Editorial Commentary

The evolving role of transcatheter aortic valve implantation computed tomography in coronary artery assessment: a deeper dive into efficiency, challenges, and future perspectives

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Introduction

The recent study on the potential of pre-transcatheter aortic valve implantation computed tomography (TAVI-CT) to assess coronary artery stenosis and its implications in reducing the need for invasive coronary angiography (ICA) by Lecomte *et al.* (1) presents a substantial advancement in the field of cardiac imaging. TAVI has become the standard treatment for patients with severe aortic stenosis who are at high or intermediate surgical risk. The study demonstrates that by using the latest CT technology and reconstruction algorithms, TAVI-CT can safely avoid 47% of ICA, benefiting both patients and healthcare systems.

CT in the context of aortic stenosis evaluation serves multiple purposes at the same time (2): (I) anatomical assessment of the heart and surrounding structures, allowing for a comprehensive understanding of the aortic valve and aortic root anatomy; (II) calcification quantification in the aortic valve, which is a key factor in the severity of aortic stenosis; (III) vascular evaluation to determine suitable access routes (e.g., femoral arteries); (IV) device planning with accurate measurements of the aortic annulus and surrounding structures, which is essential for selecting the appropriate size and type of the prosthetic valve for TAVI; (V) risk assessment: CT angiography (CTA) can identify potential complications or contraindications to TAVI or surgical aortic valve replacement (SAVR), such as the presence of aortic atherosclerotic plaques that could increase the risk of stroke during the procedure. In order to address all these points at the same time, TAVI-CT typically involves CTA of the entire aorta, subclavian, iliac, common/external iliac and superficial femoral arteries at the level of the femoral head (3), with the added option to include carotid vessels, given its increased use as a vascular access point (4). In other words, the heart and coronary arteries are unavoidably in the acquired volume.

Furthermore, pre-TAVI workup typically includes ICA for a comprehensive evaluation of coronary artery disease (CAD). This is a crucial step, as patients with severe aortic stenosis often have coexisting CAD. Identifying and treating significant CAD before TAVI is important to reduce the risk of peri-procedural myocardial infarction and improve long-term outcomes (5). However, ICA can be burdensome for patients and may pose significant risks (6).

In their retrospective study (1), the authors evaluated the potential of TAVI-CT to assess coronary artery stenosis

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and thereby reduce the need for ICA. Significant coronary artery stenosis was defined as ≥50% for the left main artery, and ≥70% for other coronary segments with a diameter larger than 2.5 mm. They utilized a new generation single heartbeat CT scanner combined with the latest reconstruction algorithms, including deep learning image reconstruction and automated motion correction. The study included 206 patients who underwent both CT and ICA before TAVI. The design was retrospective and conducted at a single expert cardiology center, excluding patients with coronary stents or coronary bypass grafts, as well as those who did not undergo TAVI, which may introduce bias.

Nevertheless, results of the study are promising: the authors found that TAVI-CT could safely rule out the need for coronary angiography in 47% of patients, thanks to a high negative predictive value (NPV) of 100%. This is a relevant finding, as it suggests that nearly half of the patients could avoid the risks and discomfort associated with ICA.

The high NPV in this study can be attributed to the authors' adoption of a straightforward analysis protocol, in which they recommended ICA at even the slightest suspicion of significant coronary artery stenosis. This approach, combined with the use of the latest CT technology, yielded a high NPV and a remarkably brief average CT interpretation time of just 2 minutes. Of note, the low prevalence of patients recommended for percutaneous coronary intervention could have artificially increased the NPV, as the authors acknowledge.

While the study's findings are encouraging, there are certain concepts that may require nuance or consideration in light of future CT imaging.

Efficiency and practicality of the interpretation process

The authors report an impressively brief two-minute reading time for coronary interpretation on TAVI-CT using the Carestream PACS (Picture Archiving and Communication Systems) platform. This rapid interpretation time underscores the efficiency of the system and the streamlined approach adopted by the authors. However, they also mention the use of a second software [GE's Advantage Workstation (AW)] for obtaining curvilinear reconstructions. Given the intricacies involved in obtaining such reconstructions, achieving this in a mere two minutes seems optimistic. It raises additional questions: How often did the authors resort to the AW for these reconstructions? Was the time to transfer images over to AW, and the processing time, including lumen segmentation and stenosis quantification measured and contained in the total interpretation time? The way they approach coronary artery interpretation diverges from the Society of Cardiovascular Computed Tomography (SCCT) guidelines, which advise interpreting coronary arteries using interactive cardiac post-processing platforms capable of presenting all 2D and 3D reconstruction modes (7). These modes encompass trans-axial 2D image stacks, multiplanar reformations (MPRs), maximum intensity projections (MIPs), curved multiplanar reformations (cMPRs), and volume rendering technique (VRT) reconstructions. Furthermore, in clinical routine, data reading and processing time could take longer than in research setting due to multiple factors (interruptions, multiplicity of tasks, concentration, etc.).

Challenges of blooming artifacts

Blooming artifacts, predominantly caused by coronary calcifications, present a significant challenge in cardiac CT imaging. The authors acknowledge these difficulties, which can obscure the vessel lumen and lead to overestimation of stenosis. While advancements in CT technology, such as deep learning image reconstruction, have made strides in reducing noise and blooming artifacts, they remain a concern, especially in the elderly population with aortic stenosis. Continued research is crucial to further mitigate the impact of blooming artifacts. Techniques that provide better differentiation between calcified plaques and the vessel lumen, including photon-counting CT (PCCT) (8) or software solutions that can correct for these artifacts (9), could be pivotal in enhancing the diagnostic accuracy of TAVI-CT.

Motion artifacts—a persistent challenge

The authors also highlight the trouble caused by motion artifacts, which can be attributed to both cardiac and respiratory movements. These artifacts can compromise image quality, making interpretations challenging. The study utilized automated motion correction algorithms, which have undoubtedly improved image quality (10). However, the quest for perfection continues. An ongoing clinical trial (ClinicalTrials.gov identifier: NCT05709652) (11), is expected to shed light on the continuing efforts to address motion artifacts. As technology evolves, we can anticipate the development of more sophisticated motion correction algorithms and perhaps real-time motion tracking systems that can further enhance image clarity and reduce artifacts.

Photon counting CT—the future?

PCCT is an emerging technology that holds significant promise in the field of cardiac imaging. Unlike conventional CT, PCCT quantifies individual photons, enabling a substantial improvement in spatial resolution, enhanced energy resolution, and the potential reduction of artifacts. As mentioned earlier, in the context of TAVI-CT, PCCT could offer unparalleled image quality, especially when dealing with challenging scenarios involving blooming or motion artifacts. Its capacity to differentiate materials based on their energy signatures could result in a clearer demarcation of coronary calcifications from the vessel lumen, thereby addressing the blooming artifact challenge. Furthermore, PCCT's potential to administer lower doses of iodinated contrast media could be particularly advantageous for the elderly population undergoing TAVI-CT. This aspect aligns with ongoing discussions regarding the environmental impact of iodinated contrast agents (12).

Saving contrast media

Indeed, another noteworthy advantage of using TAVI-CT for coronary artery assessment is the potential reduction in the use of iodinated contrast media. ICA requires the administration of contrast agents, which can pose risks to patients, particularly those with renal impairment. By avoiding unnecessary coronary angiography in a significant proportion of patients, as demonstrated in the study (1), there is a potential for reduced contrast media usage. This not only minimizes the risk of contrast-related nephropathy but also reduces the overall cost and resource utilization associated with the procedure. In the context of TAVI, where patients are often elderly and have multiple comorbidities, this advantage is of considerable importance (13).

Conclusions

This study represents a significant step forward in the pre-TAVI workup. The latest CT technology combined with a simplified analysis protocol, have the potential to safely decrease the necessity for ICA in a considerable portion of patients. This not only benefits patients by minimizing risks and discomfort but also has implications for healthcare cost savings. This study highlights ongoing challenges in cardiac CT imaging, such as blooming and motion artifacts. Advances in technology and continued research are expected to overcome these issues, leading to more precise, efficient, and safer imaging in the future. Future developments in CT technology, including the utilization of extra-cellular volume (ECV) fraction for predicting patient prognosis (14-16), may further enhance the diagnostic performance of TAVI-CT and expand its role in pre-TAVI planning.

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