JACC: CASE REPORTS VOL. 2, NO. 14, 2020

CASE REPORT

ADVANCED

CLINICAL CASE

Transcatheter Restoration of the Left Ventricular Outlet in a Patient With an Implanted Apicoaortic Conduit

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ABSTRACT

We describe the transcatheter management of severe aortic regurgitation in a middle-aged patient with a porcelain aorta who underwent implantation of an apicoaortic valved conduit 12 years ago. Instantaneous relief of heart failure symptoms was achieved by restoring antegrade blood flow to the ascending aorta. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2020;2:2131–7) © 2020 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 56-year-old man underwent aortic valve bypass (AVB) surgery in 2007. In 2019, he was admitted with progressive symptoms of fatigue and shortness of breath consistent with New York Heart Association (NYHA) functional class III.

PAST MEDICAL HISTORY

The patient had been diagnosed with non-Hodgkin lymphoma during adolescence and underwent extensive irradiation of the chest and resection of the right lower lobe of the lung. At 44 years of age, he presented with symptomatic aortic stenosis: NYHA functional class III, aortic valve area 1.0 cm^2, and mean transvalvular pressure gradient (dP mean)

LEARNING OBJECTIVES

- To understand the role of antegrade and competitive retrograde blood flow in the presence of a second artificial left ventricular outlet.
- To demonstrate the benefits of simulation software in TAVR to optimize device selection and placement in complex landing zones.
- To demonstrate technical modifications to optimize TAVR results in patients with a porcelain aorta.
- To appreciate native aortic valve regurgitation as a differential diagnosis in patients after AVB and possibly also after left ventricular assist device implantation.

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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.

Manuscript received April 3, 2020; revised manuscript received May 29, 2020, accepted June 17, 2020.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2020.06.034

ABBREVIATIONS AND ACRONYMS

AVB = aortic valve bypass

DLZ = device landing zone

dP_{mean} = mean transvalvular pressure gradient

NYHA = New York Heart Association

TAVR = transcatheter aortic valve replacement

TTE = transthoracic echocardiography

53 mm Hg. Standard surgical aortic valve replacement could not be performed because of extensive aortic calcification ("porcelain aorta"), and transcatheter aortic valve replacement (TAVR) was not yet available at our institution at the time. As an alternative, the patient underwent AVB surgery by implantation of a conduit bearing a mechanical 21-mm bileaflet prosthesis from the left ventricular apex to the descending thoracic aorta via left-sided thoracotomy (Figures 1 and 2).

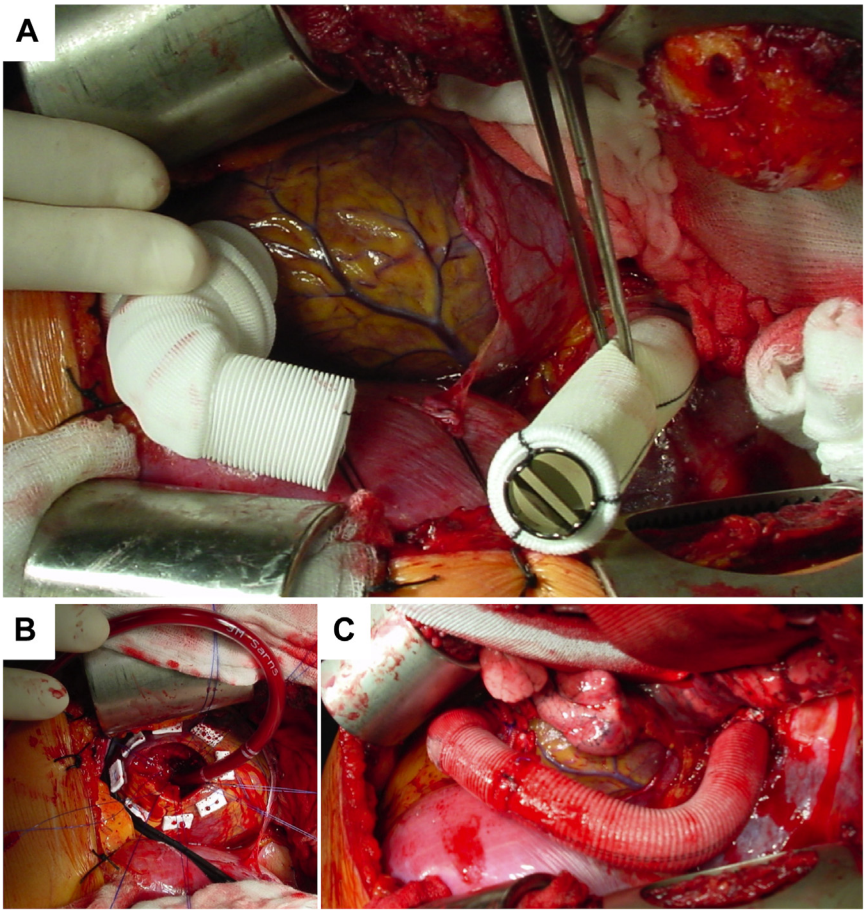
After a prolonged recovery, the patient's condition improved slightly and was ultimately rated as NYHA functional class II. Transthoracic echocardiography (TTE) confirmed low pressure gradients inside the AVB (dP_{mean} 8 mm Hg). The transvalvular gradients of the native aortic valve decreased to <10 mm Hg, corresponding to a low systolic flow through the native left ventricular outflow tract.

Twelve years after AVB implantation, severe native aortic valve regurgitation (pressure half-time of 170 to 290 ms, vena contracta 6 mm, regurgitant volume 52 ml) was observed (Video 1). Correspondingly, symptoms of heart failure deteriorated (NYHA functional class III).

DIFFERENTIAL DIAGNOSIS

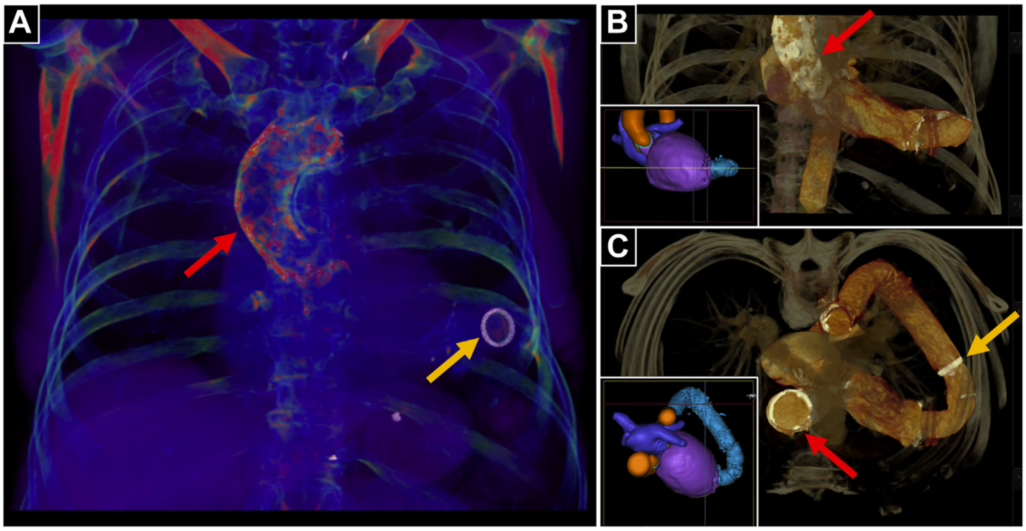
Other cardiac causes for the progression of the symptoms were excluded. A deterioration in left ventricular systolic function, a progression of pre-existing mild mitral regurgitation, and malfunction of the AVB (Videos 2 and 3) were ruled out by TTE and 4-dimensional multislice computed tomography. Coronary angiography showed moderate stenosis of

FIGURE 1 Intraoperative Views of Aortic Valve Bypass Surgery



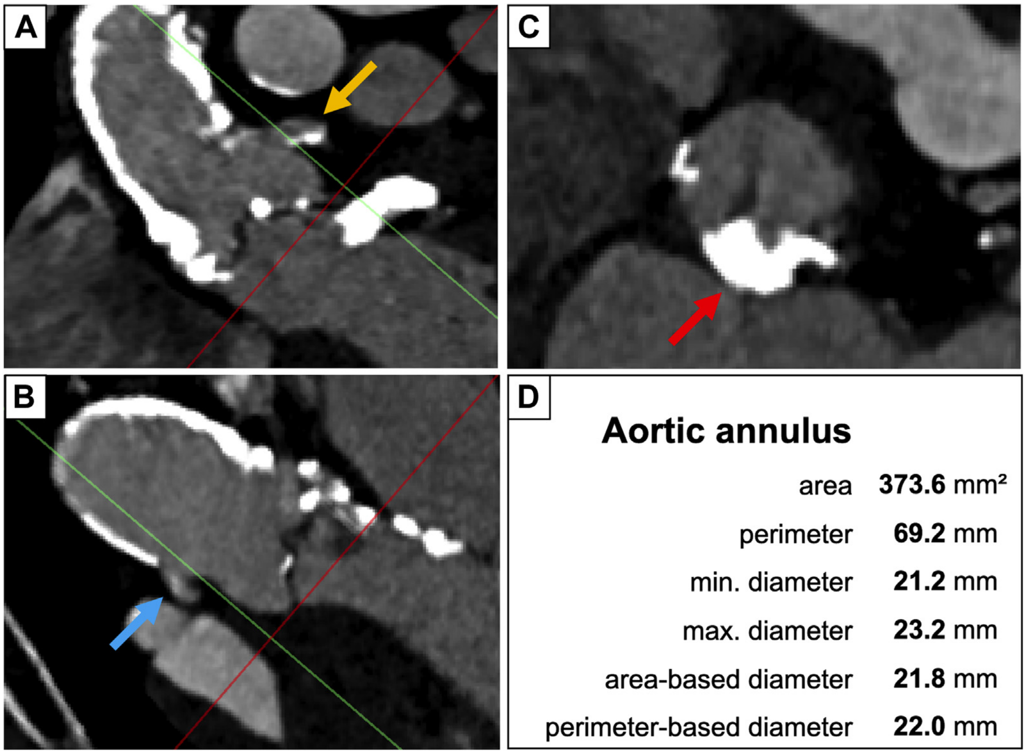
(A to C) Sequence of the conduit implantation from the left ventricular apex to the descending thoracic aorta.

FIGURE 2 **Pre-Procedural Computed Tomography**



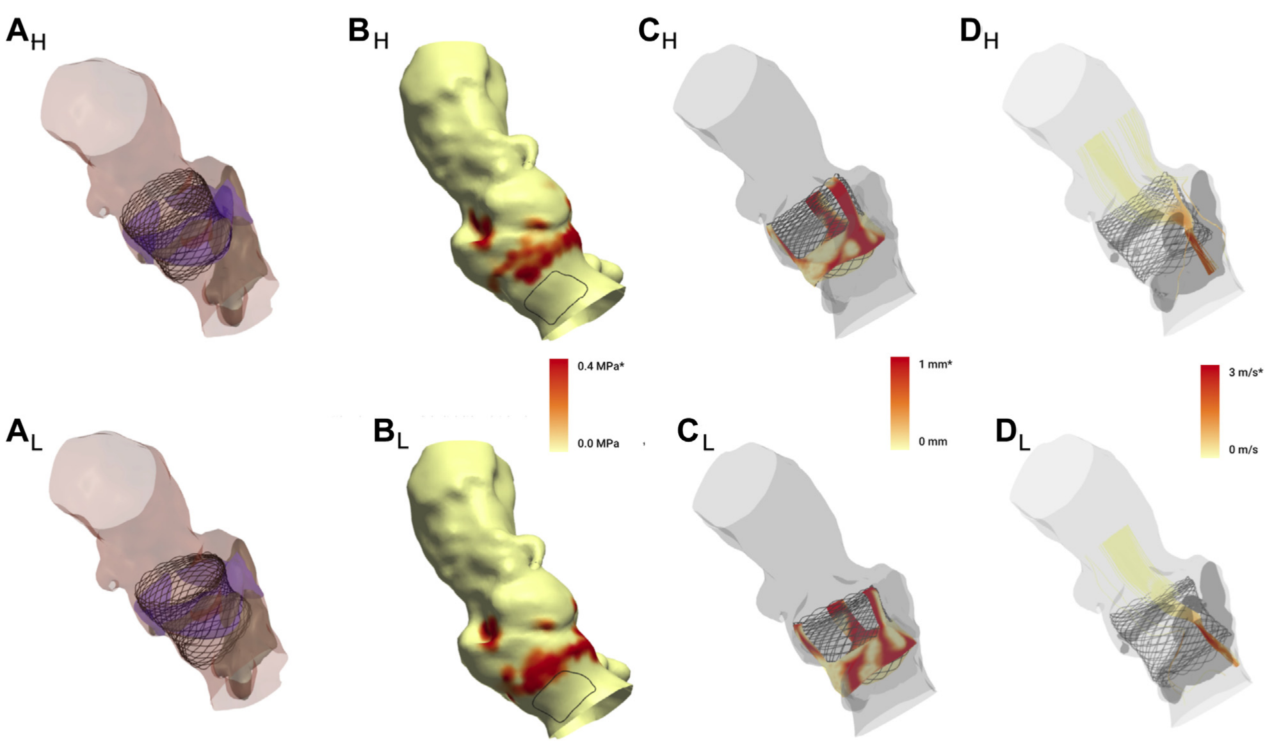
(A to C) Different views showing a porcelain aorta **(red arrow)** and an alloplastic prosthesis inside the conduit **(yellow arrow)**.

FIGURE 3 **Aortic Valve Device Landing Zone**



Different views **(A to C)** of computed tomography revealing a severely calcified aortic annulus **(red arrow)**. The ostia of the left coronary artery **(yellow arrow)** and right coronary artery **(blue arrow)** are marked. The annular dimensions are given **(D)**.

FIGURE 4 Simulation to Optimize Transcatheter Device Performance



(A) Frame deformation, **(B)** contact pressure, **(C)** skirt apposition, and **(D)** paravalvular leak in a computer simulation of a high (index H) versus a low (index L) placement of the LOTUS Edge 23-mm transcatheter valve.

the proximal circumflex artery without myocardial ischemia.

INVESTIGATIONS

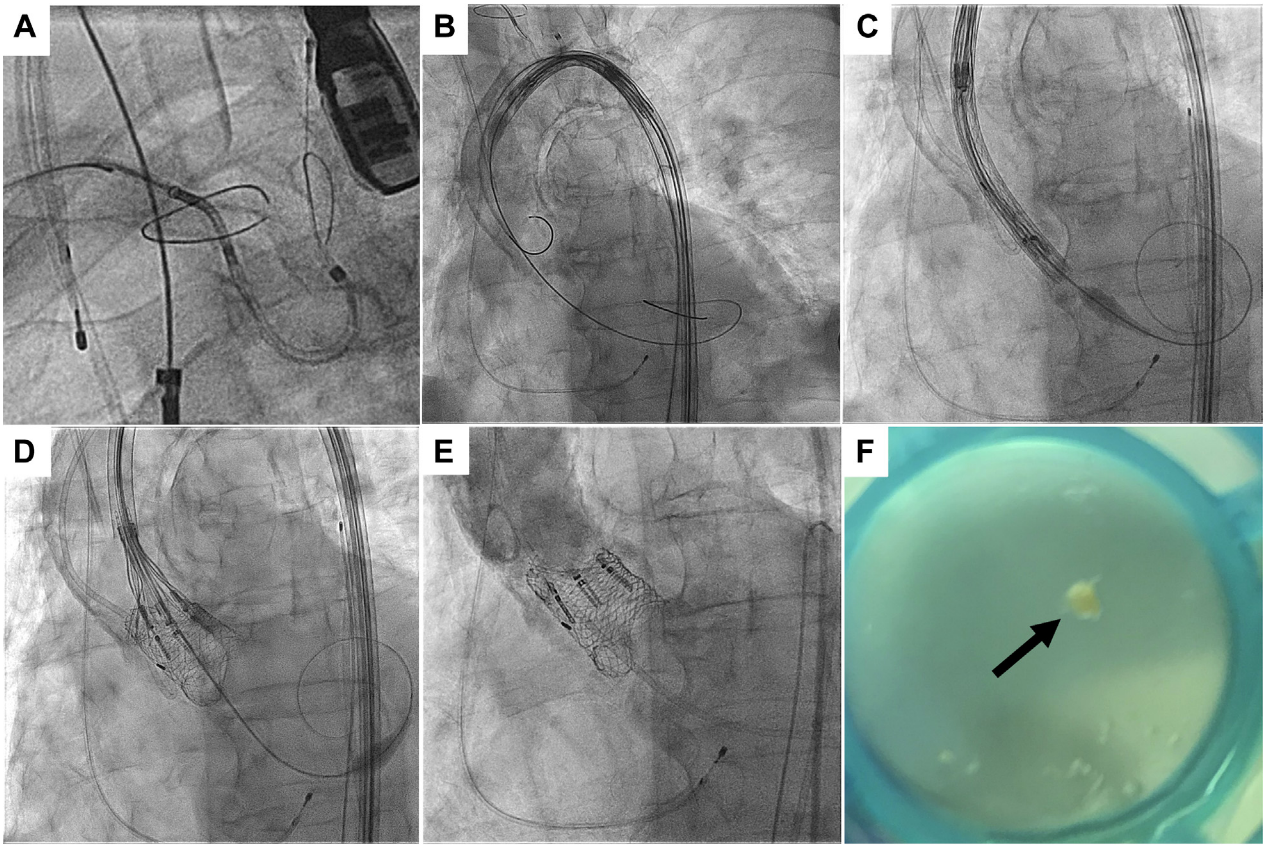
The institutional heart team decided to eliminate the aortic regurgitation and to restore flow through the native outlet by TAVR. Preference was given to a retrograde percutaneous transfemoral access route. Multislice computed tomography confirmed a hostile device landing zone (DLZ) with severe calcification of the left ventricular outflow tract, aortic annulus, and ascending aorta (**Figure 3**). Based on DLZ characteristics, a 23-mm LOTUS Edge prosthesis (Boston Scientific, Marlborough, Massachusetts) was chosen with the intention to minimize the risk of a paravalvular leak and DLZ rupture. A procedural simulation using the HEARTguide (FEops NV, Ghent, Belgium), confirmed that a higher rather than a lower implant position of the LOTUS valve (**Figure 4**) would be associated with a lower risk of conduction abnormalities (contact pressure index 0% vs. 8%). The predicted grade of residual paravalvular leak was mild irrespective of the higher or lower implant position (14.4 ml/s vs. 13.8 ml/s) (1).

MANAGEMENT

The following specifics were added to the otherwise standard TAVR procedure (**Figure 5**). A SENTINEL cerebral protection system (Boston Scientific, Marlborough, Massachusetts) was placed prior to valve manipulation. To support crossing of the LOTUS catheter system through the rigid and calcified thoracic aorta, a 2-wire technique was applied: 2 Lunderquist Extra-Stiff guidewires (Cook Medical, Bloomington, Indiana) were used. The first stiff wire was placed within a pigtail catheter located in the noncoronary cusp, while the second one was used to directly advance the LOTUS catheter system into the severely calcified DLZ. After crossing the aortic valve, the first Lunderquist wire was removed, and the second one was replaced by a pre-shaped guidewire.

After valve deployment, elimination of relevant aortic regurgitation was confirmed as predicted by transesophageal echocardiography and angiography

FIGURE 5 Sequence of Transcatheter Aortic Valve Replacement



(A) Placement of the cerebral protection device, **(B)** "2-wire technique" for retrograde passing of the calcified aortic arch, **(C, D)** stepwise deployment of the transcatheter valve, and **(E)** final aortic root angiography, **(F)** debris of 2 mm caught by the filter.

(Videos 4 and 5). No hemodynamic compromise was observed throughout the procedure and no atrioventricular block occurred.

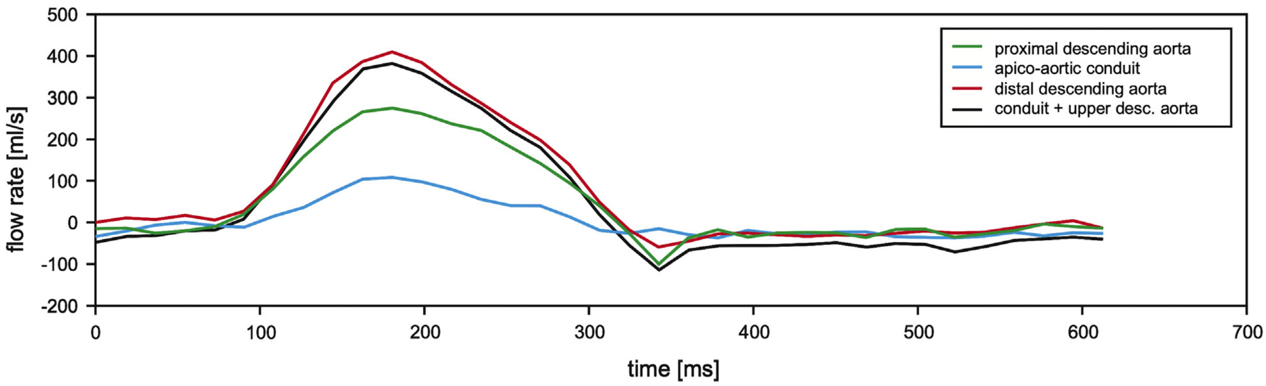
The post-procedural course was completely uneventful. The patient was discharged home on the fifth postoperative day under a lifelong regimen of phenprocoumon and a 4-week course of 100 mg/day aspirin. Cardiac magnetic resonance showed a mild paravalvular leak (regurgitant fraction 18%) of the LOTUS valve and an overall left ventricular stroke volume of 103 ml through both outlets. Depending on the phase of the cardiac cycle, perfusion of the upper part of the body was found to be delivered mainly through the restored natural left ventricular outlet, whereas all other parts of the body were supplied with blood from both outlets (**Figure 6**, Video 6). The AVB stroke volume dropped from 96 ml to 34 ml, corresponding to a decrease in the AVB proportion of the total stroke volume from 78% to 33%. TTE confirmed low transvalvular gradients: dP_{mean} 9 mm Hg (LOTUS valve) and 6 mm Hg (AVB).

DISCUSSION

Surgical treatment of aortic stenosis in the presence of a porcelain aorta is challenging. The surgical concept of AVB interposition was proposed in the pre-TAVR era more than 6 decades ago (2). As a consequence of this treatment, a second extra-anatomic outlet of the left ventricle is created, gathering about two-thirds of the cardiac output and allowing competitive aortic blood flow (3).

The advancements in TAVR have replaced this and other historical concepts. TAVR is now recommended for aortic valve replacement in patients with a porcelain aorta (4). Meticulous TAVR strategy planning is a prerequisite to achieve device success in patients who present with hostile access routes and DLZ. In

FIGURE 6 **Flow Profiles Measured by Cardiac Magnetic Resonance**



Blood flow measurements over 1 cardiac cycle measured at different levels of central circulation.

this context, novel imaging tools, including simulation software, were found to be precise (Supplemental Figure 1).

It has been shown that TAVR may improve symptoms in an AVB patient after stenosis at the aortic anastomosis site of the AVB is detected (5). We were able to demonstrate a similar benefit in our patient, who developed severe regurgitation of the native calcified aortic valve. Moreover, our patient experienced a tremendous improvement in functional performance that by far exceeded the initial effect of AVB surgery. Although it is known that AVB does not jeopardize organ and cerebral blood supply at rest (3), we assume superiority of antegrade blood flow through the aortic root on physical exertion. As a consequence of this assumption, recurrence of symptoms should be recognized when structural valve deterioration of the TAVR device occurs (which is not unlikely given the young age of the patient).

FOLLOW-UP

At the 30-day follow-up, the patient reported a dramatic improvement in symptoms (NYHA functional class I). No complications were reported at the 3-month follow-up.

CONCLUSIONS

Long-term survival can be achieved in patients after an artificial left ventricular outlet is created. In cases where aortic regurgitation additionally manifested, TAVR was found to be highly effective. Our case reflects the evolution of medical technology and therapeutic strategies to treat aortic valve pathologies in patients with a porcelain aorta to a point where today, extensive surgery is replaced by a percutaneous intervention. Restoration of antegrade blood flow through the native left ventricular outlet into the systemic circulation had a tremendous benefit on the patient's physical resilience. In perspective, we assume that in the event of a future deterioration of the transcatheter aortic valve prosthesis, blood flow through the conduit will increase again.

ACKNOWLEDGMENTS The simulation of the implantation procedure was supported by Giorgia Rocatello, FEops NV. The authors are grateful to Prof. Yuguo Weng (who has passed away), who performed the apicoaortic conduit implantation procedure, provided the authors with the intraoperative photographs for scientific use, and supervised the initial therapeutic concept. The authors thank Sarah Chalmers for editorial assistance.

AUTHOR DISCLOSURES

Drs. Unbehaun, Gerckens, Klein, and Kempfert have served as proctors to Boston Scientific. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS aortic valve bypass, aortic valve stenosis, porcelain aorta, transcatheter aortic valve replacement

APPENDIX For supplemental videos and a figure, please see the online version of this paper.