this approach, radial access is used for positioning the marker pigtail in the noncoronary cusp, femoral arterial access is used for TAVR, and contralateral radial or femoral arterial access is used for percutaneous coronary intervention, typically with the use of a guiding catheter extension. Fetahovic et al. (6) recommend stent selection (>35 mm) that protrudes above the height of the pre-existing bioprosthetic valve. A low threshold is advised when deciding to deploy these stents after THV deployment. Furthermore, flaring the proximal portion of the stent is theorized to allow for improved chances for subsequent coronary access.

Bioprosthetic or native aortic scallop intentional laceration to prevent iatrogenic coronary obstruction (BASILICA) has also emerged as a novel procedural technique performed immediately before TAVR for coronary obstruction prevention. Khan et al. (9) have developed and described the technique in detail, beginning with their in vitro studies and subsequent clinical application. A catheter is used to direct an electrified guidewire through the base of an aortic cusp into a snare placed in the left ventricular outflow tract. After snaring the guidewire, it is electrified to lacerate the corresponding leaflet, resulting in splaying of the leaflet after THV deployment, allowing coronary blood flow. The left coronary artery stents used in the chimney snorkel technique are at high risk of fatal restenosis and thrombosis. As evidenced in this case report, they are also susceptible to compression. However, a major limitation of BASILICA is difficulty with lacerating heavily calcified leaflets, which may result in embolic debris. This, however, could be obviated by systematic use of cerebral embolic protection devices during TAVR, a standard practice at our institution.

Although both the chimney snorkel and BASILICA techniques currently lack long-term, prospective outcomes, preliminary results have been reported. In 30 patients enrolled in a prospective trial, 93% had procedural success, with 100% of patients lacking coronary obstruction or reintervention at 30 days (10). The BASILICA technique requires specific training and is currently limited to high-volume centers. In addition, the data currently available do not compare BASILICA versus the chimney snorkel technique head-to-head. However, there seems to be an emerging trend toward BASILICA eventuating as the preferred technique of choice for prevention of coronary obstruction during native or ViV TAVR.

Jabbour et al. (11) have proposed other approaches that may help prevent coronary obstruction. For example, direct anchoring of THV to aortic leaflets may reduce the risk of prolapse and coronary obstruction. There are registry reports of such valves having no coronary obstruction events in 1,000 patients at 30 days. Valves with larger stent cell sizes may allow for less challenging percutaneous coronary intervention after TAVR. Low-profile valve skirts may reduce the risk of DCO that occurs due to prosthesis skirt obstruction. As mentioned, a retrievable valve design may be beneficial. Thrombus embolization from THV into coronary arteries has been suspected as a cause of DCO, and reduced leaflet motion can be a surrogate marker of thrombus formation on the leaflets due to delayed neosinus blood flow. Interestingly, BASILICA with subsequent supra-annular valve implantation compared with intra-annular valve implantation may result in improved flow dynamics in the neosinus (12). Currently, the ATLANTIS (Anti-Thrombotic Strategy After Trans-Aortic Valve Implantation for Aortic Stenosis; NCT02664649) trial is investigating anticoagulation strategies in TAVR; the results may provide insight into pharmacological means of preventing DCO (11).

As TAVR inevitably drifts toward a greater number of potential candidates at lower surgical risk and younger age, challenging anatomical substrates will continue to fuel the desire to develop techniques and valve iterations that will obviate complications such as coronary obstruction.

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REFERENCES

1. Popma JJ, Deeb GM, Yakubov SJ, et al. Transcatheter aortic-valve replacement with a self-expanding valve in low-risk patients. N Engl J Med 2019;380:1706–15.

2. Mack MJ, Leon MB, Thourani VH, et al. Transcatheter aortic-valve replacement with a balloon-expandable valve in low-risk patients. N Engl J Med 2019;380:1695–705.

3. Neylon A, Ahmed K, Mercanti F, Sharif F, Mylotte D. Transcatheter aortic valve implantation: status update. J Thorac Dis 2018;10:S3637–45.

4. Dvir D, Leipsic J, Blanke P, et al. Coronary obstruction in transcatheter aortic valve-in-valve implantation: preprocedural evaluation, device selection, protection, and treatment. Circ Cardiovasc Interv 2015;8.

5. Ribeiro HB, Sarmento-Leite R, Siqueira DAA, et al. Coronary obstruction following transcatheter aortic valve implantation. Arq Bras Cardiol 2014;102:93–6.

6. Fetahovic T, Hayman S, Cox S, Cole C, Rafter T, Camuglia A. The prophylactic chimney snorkel technique for the prevention of acute coronary occlusion in high risk for coronary obstruction transcatheter aortic valve replacement/implantation cases. Heart Lung Circ 2019;28:e126–130.

7. Jabbour RJ, Tanaka A, Finkelstein A, et al. Delayed coronary obstruction after transcatheter aortic valve replacement. J Am Coll Cardiol 2018;71:1513–24.

8. Nour D, Allahwala U, Hansen P, Brady P, Choong C, Bhindi R. Cardiogenic shock due to late chimney stent failure following valve-in-valve transcatheter aortic valve replacement. J Am Coll Cardiol Case Rep 2019;1:313–8.

9. Khan JM, Dvir D, Greenbaum AB, et al. Transcatheter laceration of aortic leaflets to prevent coronary obstruction during transcatheter aortic valve replacement. J Am Coll Cardiol Intv 2018;11:677–89.

10. Khan JM, Greenbaum AB, Babaliaros VC, et al. The BASILICA trial. J Am Coll Cardiol Intv 2019;12:1240–52.

11. Jabbour RJ, Imperial College London, United Kingdom, Tanaka A, et al. Delayed coronary occlusion after transcatheter aortic valve implantation: implications for new transcatheter heart valve design and patient management. Interv Cardiol 2018;13:137.

12. Hatoum H, Maureira P, Lilly S, Dasi LP. Impact of leaflet laceration on transcatheter aortic valve-in-valve washout: BASILICA to solve neosinus and sinus stasis. J Am Coll Cardiol Intv 2019;12:1229–37.

KEY WORDS BASILICA, chimney, coronary obstruction, PCI, transcatheter aortic valve replacement