Commentary: From 2-dimensional to 3-dimensional—Tailor-made transcatheter aortic valve replacement to minimize complications

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Coronary obstruction is a rare but catastrophic complication after transcatheter aortic valve replacement (TAVR).¹ It is most often caused by over-displacement of the aortic valve leaflet, causing obstruction of the coronary ostium. Precise simulation of the interaction between a patient's anatomy and the TAVR valve is the goal to prevent this complication. In this issue of the *Journal*, Heitkemper and colleagues² report a retrospective simulation study in which they used patient-specific 3-dimensional (3D) model to predict post-TAVR coronary obstruction. From a population of 600 TAVR cases from their institution, they created computational 3D aortic root model of 28 patients who were flagged as being at high risk for coronary obstruction (defined as either coronary ostium height <14 mm or sinus of Valsalva width <30 mm). Five of these 28 patients had unsuccessful TAVR. In the 3D model analysis, a specific parameter, distance from cusp to coronary ostium indexed with the coronary diameter, was significantly different between the models of the patients who underwent successful TAVR and the models of those who did not. A cutoff value of for the distance from cusp to coronary ostium indexed with the coronary diameter of 0.7 was a better predictive parameter, with 100% sensitivity and 95.7% specificity, than either coronary height or sinus of Valsalva width. Heitkemper and colleagues² concluded that new criteria including the parameter obtained from patient-specific 3D aortic root modeling would possibly increase the number of patients undergoing TAVR safely.

Predicting the risk of coronary obstruction can be challenging and has been met with significant contention. In the multicenter registry from which predictors of coronary obstruction (coronary height <12 mm, sinuses of Valsalva <30 mm) are derived, 21% of patients with obstruction had height greater than 12 mm, and 35% had sinuses of Valsalva greater than 30 mm.¹ Others (eg, Spina and associates³ and Okuyama and coworkers⁴) have suggested a

ratio of leaflet length to curved coronary sinus height as another potential predictor. For valve-in-valve TAVR, where the risk of obstruction is approximately 4 times that of native valve TAVR, a valve to coronary ostium distance less than 4 mm predicts obstruction.⁵ Multidetector computed tomography can be used to create a virtual cylinder of diameter equal to that of the planned TAVR that extends distally from the basal ring of the surgical valve; the distance from the cylinder to the coronary ostium is the valve to coronary ostium distance.⁶ By using 3D computer modeling, Heitkemper and colleagues² appear to have created a similar concept for use in the native valve. Their addition of the coronary ostial diameter to yield a fractional obstruction measure is interesting and requires further investigation.

Others have used computational 3D modeling to predict paravalvular regurgitation,⁷ predict conduction abnormalities,⁸ and manage challenging anatomic scenarios, such as a high-profile prosthetic valve in the mitral position.⁹ A 3D printing technology has taken this computational simulation one step further and enabled the testing of actual physical interactions between a TAVR valve and patient-specific aortic root in vitro.¹⁰ The benefit of this technology is the ability to obtain a direct visualization of the anatomy

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Central Message

Computational 3D modeling gives predictive parameters for coronary obstruction after TAVR. A new technology would standardize a patient-specific strategy for this growing treatment of aortic stenosis.

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as in open surgery and also simulate the fluid dynamics with computational modeling. Although these technologies are still in development, they will bring patient-specific treatment—tailor-made TAVR—in the near future. We congratulate Heitkemper and colleagues² for identifying new risk predictors for this important complication after TAVR by utilizing computational modeling. Recently, Khan and colleagues¹¹ reported successful TAVR even in extremely high-risk patients (median coronary height of 6.8 mm and sinus of Valsalva width of 24.3 mm) by using a unique pre-TAVR intentional laceration technique to prevent coronary obstruction. These novel procedures and technologic developments allow more precise patient selection and safe placement of TAVR valves, even in high-risk patients.

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