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Letters

RESEARCH LETTER

Outcomes in Patients Undergoing TAVR Planning with Contrast-Enhanced CT vs Noncontrast CT and CMR

The use of transcatheter aortic valve replacement (TAVR) has been on the rise and is still expected to grow. The development of new techniques has resulted in better outcomes and less risk of complications, which has led TAVR to be favored by the most recent guidelines for the management of severe aortic stenosis.[1,2] Multimodality imaging assumes a pivotal role in pre-TAVR assessment. Preprocedural imaging holds paramount importance in identifying the optimal device, the correct size, and the appropriate access route for implantation, to ensure the efficacy and safety of the procedure. Contrast-enhanced computed tomography (CECT) is currently the established imaging modality for planning TAVR procedures,[3] but advanced kidney dysfunction may preclude the use of a contrast medium, therefore, there is a pressing need to minimize the amount of contrast used for TAVR planning. The combination of noncontrast computed tomography (NCCT) and cardiac magnetic resonance (CMR) is an alternative planning strategy, but limited data exists on whether this approach has an impact on the procedural outcomes post-TAVR. This strategy eliminates the necessity for iodinated contrast medium and decreases radiation exposure. CMR measurements of the aortic annulus showed good to excellent agreement with computed tomography measurements.[4] However, given the lack of protons within calcifications, CMR is limited in the assessment of annular, valvular, and aortic calcifications, hence the addition of NCCT for TAVR access evaluation and a better assessment of calcifications.

This study sought to explore the clinical outcomes and hemodynamic changes after TAVR in patients who underwent procedural planning with the combination of CMR and NCCT, compared with the standard CECT.

This is a retrospective cohort of patients >18 years of age who underwent TAVR between 2016 and 2020. The study was approved by the institutional review board. Patients were divided into 2 groups according to the imaging strategy used for planning: CECT vs NCCT + CMR. Patients with glomerular filtration rate <30 mL/min/1.73 m^2 underwent NCCT + CMR strategy. Patients who underwent valve-in-valve TAVR and those with TAVR planning using transesophageal echocardiography (TEE) and not CECT or NCCT + CMR were excluded. Patients who underwent planning with TEE were those with chronic kidney disease and contraindications to CMR (such as having a permanent pacemaker [PPM]).

Primary postprocedural outcomes were assessed before discharge and included the need for PPM implantation, stroke, and the presence and severity of paravalvular leak (PVL). Hemodynamic parameters were assessed using transthoracic echocardiography. VARC (Valve Academic Research Consortium) 2 and VARC 3 clinical outcomes were not assessed given the difference in baseline comorbidities between patients in the 2 groups, since patients who underwent the NCCT + CMR protocol had chronic kidney disease, thus this study focused on procedural outcomes.

For patients in the CECT group, multidetector CECT technology was used. Spiral imaging was performed after the intravenous administration of contrast material. Complete heart coverage, retrograde electrocardiogram (ECG) gating, and multiphase reconstructions of the aortic root throughout the cardiac cycle enabled dynamic 4-dimensional cardiac computed tomography imaging. This is followed by non-ECG-gated data acquisition of the aorto/ilio/femoral vasculature for assessment of the access site. For patients in the NCCT + CMR group, NCCT imaging of the chest, abdomen, and pelvis was used for assessment of arterial access site, and annular, valvular, and aortic calcification. CMR was performed using 1.5-T or 3.0-T magnetic resonance imaging scanners. Turbo spin echocardiographic and gradient echocardiographic imaging were performed for anatomic definition. Dynamic cine imaging was used for cardiac chamber, wall-motion, and valvular analysis. Phase contrast imaging was done for flow quantification. Navigator-gated, whole-heart magnetic resonance angiography sequence timed to midsystole (20%-30% phase) was used for annular sizing. During coronary assessment pre-TAVR, radial access was used, and, therefore, an iliac run was not done on patients.

Statistical analysis was performed with SPSS version 23.0 (IBM Corporation). Categorical baseline,

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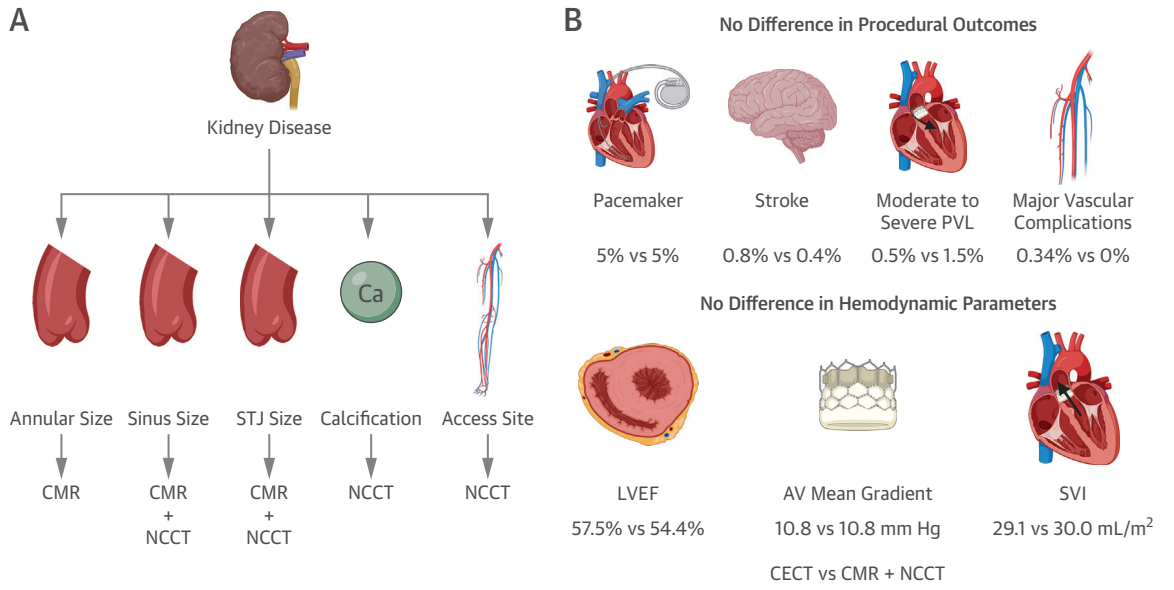
FIGURE 1 Main Findings of the Study



No difference in procedural outcomes or echocardiographic parameters after TAVR in patients who underwent TAVR planning with CECT vs the combination of CMR and NCCT. (A) The key elements of TAVR planning in patients with advanced kidney disease. (B) The procedural outcomes and post-TAVR echocardiographic parameters in patients in the CECT vs CMR + NCCT population. AV = aortic valve; CECT = contrast-enhanced computed tomography; CMR = cardiac magnetic resonance; CT = computed tomography; LVEF = left ventricular ejection fraction; NCCT = noncontrast computed tomography; PVL = paravalvular leak; STJ = sinotubular junction; SVI = stroke volume index; TAVR = transcatheter aortic valve replacement.

procedural characteristics, and outcomes were presented as frequencies (percentage of patients), and continuous variables were presented as mean ± SD with comparisons between the 2 groups using independent samples *t* test, chi-square tests, or Fisher exact tests.

At Cleveland Clinic, 2,630 patients underwent TAVR between 2016 and 2020. Included in the study were 2,305 patients. The CECT group included 2,043 patients, whereas the NCCT + CMR group included 262 patients. The study only included patients who underwent successful TAVR. Ten patients had their procedures converted to open surgery and were excluded from the study (9 in the CECT group and 1 in the CMR + NCCT group; 0.44% vs 0.38%, respectively). None of the patients in the CMR + NCCT group had inadequate sizing because a CMR was repeated in patients for whom there was difficulty sizing. Moreover, none of the patients underwent a change in valve selection or size during the procedure, and none underwent intraprocedural TEE because of suboptimal planning.

The mean age of the entire population was 79.5 ± 8.9 years with the patients in the CMR + NCCT group having a higher mean age compared with those in the CECT group. In the CECT group 1,160 patients (57%) were males and in the CMR + NCCT group 163 (62%) were males. They had a higher prevalence of coronary artery disease, atrial fibrillation, hypertension, diabetes, prior myocardial infarction, and chronic lung disease. This is reflected in a significantly higher STS-PROM (Society of Thoracic Surgeons Predicted Risk of Mortality) score in the CMR + NCCT group compared with the CECT group. The majority of patients in both groups underwent transfemoral TAVR using a balloon-expandable valve. The mean contrast volume received during TAVR for patients in the CECT group was 46.2 ± 25.4 mL vs 32.4 ± 17.8 mL for those in the CMR + NCCT group ($P < 0.001$).

There was no difference in primary outcomes between the 2 groups. Ninety-five patients (5%) in the CECT group and 14 (5%) in the NCCT+CMR group had PPM post-TAVR ($P = 0.619$). Ten patients (0.5%) in the CECT group and 4 in the NCCT + CMR (1.5%) had moderate to severe PVL ($P = 0.065$). In addition, 17 patients (0.8%) in the CECT group and 1 (0.4%) in the NCCT + CMR group had an ischemic stroke ($P = 0.712$). Moreover, the incidence of major and minor

vascular complications (defined according to the VARC 3 criteria) was similar between the 2 groups, with 7 major vascular complications, all of them in the CECT group ($P = 1.000$). The incidence of minor vascular complications was 9.7% vs 11.5% for the CECT and CMR + NCCT groups, respectively (198 vs 30 patients, respectively; $P = 0.379$). There was no difference in the hemodynamic parameters between the 2 groups post-TAVR except for a slightly lower left ventricular ejection fraction in the NCCT + CMR group that was also present at baseline.

Figure 1 summarizes the main findings of the study. The main findings of this study are: 1) 11% of patients in this study have low glomerular filtration rate and underwent TAVR planning by CMR and NCCT; 2) valve choice can be guided by CMR and NCCT; 3) hemodynamic parameters assessed using echocardiography were not different between the 2 groups; and 4) complications including stroke, PVL, and PPM implantation were not different between the 2 groups.

TEE is an alternative to CECT in patients with advanced kidney disease, but 3-dimensional assessment with TEE is limited in resolution due to calcification that is present in patients with aortic stenosis. CMR + NCCT is a noninvasive imaging strategy. In those patients, for TAVR access planning, and for assessment of aortic, annular, and valvular calcifications, NCCT is used. For aortic annular dimensions and coronary origins, CMR is used. NCCT is used in conjunction with CMR to measure the sizes of the sinus of Valsalva and the sinotubular junction. Annular sizing using CMR can be obtained with several different approaches. One method involves using a free-breathing sequence with respiratory navigator-gating and ECG triggering, commonly referred to as a "whole heart" sequence. This approach yields a 3-dimensional data set similar to that obtained through CECT, albeit typically requiring 4-6 minutes of acquisition time. Additionally, direct planimetry using steady-state free precession cine imaging obtained as a stack, using double oblique orientation in plane with the aortic annulus can be used.

Multimodality imaging is an essential component of pre-TAVR procedural planning. The present study addresses the clinical concern of TAVR planning using CMR + NCCT strategy in candidates with advanced kidney dysfunction. In the present study, there was no difference in procedural outcomes or echocardiographic parameters between patients who underwent CECT-planned vs CMR + NCCT-planned TAVR, similar to the TAVR-CMR (Cardiac Magnetic Resonance Imaging Versus Computed Tomography to Guide Transcatheter Aortic Valve Replacement) trial.[5] Therefore CMR + NCCT imaging strategy can be considered an alternative and can guide valve choice in patients with advanced kidney dysfunction.

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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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