Transcatheter aortic valve replacement (TAVR) is an established and accepted therapeutic option for both inoperable and high-risk surgical patients with severe aortic stenosis. Precise prosthetic valve positioning in the 3-dimensional (3D) aortic annulus is a critical component of a successful TAVR procedure. Improper positioning of the prosthetic valve (e.g., too high or too low in the annulus) may result in device embolization, coronary obstruction, or paravalvular leak. Proper valve positioning is best achieved by working in a 2-dimensional x-ray fluoroscopic view that is perpendicular to the native valve/annulus (e.g., the “coplanar view”). Various imaging techniques and modalities, including standard aortic root x-ray angiography, multidetector computed tomography, and 3D angiographic reconstructions of the aortic root generated by rotational C-arm x-ray angiography,

**FIGURE 1** Steps in Determining TAVR Coplanar View Using 3D Echo-X-Ray Navigation

(A) The integrated marking feature allows for the placement of a colored “marker” to highlight a particular structure or target. Colored markers are placed on or near the center of each of the coronary cusps in the en face 2-dimensional view (right panel). (B) In the long-axis view, the 3 colored markers are individually dragged (table side control, using a standard wireless computer mouse) such that each is aligned at or near the level of the aortic annulus (left panel). These 2 separate steps result in the colored markers approximating the center (en face location) and nadir (long-axis location) of each coronary cusp of the native aortic valve. (C) The x-ray fluoroscopic gantry can then be rotated by the operator to a position such that the 3 colored markers (corresponding to the approximate locations of the 3 coronary cusps in 3D space) are aligned (noncoronary cusp [NCC], right coronary cusp [RCC], and left coronary cusp [LCC] from left to right on the screen; white line) and coplanar in fluoroscopy (in this case a left anterior oblique 7, caudal 4 projection). (D) X-ray angiography confirms the optimal angiographic deployment view for the x-ray gantry determined by coplanar marker alignment (white line) in the 3D echo-X-ray navigation, demonstrating an appropriate angiographic deployment view for use during TAVR. (E) Immediately after TAVR and during sinus rhythm, the colored markers remain in coplanar alignment to the aortic annulus while the final valve orientation confirms an ideal optimal angiographic deployment projection. The green check mark (C to E) depicts the head of the transesophageal echocardiography probe that has been automatically co-registered with the x-ray system.
have all been tested and used to determine the optimal angiographic deployment projection angle (1-3). These modalities, however, remain limited by the need for iodinated contrast, which carries with it inherent risks of subsequent renal dysfunction in the elderly and high-risk TAVR patients. Recently, an integrated 3D Echo-X-Ray navigation system (EchoNavigator, Philips Healthcare, Eindhoven, the Netherlands) was employed whereby 3D transesophageal echocardiography (TEE) imaging is registered automatically in real time with live 2-dimensional fluoroscopy images acquired from the x-ray imaging system. Although use of this integrated navigation system to determine an optimal x-ray angiographic deployment projection necessitates the use of TEE during TAVR, it offers the potential to mitigate some of the contrast agent risk associated with the alternative imaging modalities. Figure 1 demonstrates a case example using x-ray/3D TEE coregistration to accurately predict the optimal x-ray angiographic deployment projection for TAVR. Further investigation of the methods described in this case example should be validated in a larger series of patients.

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Effects of Blood T1 on Extracellular Volume Calculation

We read with much interest the recent publication by White et al. (1), assessing the accuracy of the contrast bolus T1 mapping cardiac magnetic resonance technique for measuring myocardial extracellular volume fraction (ECV). The study provides the first validation of the bolus technique against collagen volume fraction from myocardial biopsy. The bolus technique was also compared with the gold standard infusion technique in 5 representative conditions. The 2 techniques provide equivalent results, except for pathological states with an ECV >0.4, where the bolus approach consistently and increasingly overestimates the ECV value.

To date, T1 mapping has been used mainly for differentiation between healthy and disease states in clinical settings associated with an increased ECV. The technique should provide even more clinical benefit through its ability to differentiate between different degrees of pathological states associated with scar or edema in such settings as post-infarction remodeling, myocarditis, and transplant rejection follow-up. In this regard, the lower precision of the bolus technique in the ECV range of myocardial scar or edema is a matter of concern.

As suggested by the authors, a possible reason for such ECV overestimation is that renal clearance might be faster than the exchange rate between the intravascular and interstitial compartments, leading to lower ΔR1 in blood compared with ΔR1 of myocardium with time. This is in line with previous observations in subjects with normal or modestly increased ECV, showing small but significant changes in ECV with time using the bolus approach (2,3). This should cause a slight overestimation in the high ECV range with the bolus approach, as a limitation of the 2-compartment model, but independent of noticeable differences in blood T1 related to the underlying clinical state.

The data in the present study show some intriguing differences in blood T1 between groups. Post-contrast blood T1 is higher for bolus than for infusion in all subjects except for the healthy and the HCM-remote groups. This includes therefore all cases of high ECV (i.e., the Amyloid, HCM LGE Zone, and Infarct Zone groups in Table 1 in White et al. (1)). As such, the relative difference in blood T1 between bolus and infusion (with pre-contrast T1 as the reference) is up to 4.3 times higher in the high ECV subjects compared with the healthy or HCM-remote group. The lower ΔR1 for blood with the bolus approach in