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IMAGES IN INTERVENTION

TAVR in a Patient With Quadricuspid Aortic Stenosis

The Role of Patient-Specific Computer Simulation in Treatment Planning and Outcome Prediction

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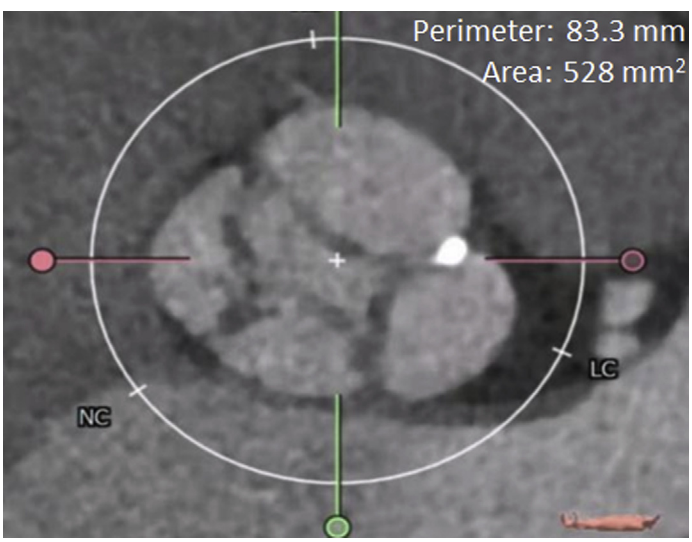
A 70-year-old man with symptomatic aortic stenosis and regurgitation was referred for transcatheter aortic valve replacement. Pre-procedural computed tomography showed a quadricuspid aortic valve (QAV) (**Figure 1**). The annular perimeter and area were 83.3 mm and 527.7 mm^2, respectively.

FIGURE 1 **Computed Tomography of Quadricuspid Aortic Valve**



The sizing chart (for tricuspid aortic valve) proposed a 29-mm Venus A-valve (Venus Medtech, Hangzhou, China). Nevertheless, a 26-mm valve was chosen given unfamiliarity with QAV plus uncertainty regarding annular measurements.

After pre-dilatation with a 23-mm balloon, the implantation of the 26-mm valve (deeper than anticipated) was associated with severe paravalvular leak (PVL) (**Figures 2A and 2B**, Video 1). Another 26-mm valve was implanted 10 mm higher, reducing PVL from severe to moderate (**Figure 2C**, Video 1).

To learn from this procedure and sizing in the setting of QAV, we retrospectively performed patient-specific computer simulation (FEops HEARTguide, FEops, Ghent, Belgium) (1). Briefly, a computed tomography-derived 3-dimensional model of the aortic root and valve was first created (segmentation), followed by the generation of high-quality meshes of the aortic root and valve. Finite-element computer modeling and computational fluid dynamics were used for simulation of valve implantation and quantification of PVL (1,2).

All steps of the actual implantation were respected during simulation, including the implantation depths of both valves (1). Simulation of the first valve confirmed

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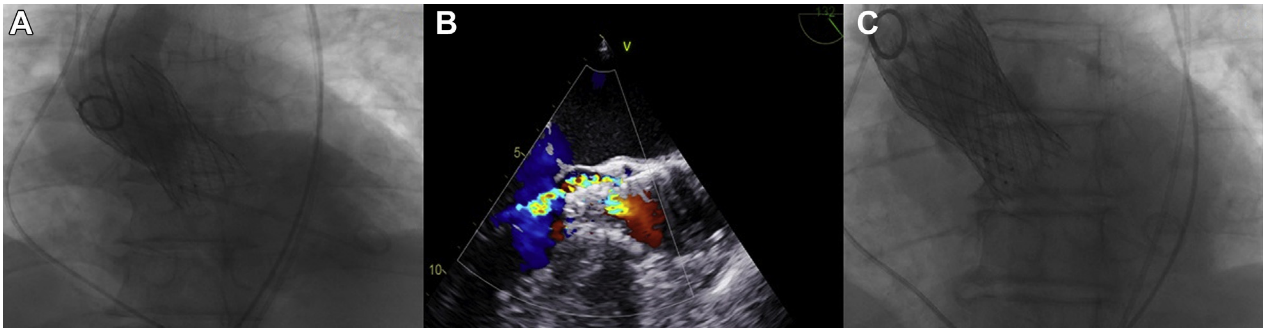
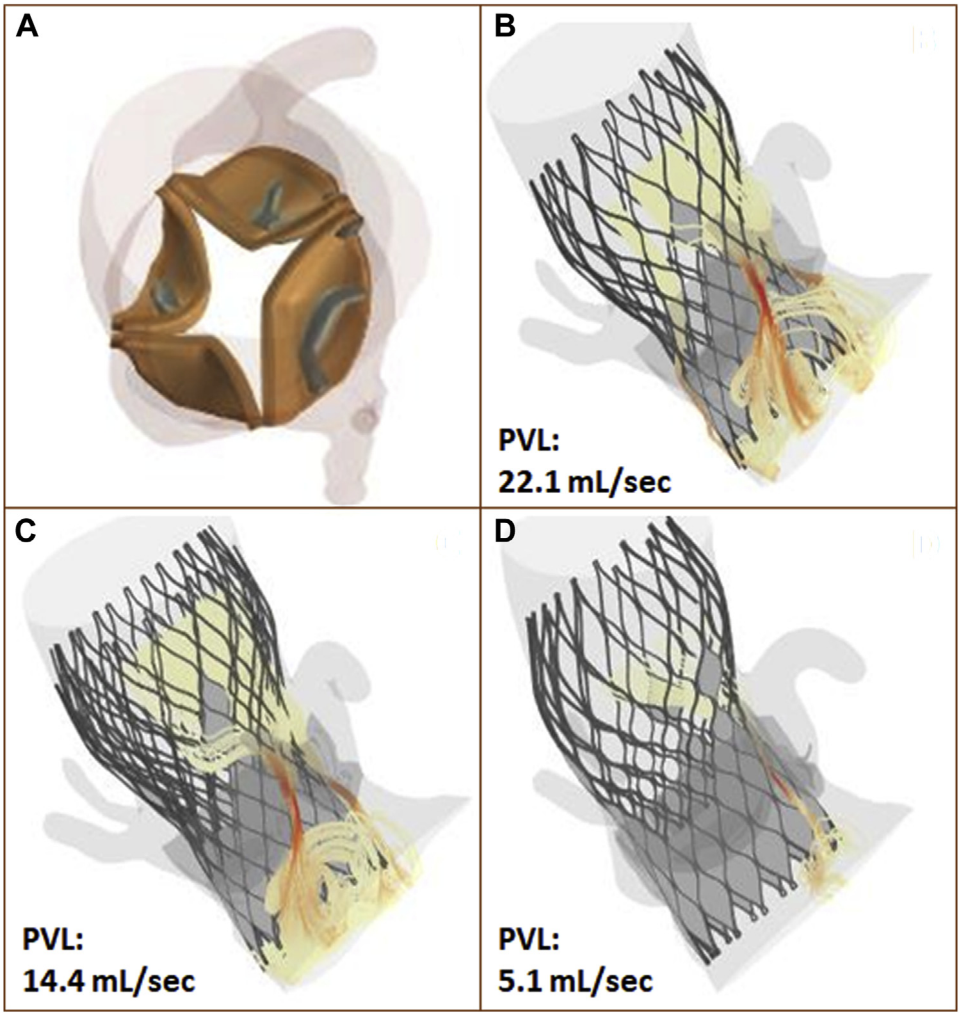
FIGURE 2 Aortic Regurgitation Severity After Valve Implantation



(A,B) Severe aortic regurgitation after first valve implantation. **(C)** Moderate aortic regurgitation after second valve implantation.

FIGURE 3 Computer Modeling and Simulation TAVR



Quadricuspid valve **(A)**, computational fluid dynamics; significant paravalvular leak (PVL) (22.1 ml/c) after first 26-mm valve implantation **(B)** and mild PVL (14.4 ml/s) after second 26-mm valve implantation **(C)**. Mild PVL (5.1 ml/s) after 29-mm valve implantation **(D)**. TAVR = transcatheter aortic valve replacement.

severe PVL (22.1 ml/s), reduced to 14.0 ml/s after the second valve, consistent with angiography (**Figures 3A to 3C**, Video 1) (2). Given PVL of 14.0 ml/l (<16.25 ml/s, which defines mild PVL), the decision not to perform dilatation after the implantation of the second valve proved correct in hindsight (2). Simulation with a 29-mm Venus valve (the size selected by the independent computed tomographic analyst at FEops) predicted mild PVL even at a lower depth (**Figure 3D**, Video 2), confirming that this was the optimal valve size.

This case highlights the role of patient-specific computer simulation in the planning of transcatheter aortic valve replacement for patients with rare or complex aortic root pathology, with implications in valve size selection and depth of implantation.

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KEY WORDS aortic stenosis, computer modeling, TAVR

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