



# Balloon expandable transcatheter aortic valve for degenerative prior prosthetic valve dysfunction

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Bioprosthetic surgical aortic valve replacement (SAVR) has increased dramatically over the past decade as patients seek to avoid lifelong anticoagulation (1). The trend has been fortified by the assurance of a future percutaneous treatment with a transcatheter aortic valve replacement (TAVR) within the existing SAVR, dubbed valve-in-valve (ViV) (2). The implications are most significant for younger, low-risk patients whose life-expectancy will exceed that of the initial SAVR valve and may in fact exceed the ViV-TAVR, as all current bioprosthetic valves will eventually fail. TAVR as the initial valve in young patients further complicates decision making as long-term durability data is lacking (3-5). However, both ViV-TAVR and TAVR-in-TAVR (redo-TAVR) are now viable options with improved short-term morbidity and mortality, when compared to redo-SAVR for higher risk patients (2).

Results from the PARTNER (Placement of Aortic Transcatheter Valves) II registry are encouraging for ViV-TAVR with SAPIEN XT (Edwards Lifesciences, Irvine, CA, USA) balloon expandable valve (BEV), demonstrating sustained performance at three years with no change in gradients, effective orifice area, or aortic regurgitation, as well as improvement in quality of life and functional status (6). However, patients were high-risk and treated with only 23 or 26 mm Sapien XT valves, and SAVR valves <21 mm were excluded.

The appropriate valve for a ViV-TAVR requires special attention to individual patient anatomy, as assessed by computed tomography angiography (CTA). Measuring the SAVR true internal diameter for TAVR valve sizing, and diameters of the sinotubular junction (STJ) as well as coronary heights for coronary obstruction risk, assists

in determining ViV feasibility. The SAVR leaflet tissue creates a continuous skirt above the annulus when the TAVR is implanted and can result in sinus sequestration and coronary obstruction. A valve-to-coronary distance of 4 mm determines feasibility of ViV to avoid a catastrophic complication. The height of the BEV frame and intra-annular position are favorable in this regard as the TAVR lands within or below the SAVR leaflets. However, the cylindrical frame of the BEV causes the SAVR leaflets to open fully, making future coronary access potentially challenging. Coronary access after ViV is a concern that applies to all transcatheter heart valve (THV) designs and the BEV may hold an advantage over the self-expanding valve (SEV), with regards to coronary access and risk for coronary obstruction during ViV-TAVR or future redo-TAVR procedures. While using a SEV for ViV procedures may allow for retrieval or repositioning if there is evidence of impending coronary obstruction, the leaflets of the supra-annular SEV will often reach the STJ, thus making coronary access challenging and likely prohibiting a future redo-TAVR. In CTA analysis, coronary arteries originated below the top of the neo-skirt in 90% of SEV first cases, compared with 67% of BEVs, which may be compounded when the THV is within a SAVR frame. Further, the risk for technically impossible coronary access has been estimated at 27% for SEV and 10% for BEV (7). Leaflet modification strategies have been employed, such as electrosurgical techniques (BASILICA), in order to split the leaflets and increase coronary flow, but the technique is not yet widely adopted. Currently, there is no percutaneous leaflet removal strategy available for failed SAVR valves that mimics surgical leaflet excision. This has important implications for

young patients, who may require three valves during their lifetime, and this further supports the use of ViV only in high-risk re-operative SAVR patients.

Although the BEV's low frame height has advantages with respect to coronary access, the position within an existing SAVR may come at the detriment of hemodynamics and long-term durability. The BEV intra-annular design has been associated with inferior hemodynamics compared with the supra-annular SEV. The Valve-in-Valve International Data Registry (VIVID) found elevated post-procedural gradients, defined as mean gradients >20 mmHg, more common after BEV ViV than SEV ViV (40% vs. 21.3%,  $P<0.0001$ ). Furthermore, BEV also appeared to perform poorly in small surgical valves (ID <21 mm), with higher rates of elevated post-procedural gradients when compared to SEV (58.8% vs. 20%,  $P=0.005$ ) at one year follow-up (8). While these findings did not necessarily translate to obvious mortality differences, the long-term clinical implications are worrisome (9).

When assessing long-term outcomes, pre-existing SAVR patient prosthesis mismatch (PPM) was an independent predictor for re-intervention after ViV and was associated with decreased patient survival, demonstrating the need for careful valve selection at the time of the initial surgery as well as subsequent ViV (10). The poor hemodynamic results of BEV in small SAVR valves with pre-existing PPM, high residual gradient and increased need for re-intervention after ViV with BEV, cumulatively suggests the intra-annular valve may not be the right choice for these patients. Often THVs fail to fully expand in ViV procedures. Although elevated gradients can be seen in all ViV procedures, the BEV intra-annular design with leaflets constrained within the SAVR, can result in leaflet dysfunction which may increase the risk of thrombosis and earlier structural valve deterioration. Under-expanded THVs can be optimized by balloon fracture of the SAVR frame, resulting in lower gradients and potentially improved long-term durability. Due to lack of guidelines for anticoagulation post-ViV, many centers opt for six to twelve months of oral anticoagulation (warfarin or a novel oral anticoagulant such as apixaban) in addition to aspirin antiplatelet therapy.

In summary, the choice of THV for ViV procedures has long-term implications for hemodynamics and coronary access. Heart teams must carefully weigh the advantages and disadvantages of each THV. If the last 20 years of TAVR development can predict future device development, newer devices and adjunctive procedures will be invented to solve these issues. While we await these solutions, we

must counsel patients on the lifetime management of aortic stenosis, presenting an anatomically optimized strategy not only for the immediate valve but also accounting for patients who may have more than 30 years to live and potentially require three valves. While SEV may be appropriate in patients with small surgical valves at risk for PPM, an optimized BEV with leaflet modification and fracture of the SAVR can provide excellent hemodynamics with superior coronary access and may therefore be the most appropriate choice for younger patients, who will most likely require an additional valve procedure during their lifetime.

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### Footnote

*Conflicts of Interest:* KJG is a consultant for Edwards Lifesciences and Medtronic; national PI for Medtronic. The other authors have no conflicts of interest to declare.

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