Coronary stenosis assessment prior to a transcatheter aortic valve replacement – revascularization?

Prof. Hatem Alkadhi, MD
Diagnostic and Interventional Radiology, University Hospital Zurich, Switzerland

History

A 62-year-old male patient with severe symptomatic low-flow, low-gradient aortic stenosis was scheduled for transcatheter aortic valve replacement (TAVR). A coronary CT angiography (cCTA) was performed prior to the procedure, using an ultra-high resolution (UHR) scan mode due to the patient's high coronary calcium load.

Diagnosis

The assessment of the calcium scoring revealed an Agatston score of 1,188, being beyond the 90th age- and gender-percentile. The cCTA images were reconstructed at 0.6 mm with a standard resolution kernel of Bv40 (reference images), as well as at 0.2 mm with a sharper kernel of Bv60 (UHR images). A stenosis at the proximal right coronary artery (RCA) caused by calcified plaques was seen and therefore an evaluation of the vessel lumen was performed using both the reference images and the UHR images. The reference images showed a moderate stenosis (84% in area and 60% in diameter) while the latter revealed a mild stenosis (61% in area and 38% in diameter). The blooming effect of the calcified plaques affecting the visualization of the vessel lumen and the stenosis grading was clearly reduced in the UHR images. Other stenoses caused by calcified plaques in the left main (LM) and the left anterior descending artery (LAD) were also evaluated with UHR images, showing less than 50% diameter stenosis. Subsequently, the cCTA results from the UHR image evaluation were confirmed by an invasive catheter coronary angiography. Coronary revascularization was considered not necessary, and the patient underwent the TAVR procedure with a good outcome.

Comments

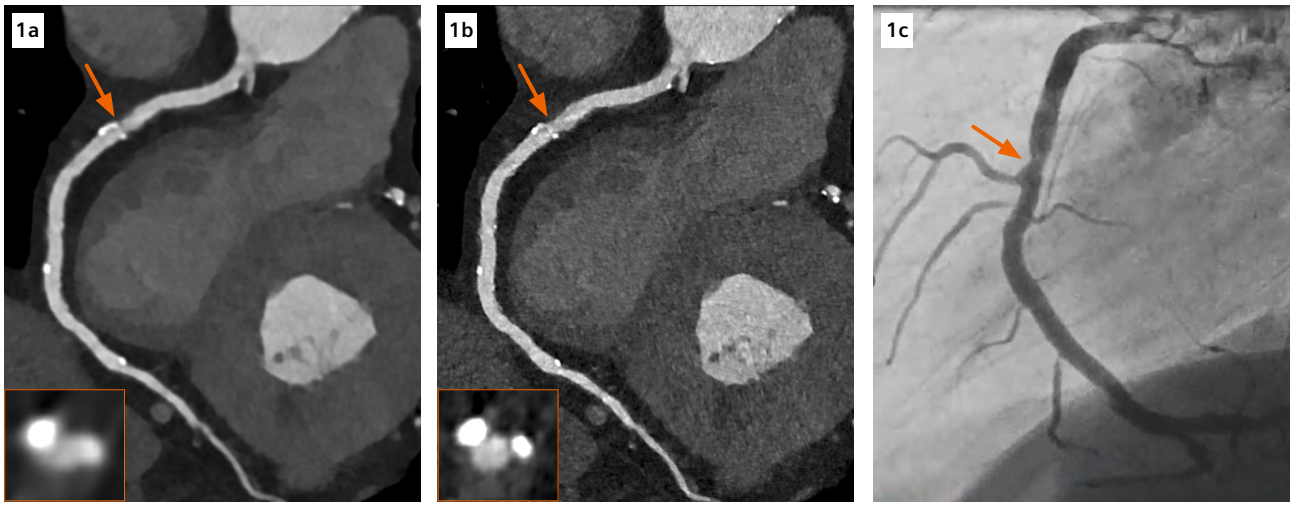
In the diagnostic workup of patients with suspected coronary artery disease, cCTA has shown an excellent sensitivity and negative predictive value. However, it is still challenging in patients with a high coronary calcium burden – in the presence of severe calcifications, calcium blooming may affect the delineation of the luminal stenosis leading to an overestimation of the stenosis grade. To overcome this shortcoming, an increased spatial resolution, which reduces partial volume effects, is desired. [1]

This case was performed on a newly developed Dual Source CT scanner, NAEOTOM Alpha, with photon-counting detectors (QuantaMax™). It provides energy-resolved CT data with improved spatial resolution, without electronic noise, which is eliminated by setting up a predefined digital threshold for counting X-ray photons far above the electronic noise floor. This leads to less image noise. [2] An UHR mode is predefined for cCTA scans, featuring a slice collimation of 120 x 0.2 mm, in which the sub-pixels of the detector with a size of 0.15 x 0.18 mm^2

Examination Protocol

Scanner	**NAEOTOM Alpha**
Scan area	Heart
Scan mode	Retrospective ECG gated spiral mode
Scan length	145 mm
Scan direction	Cranio-caudal
Scan time	5.5 s
Tube voltage	120 kV
Effective mAs	58 mAs
Dose modulation	CARE Dose4D
$CTDI_{vol}$	28.8 mGy
DLP	471 mGy*cm
Rotation time	0.25 s
Pitch	0.26
Slice collimation	120 x 0.2 mm
Slice width	0.2 mm
Reconstruction increment	0.2 mm
Reconstruction kernel	Bv40/Bv60, QIR4
Heart rate	74 bpm

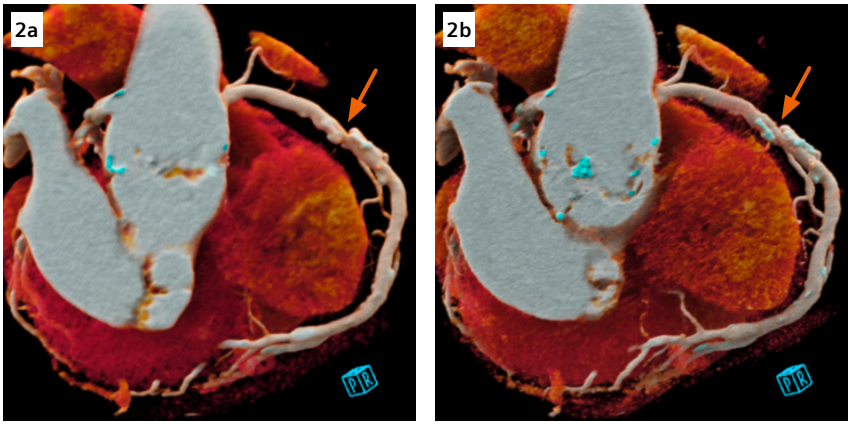
Contrast	**370 mg/mL**
Volume	Triphasic injection: • 55 mL pure CM • 55 mL (20% CM, 80% Saline) • 20 mL pure Saline
Flow rate	5.5 mL/s
Start delay	Bolus tracking triggered at 100 HU in the ascending aorta +5 s



1 **Curved MPR images (Figs. 1a & 1b) show a proximal RCA stenosis caused by calcified plaques (arrows). Images are reconstructed at 0.6 mm with kernel Bv40 (Fig. 1a) and at 0.2 mm with kernel Bv60 (Fig. 1b). The corresponding axial slices, perpendicular to the vessel centrelines at the stenosis, are shown in the left lower corners. The blooming effect of the calcified plaques affecting the visualization of the vessel lumen and the stenosis grading is clearly reduced in the UHR images. An invasive catheter coronary angiography (Fig. 1c) confirmed a mild stenosis in the proximal RCA (arrow) consistent with the result from the UHR image evaluation.**

(at the isocenter) are read out individually. There are no physical septa between the sub-pixels. To reduce scattered radiation, each group of 4 x 6 sub-pixels is confined by collimator grids. This increases the spatial resolution without degrading the geometric dose efficiency of the detector, resulting in an improved anatomic delineation of plaque characteristics and vessel lumen. Image noise can be further reduced by applying a model-based iterative reconstruction approach – Quantum Iterative Reconstruction (QIR) – in the image reconstruction process. Owing to the reduced image noise, even UHR images can be used for three-dimensional reconstructions, such as cinematic volume rendering technique (cVRT), demonstrating a photo-realistic visualization of anatomical details.

As shown in this case, the UHR mode, provided by a photon-counting CT for cCTA examinations, enables the visualization of calcified coronaries with reduced blooming effect and improved sharpness. This may enhance the confidence of the physicians in evaluating coronary stenosis for patient with high coronary calcium burden and, as the decision on coronary revascularization depends upon the degree of stenosis, may have an impact on the management of the patient. ●



2 **cVRT images reconstructed with reference images (Fig. 2a) and UHR images (Fig. 2b), using the same preset, show the differences in the delineation of the calcified plaques, the stenosis (arrows) and the small vessels in three dimensions. Note that even UHR images as thin as 0.2 mm reconstructed with sharper kernel of Bv60 can be used to create a cVRT image with optimal image quality, owing to the reduced image noise.**

References

[1] V. Mergen, et al. Ultra-High-Resolution Coronary CT Angiography with Photon-Counting Detector CT – Feasibility and Image Characterization. Invest Radiol. 2022 Dec 1; 57(12):780-788.

[2] Thomas Flohr, et al. Photon-counting CT review. Physica Medica 79 (2020) 126–136.