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IMAGING VIGNETTE

ADVANCED

CLINICAL VIGNETTE

Novel Humanized Biosimulator to Predict Coronary Obstruction in High-Risk Valve-in-Valve Procedures

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ABSTRACT

We developed humanized biosimulator to predict the risk of coronary obstruction among high-risk patients undergoing valve-in-valve (ViV) procedures. In this case, based on unchanged instantaneous wave-free ratio values measured during a ViV simulation session, the procedure was performed safely in the patient the day afterward, without coronary artery issues and with good hemodynamic results. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2023;7:101711)

The wide use of bioprosthetic aortic valves has led to an increasing number of bioprosthetic valve failures in patients at high risk for reoperation.[1] Transcatheter aortic valve-in-valve (ViV) has become an alternative option with promising results,[2] although the risk of coronary obstruction remains a major limitation. We aimed to predict the risk of coronary obstruction among high-risk patients undergoing ViV by using a humanized biosimulator. This initiative was approved by our institutional review board.

A 3D patient-specific printed model (BIOMODEX) was developed based on cardiac computed tomographic (CT) images with precise segmentation of the aortic root anatomy, including assessment of calcium distribution and leaflet thickness. An optimization algorithm was then applied on the model using multimaterial distribution, recreating the tissue characteristics of the cardiac structures (Invivotech technology) and transferring real haptic tactile feedback to the operators (**Figure 1A**). The model was coupled to a pulsatile pump generating physiologic flow in the aorta and coronary arteries. Beside its use for ViV procedures, a similar model was developed for left atrial appendage occlusion, with favorable reproduction of in-human procedures.[3]

We implanted on the simulator a 23-mm Evolut PRO valve in a 21-mm degenerated Mitroflow bioprosthesis (**Figures 1B to 1E**). The risk of coronary obstruction was deemed high because of a 3.6-mm virtual valve to

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ABBREVIATIONS AND ACRONYMS

CT = computed tomography

iFR = instantaneous wave-free ratio

LAD = left anterior descending

RCA = right coronary arteries

ViV = valve-in-valve

coronary distance and a 6-mm height of the left main. Preprocedural CT measurements are illustrated in Supplemental Figure 1. Coronary patency was assessed using instantaneous wave-free ratio (iFR) wires in the left anterior descending (LAD) and right coronary arteries (RCA). No significant changes in iFR measures before and after ViV were reported (**Figure 1F**). The next day, we performed the same procedure in a real 74-year-old patient, with a final mean gradient of 12 mm Hg, mild paravalvular leak, and absence of significant change in iFR values (Video 1). Predischarge CT showed a decent distance between the prosthesis and the coronary ostia (**Figure 1G and 1H**).

The development of patient-specific simulators helps identify patients at high risk for coronary obstruction in whom ViV might be feasible and safe. New human-grade simulation platforms may have an important role in structural heart intervention planning, but robust data on clinical outcomes and safety are required to determine whether or not the simulator can be used in patients with high-risk anatomy.

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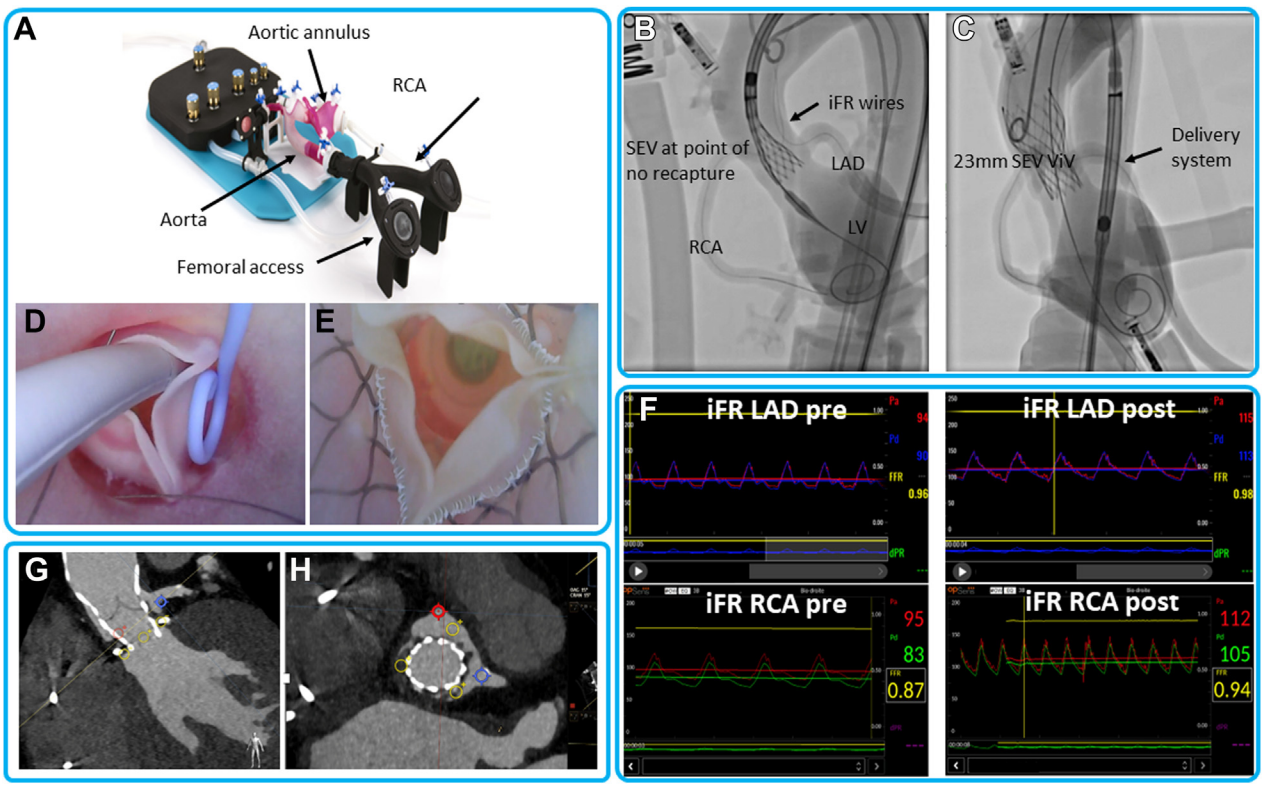
FIGURE 1 Valve-in-Valve Procedure Using a Novel Humanized Biosimulator



(A) Patient-specific simulator. **(B)** 3-cusp fluoroscopic view of transcatheter heart valve (THV) during deployment.. **(C)** Cusp-overlap view after valve deployment. **(D, E)** Intra-aortic live views during and after valve deployment. **(F)** Measures of instantaneous wave-free ratio (iFR) in left anterior descending (LAD) and right coronary artery (RCAU) before and after ViV. **(G, H)** Distance between THV and coronary ostia (**blue circle** = LAD; **red circle** = right coronary artery [RCA]) on computed tomography.

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KEY WORDS case planning, coronary obstruction, simulator, valve-in-valve, virtual-to-coronary distance

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