

Chapter 16: Valve in Valve TAVR

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Rationale and Clinical Data

The rapid growth of TAVR in native valve disease has expanded to use in patients with surgical bioprosthetic heart valve (SHV) degeneration who are at high risk for repeat surgical intervention. There are no data from randomized trials, but accumulating experience in high risk patients and published observational series, have demonstrated the efficacy and feasibility of Valve-in-Valve (ViV) TAVR among patients who would previously have had no recourse beyond repeat high-risk surgery or palliation. The success of ViV TAVR has yielded expansion of the ViV concept to mitral valve pathology and has also supported the growing use of bioprosthetic valves in younger patients, given the feasibility of ViV TAVR as a viable and anticipated long-term management strategy for SHV degeneration (1).

The Valve-in-Valve International Data registry (VIVID), which began collecting data in December 2010, is the largest repository of evidence documenting clinical outcomes. ViV registry data, including 459 patients from 55 sites between 2007 and 2013, demonstrated an overall 83.2% survival at one year (2). First generation balloon- and self-expanding trans-catheter heart valves (THV) were both included in the analysis and did not show any difference in outcomes. One-year survival varied significantly, however, by the mechanism of SHV degeneration: stenosis (76.6%), combined (83.9%), regurgitation (91.2%), and by the size of the SHV (significantly favoring larger surgical valves). These data highlight the influence of pre-existing SHV characteristics on ViV procedural outcomes. While SHV characteristics are an unmodifiable predictor of outcomes, future SHV designs will likely reflect elements conducive to later ViV therapy, such as clearly defined neo-annular markers visible by fluoroscopy or more pliable sewing rings. TAVR-in-TAVR procedures are uncommon. In a recent series of 13,876 patients from 14 centers, only 50 patients (0.4%) underwent re-do TAVR beyond two weeks of initial implantation (3).

Valve in Valve Smartphone App

Through a collaborative effort between UBQO Limited (London, UK) and Dr. Vinayak Bapat (St. Thomas Hospital, London, UK), the free “ViV” smartphone application (available at: <https://www.ubqo.com/viv>) has become a widely-used tool for informing and guiding ViV procedures. This app was developed using the large array of SHVs that have been developed over time. Incorporating multiple fluoroscopic still frame and video depictions of deployments and ex-vivo photographs of all commercially available surgical and trans-catheter bioprostheses, the app offers salient and succinct guidance on both pre-procedural and procedural steps, including: SHV design and structural elements, fluoroscopic identification of the SHV and its neo-annulus, THV sizing by the identified SHV, and characteristics of successful THV placement. Given that each ViV case is unique and there exist a wide

array of SHVs, this app allows operators to quickly answer case-specific questions in a timely fashion. Many aspects of ViV TAVR that are beyond the scope of this chapter can easily be addressed through this app. While valve-in-mitral will not be discussed in this chapter, it should be noted that there is similar application available for planning valve-in-mitral procedures (available at: <https://www.ubqo.com/vivmitral>).

Valve positioning and the Neo-annulus

Native transcatheter valve replacement is described in detail in other chapters. While the procedural steps for ViV TAVR are similar, there are some distinct elements requiring careful attention. Most important among these considerations is defining the neo-annulus, which serves as the plane for valve positioning. The neo-annulus will vary depending on the SHV used, and its specific design and implantation characteristics (1). In turn, successful ViV deployment will depend on the physical interaction between the selected THV and the neo-annulus. Careful review of the operative note is imperative to confirm the SHV size and model. Fortunately, the array of available SHVs, as well as THVs (for TAVR-in-TAVR procedures) are captured by the ViV app, which includes valve-specific images of fluoroscopic neo-annular position.

Bioprosthetic SHVs fall into two broad categories: stentless and stented. Stentless valves do not have a rigid stent frame and are used in complete root replacement with coronary artery re-implantation. For isolated aortic valve replacement, which most commonly involves use of a stented bioprosthesis, valve replacement typically yields sub-coronary implantation which raises the risk of coronary obstruction with a ViV procedure (1). Stented valves have three struts which suspend bovine or porcine leaflets on a rigid frame. A sewing ring covered by fabric forms the base. Variations of stented valves include leaflets mounted internally (most common), externally, or positioned supra annularly. The leaflets dictate the true internal diameter (TID) of the valve, which in turn dictates ViV THV sizing. It is important to note that two valves with the same manufacturer reported nominal size, reflecting the outer stent diameter, may have different TIDs. THV sizing for stentless valves is based on tissues annular measurement and is similar to TAVR in native annuli.

Procedurally, obtaining a fluoroscopic view perpendicular to the annular plane of the SHV is critical for optimal positioning. This is often obtained with LAO angulation. Trans-esophageal echocardiography can be very useful in identifying the neo-annulus for stentless valves, stented valves with radiolucent basal rings, or degenerative SHVs with minimal calcification (4). In addition, aortic root aortography during deployment can facilitate appropriate positioning. For balloon expandable devices, a two-stage deployment with slow initial inflation and mid-inflation injection can permit fine adjustment if necessary. Pivoting of the valve about the first point of contact should be anticipated. Coronary wiring can also be performed to establish a landmark, followed by slow valve deployment with contrast injections. For self-expanding devices, slow deployment is important to permit adjustment and recapture if necessary. Of course, images and experience drawn from prior deployments with the same SHV is invaluable. Although pacing is not always necessary for self-expanding devices, it may be beneficial if there is any ambiguity regarding the neo-annular plane, or if the SHV degeneration is predominantly regurgitant in nature. TAVR-in-TAVR procedures follow similar principles, again hinging on identification of the device-specific neo-annulus.

Procedural considerations

Coronary obstruction. The risk of coronary obstruction is higher after ViV (3.5%) compared to native-valve TAVR (0.7%) (5). This may be underestimated and under-recognized due to the presence of bypass-grafts and partial coronary obstruction (6). The most common mechanism is displacement of SHV leaflets by the THV, causing direct contact with the coronary ostium. Anatomic risk factors for coronary obstruction include low-positioned or re-implanted coronary ostia, narrow sinuses, and a supra-annular SHV position. Device factors include high THV positioning, over-sizing, externally mounted SHV leaflets, heavily calcified SHV leaflets and stentless SHVs with sub-coronary implantation (1). To minimize risk, pre-procedure and intra-procedure planning is essential (4,6). A multi-modality approach with echocardiography, CT, and procedural aortography and fluoroscopy is required to define the relationship of the SHV to the aortic root and coronary ostia (4). Coronary wiring prior to THV deployment may be required in high risk cases to facilitate emergent PCI.

High transvalvular gradients. Due to a rigid annulus and stent posts, SHVs are less distensible than native annuli. THV under expansion can result, causing higher gradients - particularly in patients with smaller SHVs (sizes < 23 mm) (7). Registry data has shown that gradients >20 mmHg were seen in 28% of the patients (5). Patients with SHVs that are 19 mm or 21 mm may be considered ineligible for ViV TAVR or anticipate very high gradients, respectively. Moreover, valve degeneration would presumably proceed at a faster rate if immediate post-implant gradients are high. These considerations are important given the growing use of bioprosthetic SHVs in younger patients with the intention of ViV TAVR as an anticipated therapy for SHV denervation. Higher post-operative gradients have been noted in the Sapien THV compared to CoreValve, an effect that was even further pronounced with smaller SHVs. This difference is likely due to supra-annular positioning of valve leaflets in CoreValve, generating a wider effective orifice area (8). Updated data with current generation devices is not available, but CoreValve implantation may be preferred in patients with smaller SHV size and imaging features concerning for patient-prosthesis mismatch.

Migration/Malposition. Early ViV data demonstrated a valve malposition rate (too aortic or ventricular) as high as 15%. This led to a high attempted retrieval rate (9%) and implantation of a second THV (8.4%) - valve-in-valve-in-valve (5). Early results were hampered by operator inexperience, challenges with identification of landmarks during fluoroscopy (stentless valves, less calcified bioprosthetic valves), and selection of smaller THVs (1,4). To avoid this complication, careful study of imaging and a thorough understanding of the SHV design and neo-annular fluoroscopic signature is essential. Again, the ViV app is an excellent, centralized tool to inform each planning step. It is also imperative that heart team members are equipped with skills to manage retrieval or second valve implantation.

Post procedure Follow-up

Despite the growth in ViV TAVR, there are no practice guidelines or consensus statements regarding post-procedure management. Important issues during follow-up include selection and duration of antiplatelet and/or anticoagulant agents, and the role of non-invasive testing, particularly to detect thrombus or heightened gradients. At this time, practice patterns have generally been extrapolated from

guidelines for native-valve TAVR (9,10). There is a growing literature on the risk of prosthetic leaflet thrombosis following TAVR with an observed incidence ranging from 7-13% (11-13). This may be an underestimate since routine surveillance for leaflet thrombosis is uncommon. The risk of thrombosis could be even higher following ViV procedures due to double-layering of prosthetic material (3). Currently, the most commonly used post-TAVR treatment regimen has been 3-6 months of therapy with 75 mg of clopidogrel along with 75 mg to 100 mg of aspirin daily (9). Importantly, about 25% of patients undergoing TAVR have pre-existing atrial arrhythmias requiring anticoagulation. In these patients, aspirin is used with an anticoagulant (9). Given recent studies showing evidence of subclinical and clinically relevant valve thrombosis following TAVR, updates to the valve guidelines have included a grade IIb recommendation for 3 months of warfarin following TAVR, (INR goal 2.5) (10,12,13). In the absence of randomized trial data, it may be prudent to employ this strategy following ViV procedures. Overall, patient specific risk factors should dictate treatment decisions.

Clinical and imaging follow-up after ViV procedures is similar to patients who have undergone TAVR (14). Careful attention should be given to elevated gradients, abnormalities in leaflet motion, and worsening of symptoms - features that should raise suspicion for valve thrombosis and justify prolonged anticoagulation (12,13). TEE can be obtained if TTE is insufficient and in the future, CT imaging may play a greater role in the detection of subclinical valve thrombosis (11).

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