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CASE REPORT

INTERMEDIATE

CLINICAL CASE

Transcatheter Valve-in-Valve Implantation in an Aortic Bioprosthesis With Severe Regurgitation and a Challenging Aortic Anatomy

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ABSTRACT

Valve-in-valve transcatheter aortic valve replacement for failing surgical bioprosthetic valves becomes troublesome if a stiff vascular prosthesis replaces the ascending aorta. We report the off-label use of a new transcatheter aortic valve for treatment of a patient with a bioprosthetic valve with central regurgitation, a horizontal aorta, and kinking of the aortic prosthesis. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2022;4:336-342) © 2022 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 76-year-old woman with diabetes, hypertension, and moderate renal failure was urgently admitted to the emergency department for pulmonary subedema and chest pain. Her blood pressure on admission was 170/50 mm Hg, and her physical examination showed a soft, high-pitched, early diastolic decrescendo murmur (Erb's point).

LEARNING OBJECTIVES

- To overcome multiple technical challenges arising during VIV TAVR in patients with a failing surgical bioprosthetic valve.
- To select a tailored TAV for patients undergoing VIV TAVR with multiple hindrances deriving from complex aortic scenarios.

PAST MEDICAL HISTORY

The patient's history included a stenotic native bicuspid aortic valve with a preserved aortic root and a dilated ascending aorta. In 2012, she underwent the root-sparing Wheat surgical operation consisting of an ascending aortic synthetic graft implantation and an aortic valve with a 27-mm Mitroflow (Sorin) porcine bioprosthetic valve replacement (**Figure 1**).

DIFFERENTIAL DIAGNOSIS

Refractory hypertension, severe aortic valve disease, and aortic dissection were considered in the differential diagnosis of her clinical presentation.

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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 Author Center.

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INVESTIGATIONS

An urgent 2-dimensional (2D) echocardiogram showed a prosthetic valve with severe aortic regurgitation (AR) secondary to aortic valve cusp thickness and retraction and a prolapse of the cusp in the noncoronary position (**Figures 2A and 2B**). The left ventricular ejection fraction was 44%. After hemodynamic stabilization, coronary artery disease was excluded by invasive angiography. Aortography confirmed the severe AR and highlighted a horizontal aorta (ventriculoaortic axis, 69°) with a severe aortic bend (**Figures 2C to 2E,** Video 1). Multislice computed tomography (CT) confirmed horizontal aortic root anatomy (ventriculoaortic axis, 57°) (**Figures 3A and 3B**), a risky right coronary artery (RCA) take-off at 6.5 mm (**Figure 3C**), and a severe bend of the ascending aorta at the level of the stiff aortic vascular graft (**Figure 3D**).

MANAGEMENT

Considering the patient's EuroSCORE II (European System for Cardiac Operative Risk Evaluation II) of 18.52% and the Society of Thoracic Surgeons score for mortality of 8.60%, the heart team considered the patient ineligible for redo surgery and opted for valve-in-valve (VIV) transcatheter aortic valve replacement (TAVR). The following challenges emerged during preprocedural planning: possible interaction between the transcatheter aortic valve (TAV) and the stiff aortic graft; the horizontal aorta with severe AR; and the risk of a high postprocedural gradient. Thus, even though VIV TAVR represented an off-label indication for the Portico TAV (Abbott), it was preferred because of the enhanced flexibility and trackability of its new delivery system and the familiarity of the operator with this specific device. A 14-F sheath was inserted through the femoral artery, and a 0.035-inch stiff wire was placed into the left ventricle. Aware of the low opening force of the aforementioned TAV, the operator performed mild predilation with an 18-mm balloon (BD Interventional) to optimize release. On the basis of CT evaluation of the prosthetic true inner diameter (ID); (average ID, 26.1 mm) (**Figure 4A**), a 27-mm TAV was loaded in the FlexNav delivery system (Abbott). Once the TAV arrived at the ascending aorta level, the flexibility of the delivery system was instrumental in achieving safe crossing of the aortic bend (**Figures 4B and 4C**). Slow and controlled unsheathing of the device allowed us to center the valve and to secure it to the surgical prosthetic ring without cardiac pacing. Valve coaxial alignment in the horizontal bioprosthetic aortic annulus was obtained by applying a moderate push on the delivery system (**Figure 4D**). Once two-thirds of the valve were unsheathed, the stiff wire was partially retrieved, and the tension was reduced. This maneuver, combined with the high flexibility of the device, allowed the operator to push further onto its system and to pull it away from the inner aortic curve bend (**Figure 4E,** Video 2). The valve was completely released without any friction with the aortic bend, and no stent-frame infolding, underexpansion, or migration was observed. The final angiogram showed no trace of a paravalvular leak, with a final transvalvular aortic gradient of 8 mm Hg. Therefore, additional postdilation was not required (**Figures 5A and 5B,** Video 3). The RCA patency was confirmed (**Figure 5C**). An electrocardiogram revealed unchanged normal sinus rhythm. A predischarge 2D echocardiogram (72 hours later) showed favorable prosthesis performance (mean gradient, 7 mm Hg; effective orifice area, 2.7 cm^2; no valvular or paravalvular leakage). At the 6-month outpatient clinic follow-up, the patient reported only mild effort dyspnea (New York Heart Association functional class I).

DISCUSSION

The Wheat procedure consists of root-sparing replacement of the ascending aorta aneurysmal portion with a straight vascular prosthesis and repair or replacement of the native aortic valve. However, introduction of the inelastic graft determines a compliance mismatch between the host artery and the synthetic graft. In the long term, this issue may determine some negative effects on the ascending aorta and on the bioprosthetic valve cusps (ie, aortic root aneurysm, enlargement of the residual aortic hemiarch, bending of the vascular prosthesis, severe valve stenosis and/or regurgitation).

When performing VIV TAVR in patients with these anatomical aortic challenges, accurate preprocedural planning according to specific TAV characteristics and the operator's expertise with each device (ie, balloon-expandable [BE] vs self-expandable [SE] valves) becomes crucial for procedural success.

The new-generation BE prostheses are considered particularly suitable for VIV TAVR, especially in patients with tortuous anatomy. The unique flex catheter control systems of these prostheses facilitate positioning, which helps when faced with challenging aortic anatomy. Furthermore, the short stent frame of BE valves (14.0-22.5 mm) provides less resistance to

ABBREVIATIONS AND ACRONYMS

AR = aortic regurgitation
BE = balloon-expandable
CT = computed tomography
ID = inner diameter
RCA = right coronary artery
SE = self-expandable
TAV = transcatheter aortic valve
TAVR = transcatheter aortic valve replacement
VIV = valve-in-valve
2D = 2-dimensional

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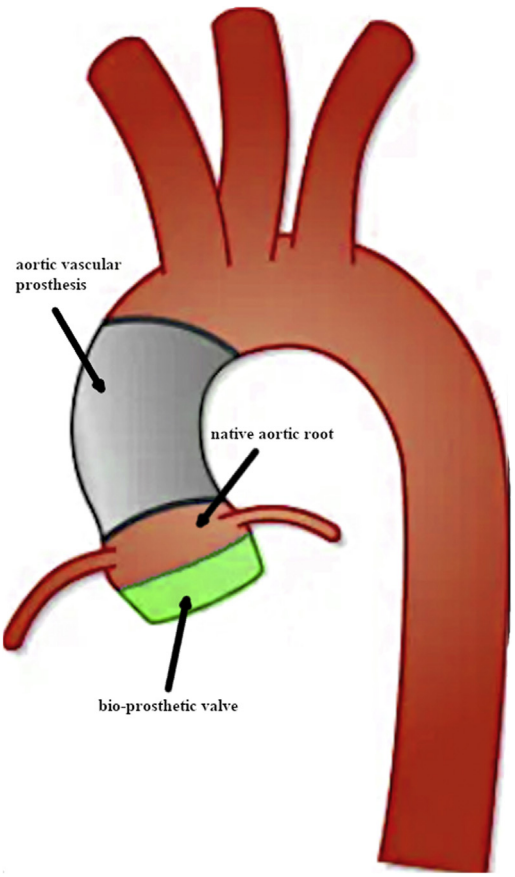
FIGURE 1 Wheat Operation



device advancement through angulated aortas and allows for easier coronary access. However, intra-annular TAVs tend to develop higher transvalvular gradients after VIV TAVR, and the presence of central severe AR may increase the risk of slippage and valve migration if the valve is implanted by inexperienced operators. Despite the aforementioned advantages, these shortcomings advised against the "one-shot" option of an intra-annular, not-recapturing BE valve in this case.

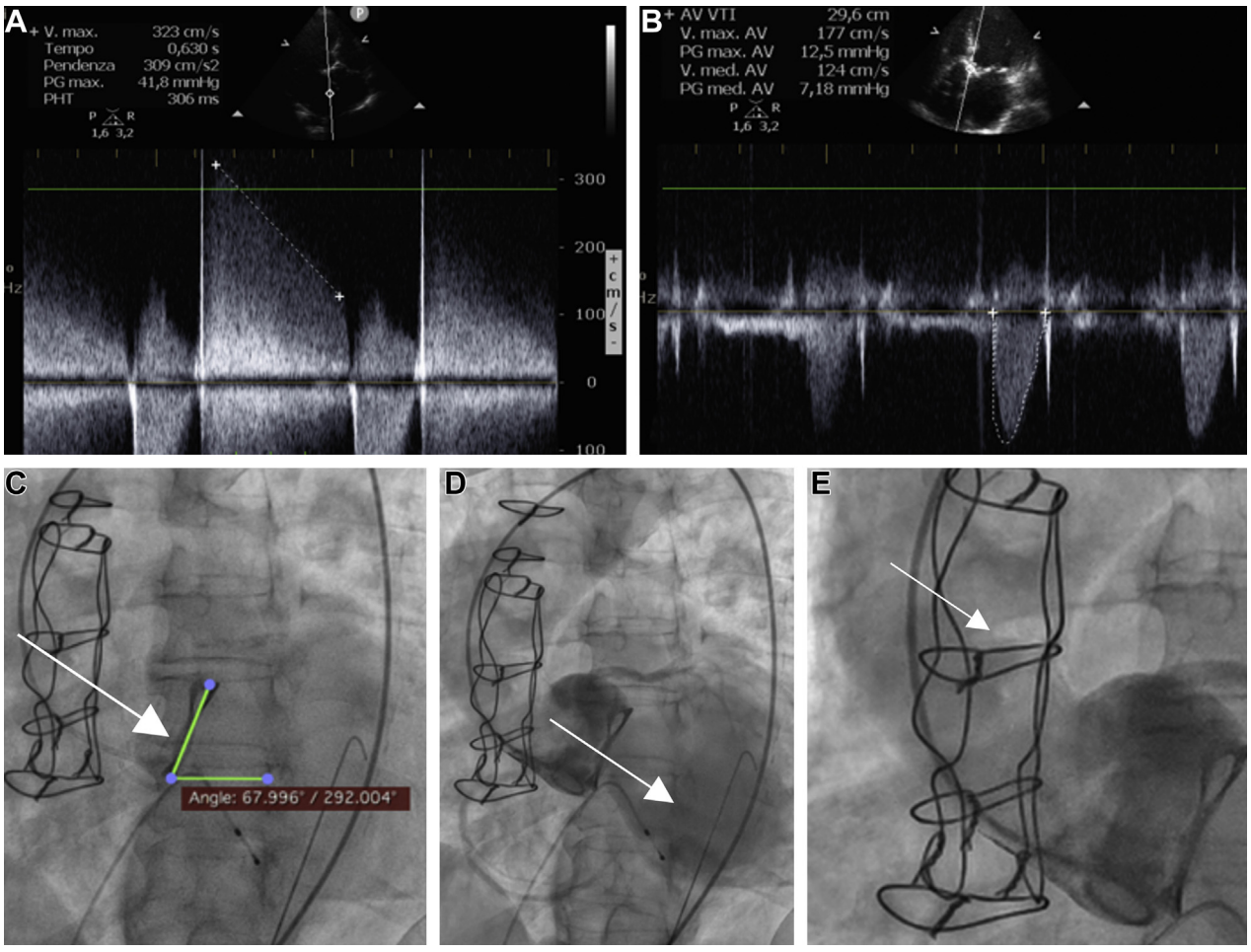
Conversely, an SE TAV with a supra-annular design provides better postprocedural gradients following VIV TAVR than BE TAV, especially in smaller stented valves (ID, <21 mm). However, the longer valve stent frame (49-52 mm) creates a more rigid delivery system, which may result in less accurate delivery of the valve in the presence of bending and horizontal orientation. In fact, investigators showed that increased aortic angulation adversely influences acute procedural success following TAVR with SE valves but not with BE valves because of stent frame length, stent deformation, radial force, and flexion control of the delivery system.[1] SE TAV counter-rotation may help flexion in 1 primary direction; however, it may be ineffective, and the use of traditional troubleshooting options (ie, buddy balloon technique, snare catheter, and wire escalation for the stiffer Lunderquist 0.035-inch guidewire [Cook Medical]) may be used to overcome these hindrances.[2] However, these maneuvers increase the risk of cerebrovascular events and certain other complications. The concrete risk of requiring these bailout techniques discouraged the operator from using a long and more rigid SE delivery system.

With regard to new-generation SE TAVR devices, the presence of a horizontal aorta seems not to affect outcomes regardless of the implanted valve type, as a result of their stent frame design improvement.[3] Recently, Casenghi et al[4] studied the 1-year safety and efficacy of the same SE valve used in our case, during VIV procedures. These investigators highlighted that new specific valve design features could be advantageous in particularly demanding VIV procedures.[4] In this regard, favorable data on this valve were reported in the Portico IDE substudy adopting the FlexNav delivery system.[5] In fact, several key design modifications of the new valve delivery system (ie, low nitinol density, large stent cell design) have increased its flexibility and facilitated the gradual, controlled deployment (ie, stability layer) of this prosthesis. Furthermore, the location of the leaflets is actually slightly supra-annular, approximately 7 mm above the inflow cutouts, and a proper implantation target 3 to 5 mm below the surgical bioprosthetic sewing ring may reduce the overall risk of a high postprocedural gradient. Thus, we used this device because of its improved deliverability when tackling bends and horizontal anatomical features. The new stability layer and its "functional" supra-annular design allow an optimal implantation depth with excellent hemodynamic parameters. Finally, the large frame stent cell design guarantees rapid access to the RCA.

CONCLUSIONS

With expanding TAVR indications, increasing numbers of patients with aortic and valve concerns undergo complex VIV TAVR procedures. Rigorous preprocedural planning and the operator's experience with each device are crucial to overcome the multiple challenges that may be encountered in complex scenarios.

FIGURE 2 **Echocardiographic and Angiographic Pre-TAVR Assessment**



(A and B) Severe aortic regurgitation shown on 2-dimensional echocardiography. **(C to E)** Aortography showing the horizontal aorta, severe aortic regurgitation, and bending **(arrows).** TAVR = transcatheter aortic valve replacement.

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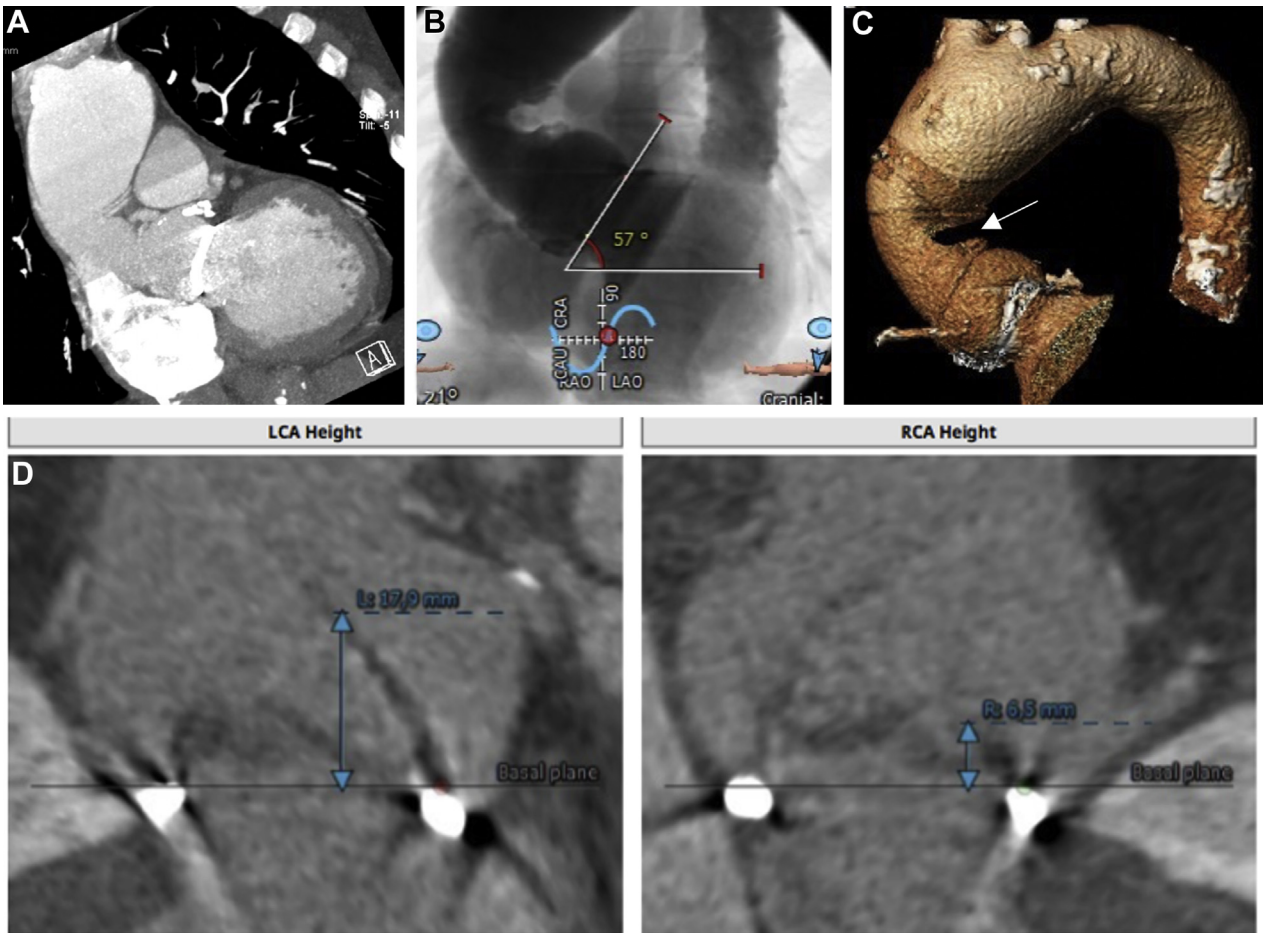
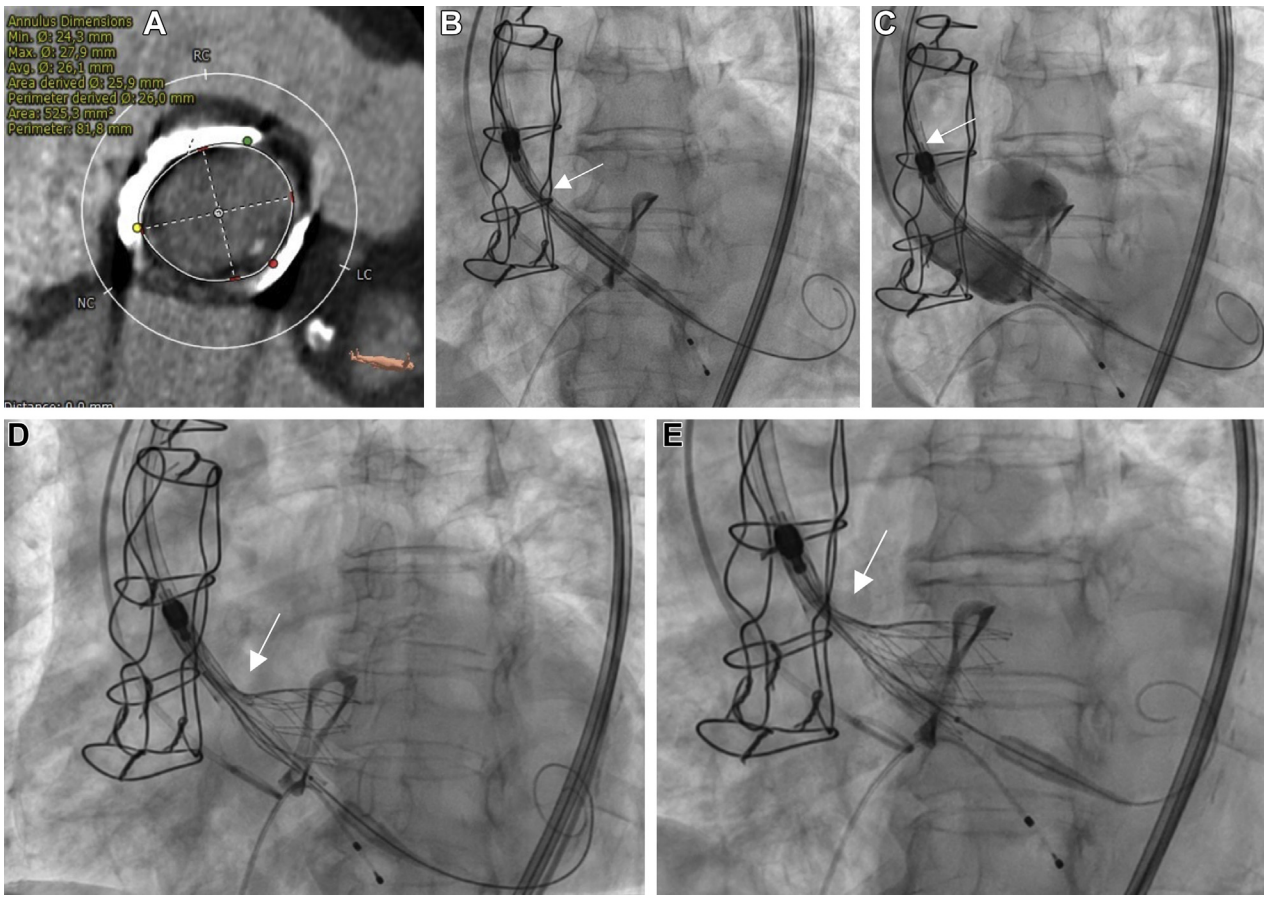
FIGURE 3 Computed Tomography Scan Assessment



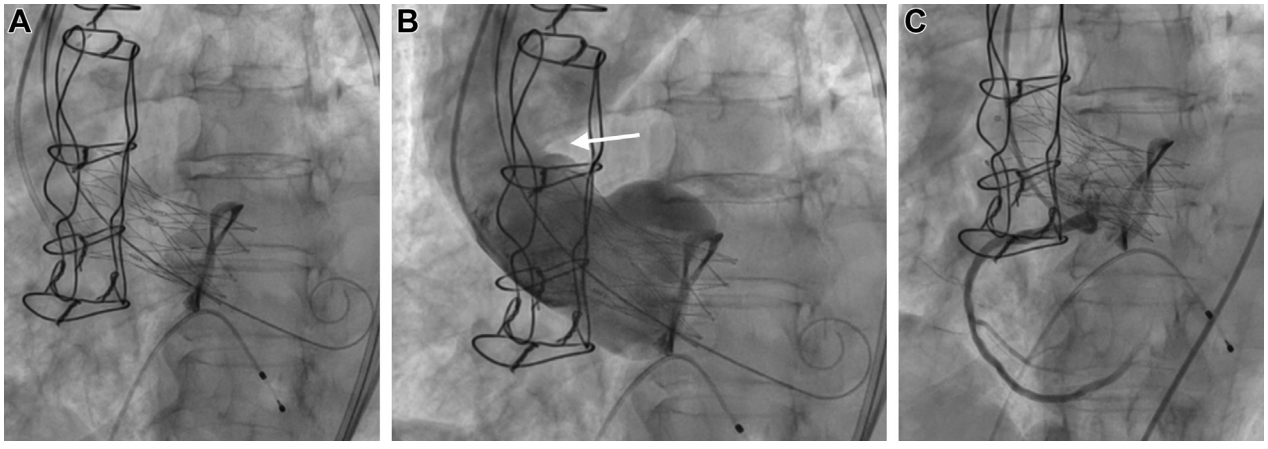
(A and B) Computed tomography scan showing a horizontal ventriculoaortic axis. **(C)** Aortic bend shown on a computed tomography 3-dimensionalimaging reconstruction **(arrow). (D)** Coronary artery take-off. CAU = caudal; CRA = cranial; LAO = left anterior oblique; LCA = left coronary artery; RAO = right anterior oblique; RCA = right coronary artery.

FIGURE 4 **Transcatheter Aortic Valve Replacement Procedure**



(A) Computed tomography scan showing the true inner diameter. **(B and C)** Valve crossing of the aortic bending and prosthetic valve **(arrows). (D)** Valve coaxial alignment **(arrow). (E)** Valve stent frame pulled away from the inner aortic bending and active pushing on the device **(arrow).** LC = left coronary cusp; NC = noncoronary cusp; RC = right coronary cusp.

FIGURE 5 **Final Result**



(A to C) Final result and right coronary artery patency. The **arrow** indicates the severe aortic bend at the level of the stiff synthetic graft.

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KEY WORDS bioprosthetic aortic valve regurgitation, horizontal aorta, surgical Wheat operation, valve-in-valve transcatheter aortic valve replacement

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