Transfemoral aortic valve replacement for severe aortic valve regurgitation in a patient with a pulsatile-flow biventricular assist device

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Abstract

Severe aortic regurgitation (AR) is a rare but significant complication of ventricular assist device therapy. Experience with transcatheter aortic valve replacement (TAVR) in this setting of patients is very limited, while the scarcely reported cases exclusively refer to TAVR under continuous-flow left ventricular assist devices. Here, we present the first successful TAVR while running a pulsatile-flow biventricular assist device (PF-BiVAD). Clinical data were collected based on the patient's electronic medical records after the patient's consent was obtained. We describe the case of a 57-year-old man in whom a PF-BiVAD (EXCOR, Berlin Heart, Berlin, Germany) had been initially inserted after fulminant myocarditis with subsequent severe dilated cardiomyopathy as bridge-to-transplantation therapy. Over the following 2 years, the patient developed severe *de novo* AR under PF-BiVAD therapy. This, along with progressive cardiac decompensation, led to the decision for TAVR by our heart team as a minimal invasive approach for severe AR. TAVR using two Edwards SAPIEN 3 bioprostheses as a valve-in-valve procedure resulted in a significant reduction of AR from severe to mild, with trace paravalvular leakage and without significant pressure gradients. The patient underwent total orthotopic heart transplantation afterwards. This is the first report of successful TAVR in a patient with severe *de novo* AR while running a PF-BiVAD.

Introduction

Over the last decade, catheter-based technologies have been developed as an alternative to established surgical techniques for the treatment of cardiovascular diseases. For example, transcatheter aortic valve replacement (TAVR) has become a standard therapy in patients with symptomatic severe aortic stenosis at high or prohibitive surgical risk and as an alternative in patients with intermediate surgical risk.[1,2] In parallel, there has been significant improvement in cardiac surgery techniques and therapy options. For instance, ventricular assist devices (VADs) are of increasing importance in the treatment of end-stage congestive heart failure.[3] Currently, continuous-flow VADs (CF-VADs) represent the most frequently used devices, opposing to first-generation pulsatile-flow VADs (PF-VADs).[4–6] Compared with PF-VADs, CF-VADs feature improved reliability, durability, and survival, but the diminished pulsatility is considered to be responsible for some complications: gastrointestinal bleeding, pump thrombosis, and aortic regurgitation (AR).[5,7] However, AR is also seen in patients implanted with pulsatile-flow biventricular assist devices (PF-BiVADs), which are used in selected patients with severe biventricular heart failure as bridge-to-transplantation strategy.[8]

Aortic regurgitation in patients with VADs represents a medical challenge, and to date, there are no consensual

recommendations regarding treatment strategies of VAD-associated AR, varying from medical therapy, and optimizing VAD-pump speed, to minimal invasive and surgical treatment options.[9] Moreover, most patients with VAD and progressive AR present several co-morbidities and are demanding to (re-)operate, posing them to high or prohibitive surgical risk. Considering this, percutaneous methods of intervention including TAVR and occlude devices have emerged as alternative treatment strategies in patients with VADs.[10,11] However, there is a very scarce experience of TAVR in this setting of patients, mainly focused on CF-VAD technology.[10,11] Here, we report for the first time the treatment of severe AR in a patient with a PF-BiVAD by performing TAVR using two Edwards SAPIEN 3 (Edwards Lifesciences, Irvine, California, USA) bioprostheses as a valve-in-valve procedure.

Case report

A 57-year-old male patient with a PF-BiVAD (EXCOR, Berlin Heart) was readmitted at our institution via our VAD outpatient clinic with signs of progressive cardiac decompensation, including increasing exertional dyspnoea, peripheral oedema, and ascites during the past few weeks. Two years earlier, an extracorporeal membrane oxygenation had been performed

as *ultima ratio*, as incipient multiple organ failure subjacent to severe dilated cardiomyopathy after fulminant myocarditis had taken place. Extracorporeal membrane oxygenation could be successfully explanted after 2 weeks, and a PF-BiVAD as a bridge-to-transplant therapy had been inserted, as severe biventricular heart failure remained. Moreover, a permanent pacemaker had been implanted after third-grade atrioventricular block. Afterwards, the patient was placed on the Eurotransplant heart transplantation waiting list and could be discharged in a clinical stable condition. He was followed up by regular visits in our VAD outpatient clinic.

On the present admission, evaluation of PF-BiVAD showed a completely satisfactory function. However, echocardiography showed a new finding of severe central aortic valve regurgitation (*Figure 1*), as well as severe eccentric mitral regurgitation. Colour Doppler regurgitation jet of the aortic valve showed a width of 75%; Doppler vena contracta was 0.7 mm wide. Pressure gradients of the aortic valve were normal (peak pressure gradient of 3 mmHg and mean pressure gradient of 1 mmHg). Morphologic evaluation of the native tricuspid aortic valve did not reveal signs of calcification, fusion, or degeneration that could explain the incomplete valve coaptation and resulting incompetence so that alteration of the pressure-volume loop with increased transvalvular pressure after PF-BiVAD may explain the development of

Figure 1 Transoesophageal echocardiography displaying severe aortic regurgitation: (A) three-chamber view and (B) axial view.
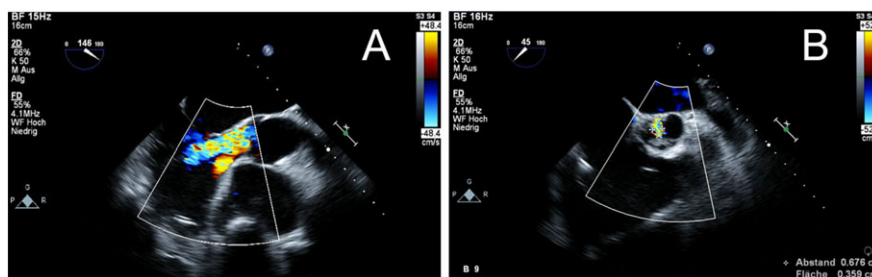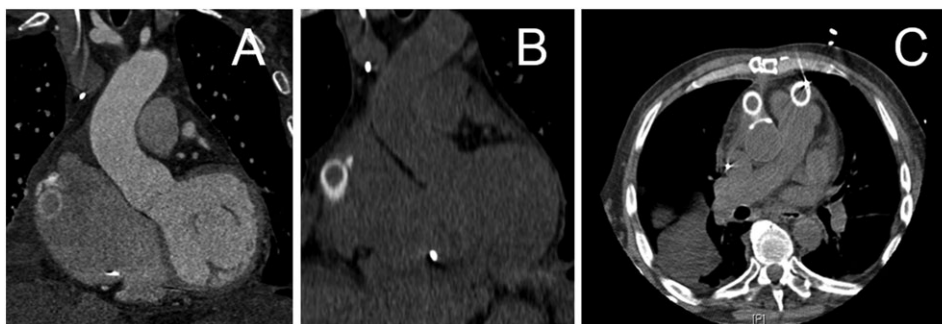

Figure 2 Absent calcification of the aortic annulus. Visualized with multidetector computed tomography: (A) coronary view with contrast medium; (B) coronary view without contrast medium; and (C) axial view.

AR (*Figures 1* and *2*). Laboratory exams showed increased bilirubin (2.9 mg/dL) and serum creatinine (2.3 mg/dL) as well as an increase in N-terminal pro brain natriuretic peptide (8564 ng/L), documenting early end organ failure and cardiac decompensation. Inflammatory markers were only slightly increased, and urine analysis, blood cultures, and computed tomography of thorax and abdomen did not reveal a focus of infection.

Because of a progressive clinical deterioration, the case was discussed in the interdisciplinary heart failure board, and TAVR as emergency treatment strategy for the severe AR was favoured by the heart team. As TAVR was described before in CF-VAD patients even without aortic valve calcification,[12] absent calcification of the aortic root in the present patient (*Figure 2*) was not seen as contraindication for TAVR. Planning access and valve selection for the TAVR procedure relied on the measurements of aortic annulus, aortic root, and iliofemoral anatomy based on computed tomography imaging. Assessment of cross-sectional area was based on the measurements derived from the short-axis plane through the nadir of each coronary cusp, whereas aortic annular area was 621 mm^2, and aortic annular perimeter was 102 mm. Area-derived and perimeter-derived aortic annulus diameters were both 28 mm. Analyses of aortic valvular structures were based on systolic images (40% of the cardiac cycle). Minimum access vessel diameter was 6.7 mm. There was no significant calcification or tortuosity of the iliofemoral vessels.

Considering the absence of valve and aortic root calcification, we favoured the SAPIEN 3 valve over a self-expandable valve such as Evolut R, aiming at enhanced valve anchoring and at the lowest paravalvular leakage (PVL) possible, subjacent to the balloon-expandable nature of deployment. Both JenaValve and Symetis Acurate TA are approved for the treatment of severe AR, contrasting with the off-label use of SAPIEN 3. However, at the time of implantation, we had limited experience with both bioprostheses in our centre and aimed to avoid a transapical access, which was considered to be of significant higher risk regarding prior PF-BiVAD implantation.

The procedure was performed under conscious sedation and local anaesthesia using two Edwards SAPIEN 3 29 mm bioprostheses sequentially (*Figure 3*). After vascular puncture and access site pre-closure using the ProGlide system (Abbott Vascular, Lake Bluff, Illinois, USA), a 16 F sheath was placed into the right femoral artery, followed by positioning of a Safari guidewire (Boston Scientific, Marlborough, Massachusetts, USA) in a midventricular position. Predilation with a 25 mm balloon was performed for sizing purposes, resulting in the choice of a 29 mm valve prosthesis size. Haemodynamic assessment after valve deployment showed a moderate PVL, possibly due to the positive transvalvular pressure associated with the PF-BiVAD leading to the slight movement and suction of the bioprosthesis towards the left ventricular outflow tract.

Figure 3 Transfemoral aortic valve replacement under a pulsatile-flow biventricular assist device: (A) predilation with a 25 mm balloon for sizing purposes; (B) 29 mm Edwards SAPIEN 3 prosthesis positioning; (C) valve deployment of first 29 mm Edwards SAPIEN 3; (D) angiography to evaluate for paravalvular leakage; (E) deployment of the second 29 mm Edwards SAPIEN 3; and (F) final angiography. LV, left ventricular cannula of the pulsatile-flow biventricular assist device.
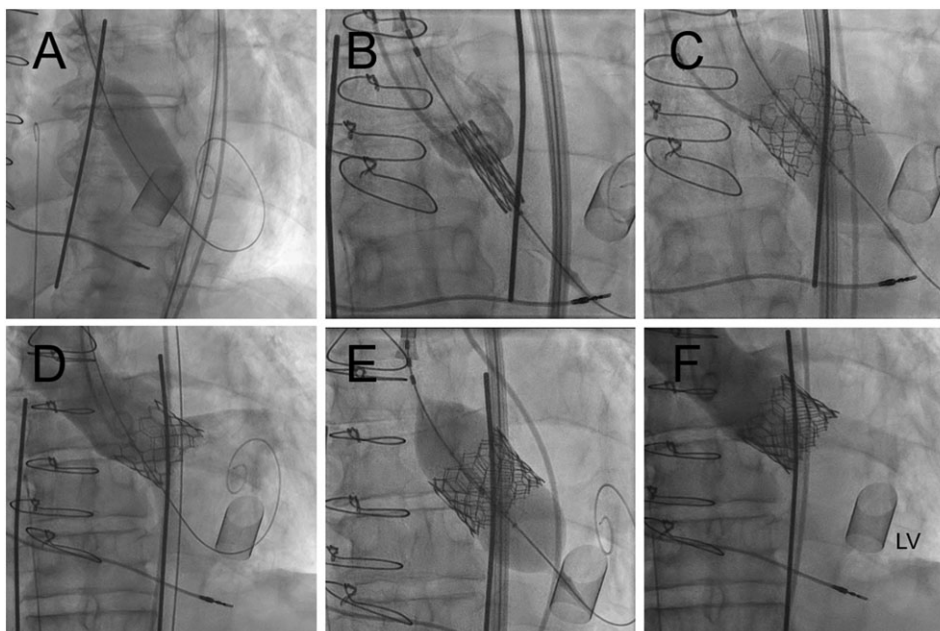
Therefore, we decided for a valve-in-valve strategy, and a second 29 mm SAPIEN 3 was implanted. During the second valve deployment, the first prosthesis moved to a higher position towards the aortic root. A second angiographic assessment showed a satisfying reduction of AR.

Post-operative course was uneventful; no major vascular or bleeding complications, acute kidney injury, or thromboembolic events were registered. Heart failure symptoms receded shortly after the procedure. Echocardiography revealed a significant reduction of central AR from grade 3 to 1, with trace PVL. Edwards SAPIEN 3 bioprotheses were in correct position (*Figure 4*). Moreover, no significant pressure gradients over the mitral valve could be depicted, there was no significant restriction of valve leaflet movement, and there was even an improvement from severe to mild mitral regurgitation. Step-down to a general ward took place 2 days after TAVR, but the patient was further hospitalized for high-urgency listing for heart transplantation. Finally, the patient underwent a total orthotopic heart transplantation approximately 7 months after TAVR, had an uneventful post-transplant course, and currently has a good capacity in daily life.

Discussion

To our knowledge, this is the first report of TAVR in a patient with *de novo* severe central AR under PF-BiVAD implantation. AR development under VAD therapy has been well described, caused by disarrangement of the pressure-volume loop with a positive transvalvular pressure and decreased aortic valve opening.[7,9] There is a paucity of experience with minimal invasive approaches for AR in patients with VADs, specifically CF-VADs. Knowing this, as well as that CF-VADs are a more frequently used VAD technology, and that *de novo* progressive AR is more pronounced in recipients of CF-VADs compared with PF-VADs,[5] underlines the relevance and uniqueness of the herewith presented TAVR experience while running a PF-BiVAD.

Recently, a meta-analysis described the experience of TAVR or occluder devices in only 29 patients with AR after CF-VAD insertion, whereby TAVR was performed in only 27.6% of these patients. Experience with Edwards SAPIEN 3, Medtronic CoreValve, Medtronic Evolut R, and Medtronic Melody has been described.[10] A major advantage of TAVR compared with occluder devices is that patients are not fully dependent on the VAD, as it does not completely unload the left ventricle by occluding either the aortic valve or left ventricular outflow tract. Nevertheless, challenges of TAVR include PVL, difficult valve housing due to absent annular calcification and continuous or pulsatile suction from CF-VAD or PF-VAD, respectively, higher costs compared with intervention via occlude devices, and limitation of available sizes.

The implantation presented here was challenging due to a lack of calcification, with difficult anchoring of the prosthesis and a movement of the prosthesis towards the ventricle during balloon expansion. To evaluate procedural stability of the non-calcified annulus, we pre-dilated with a 25 mm balloon, and implantation of the second valve further contributed to overcome this limitation. A short interruption of the pump could have been helpful and should be advised for future attempts. Others used an oversized balloon after implantation of a self-expandable transcatheter aortic valve prosthesis (Medtronic Evolut R 29 mm) to optimize anchoring in a non-calcified valve in the setting of an CF-VAD.[12] In our patient, we did use an appropriate prosthesis [annulus 28 mm, valve prosthesis (Edwards SAPIEN 3 29 mm)] and observed only a trace of PVL.

Here, we demonstrate that TAVR using two Edwards SAPIEN 3 bioprostheses as a valve-in-valve procedure in the setting of severe AR while running a PF-BiVAD is feasible, when adequate preoperative imaging and a tailored interventional strategy are adopted. As we have a 7 month follow-up of the patient until heart transplantation, we can conclude

Figure 4 Transoesophageal echocardiography after transfemoral aortic valve replacement documents correct position of the bioprostheses: (A) three-chamber view and (B) axial view.
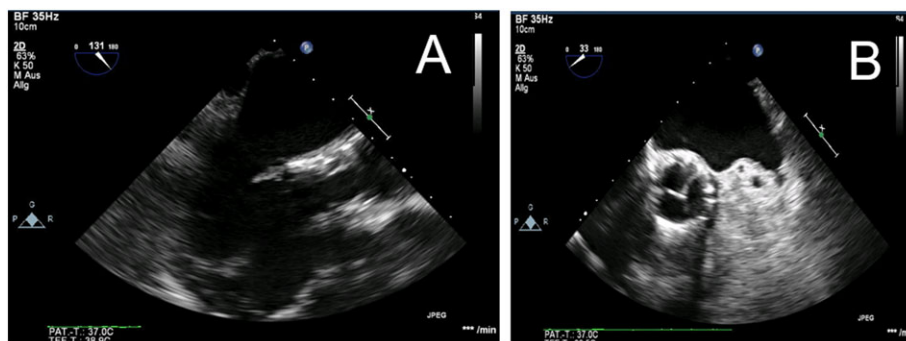
that this is a treatment option at least as a bridge-to-transplantation strategy.

Conflict of interest

Funding

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