Cardiac CT
Chapter 4

ASSESSING CORONARY ARTERY PLAQUES

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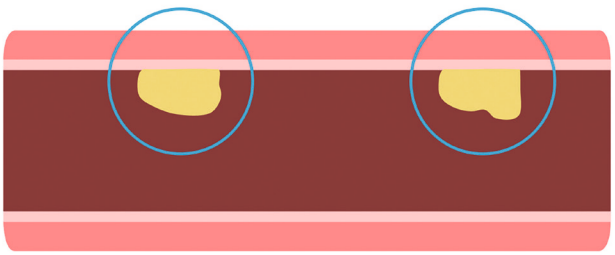
Assessing coronary artery plaques

SCORING CORONARY ARTERY CALCIFICATION (CAC)

Coronary artery calcification can be quantified using the Agatston score. This method uses a multiplication factor for ranges of calcium attenuation values, which is then multiplied by the area of the calcified plaque.

Hounsfield unit (HU) number	Mulitiplication factor (Agatston scoring)
130–199	1
200–299	2
300–399	3
> 400	4

The total coronary artery calcification score is the sum of all the calcified plaques in the coronary arteries.



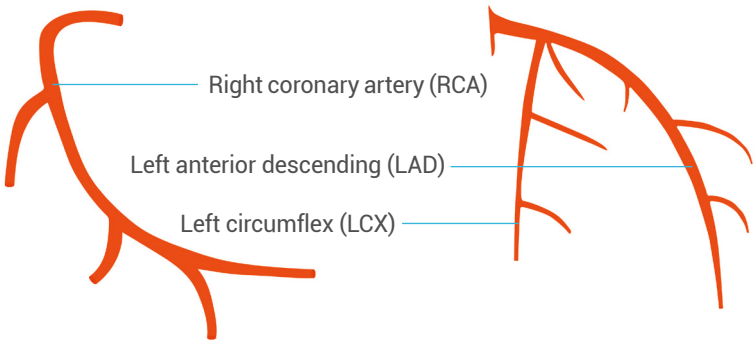
Area = 5 mm	Area = 10 mm
Hounsfield unit number = 250	Hounsfield unit number = 450
Agatston score = 10 AU	Agatston score = 40 AU

Coronary artery calcium is similar to taking a snapshot of an individual's lifetime exposure to cardiovascular risk factors and seeing what degree of atherosclerosis this has caused.

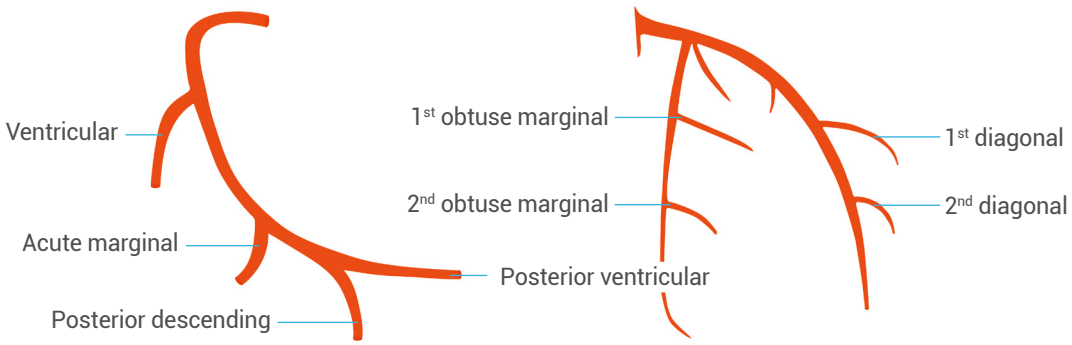
Assessing coronary artery plaques

RECOGNIZING THE CORONARY SEGMENTS

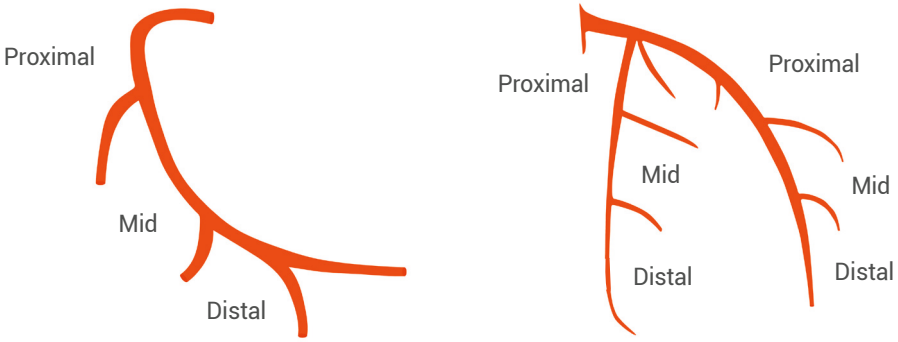
In bifurcation anatomy, there are three main coronary arteries.



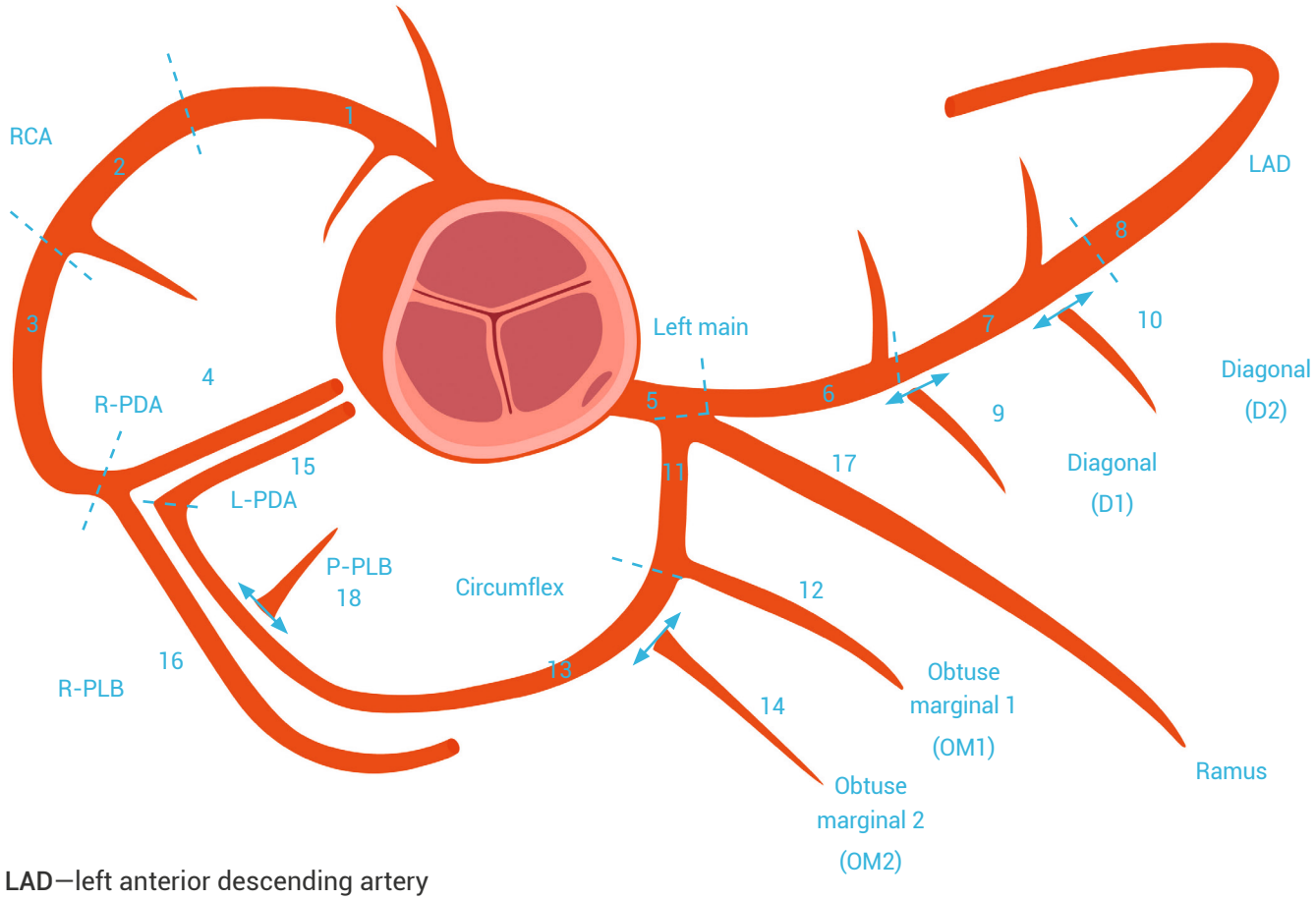
These vessels all have a number of branches.



These branches are used to split the coronary arteries into segments.



The segments on coronary CT, that should be reported, are shown below.



LAD—left anterior descending artery
L-PDA—left posterior descending artery
L-PLB—left posterolateral branch
RCA—right coronary artery
R-PDA—right posterior descending artery
R-PLB—right posterolateral branch

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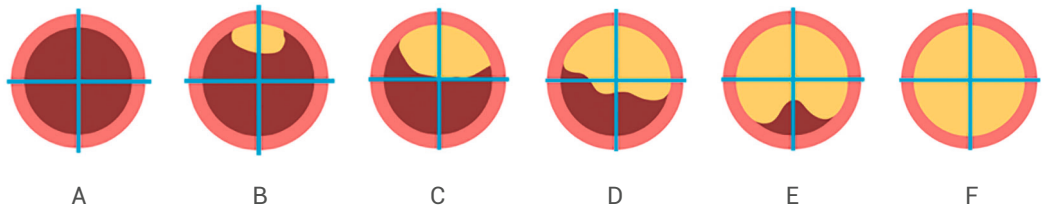
GRADING THE SEVERITY OF STENOSIS

Coronary stenosis severity should be graded in the following manner:



A) 0% no disease

B) 1–24% minimal plaque

C) 25–49% mild plaque

D) 50–69% moderate plaque

E) 70–99% severe plaque

F) 100% occluded

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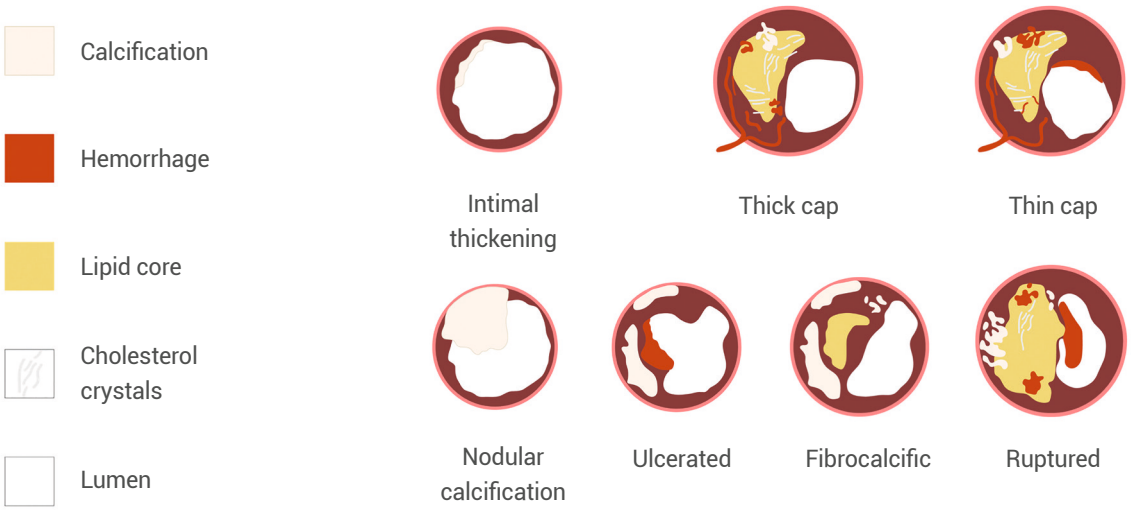
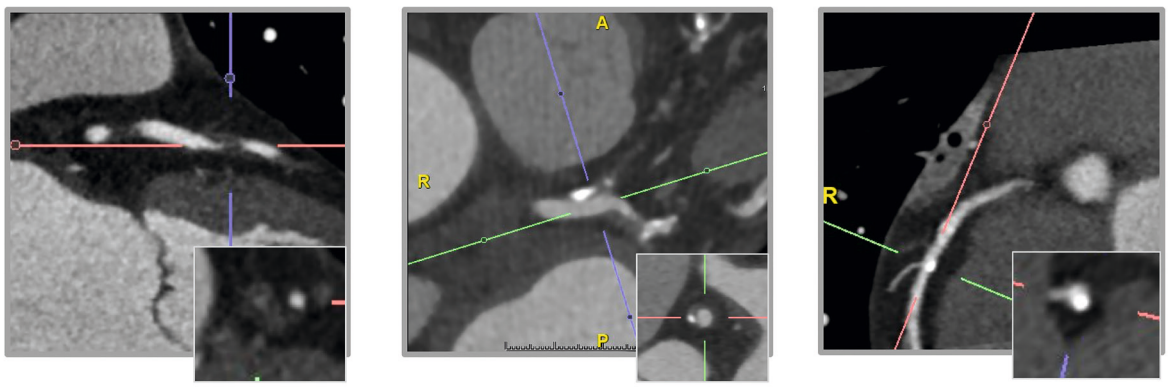
EVALUATING CORONARY PLAQUE MORPHOLOGY

Coronary plaque morphology can be complicated. In coronary CT, it is only necessary to report three types of plaque morphologies.





Non-calcified | Partially calcified | Calcified

Non-calcified plaque

Vessel lumen narrowing secondary to plaque with no calcium.

Partially calcified plaque

Contains both calcified and non-calcified plaque.

Calcified plaque

Plaque is predominantly calcified

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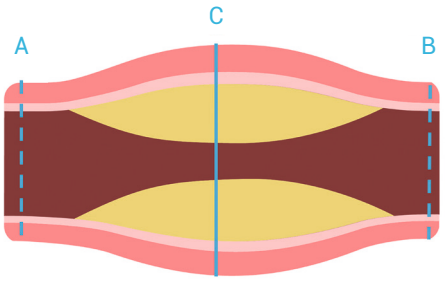
IDENTIFYING HIGH-RISK PLAQUES

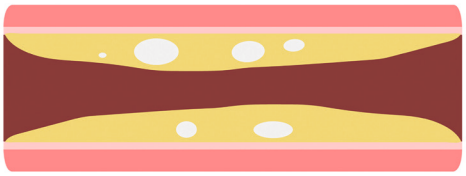
It is important to describe high-risk plaque features, as well as evaluating plaque stenosis severity, and plaque morphology. The four high-risk plaque features reported in the literature are as follows:

Positive remodeling



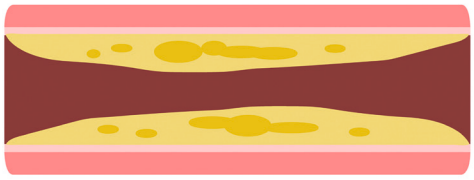
> 10% = positive remodeling

Spotty calcification



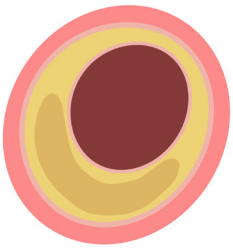
< 3 mm length and < 180 degrees circumference

Low attenuation plaque



< 30 HU = low attenuation plaque

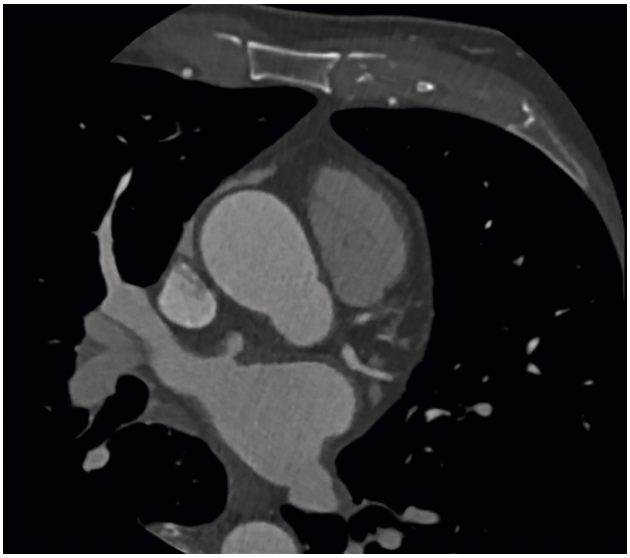
The napkin ring sign



Assessing coronary artery plaques

USING AXIAL IMAGING

Axial imaging uses only the axial cross-sectional data for image interpretation. This technique can be very fast, for looking at coronary artery disease, but requires significant experience. To use axial imaging effectively increase the slice width thickness to 3–4 mm and scroll through the dataset. Use this as your scout to identify problem areas quickly. For a precise review, evaluate the coronary arteries on the thinnest slices available from the scan.



As you do this, remember the four C's:

Focus on the Coronaries.
Look at change in vessel Calibre.
Look for a drop in Contrast in successive slices.
Confirm with multiplanar reformatted images.

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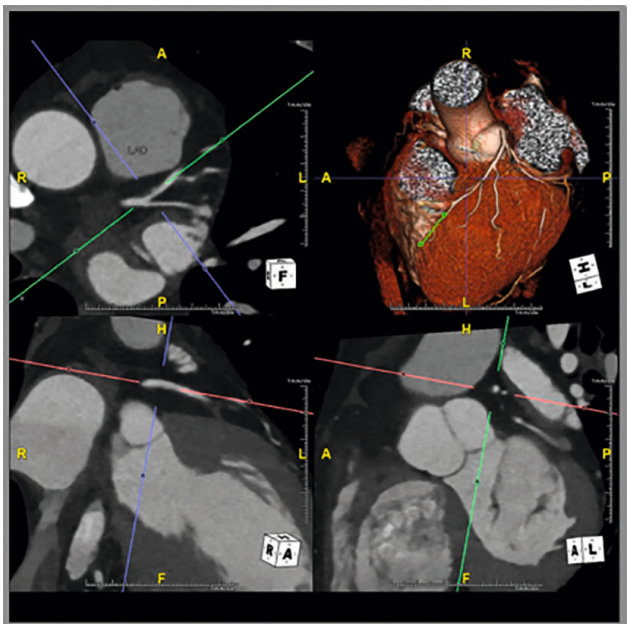
MASTERING MULTIPLANAR RECONSTRUCTION IMAGING



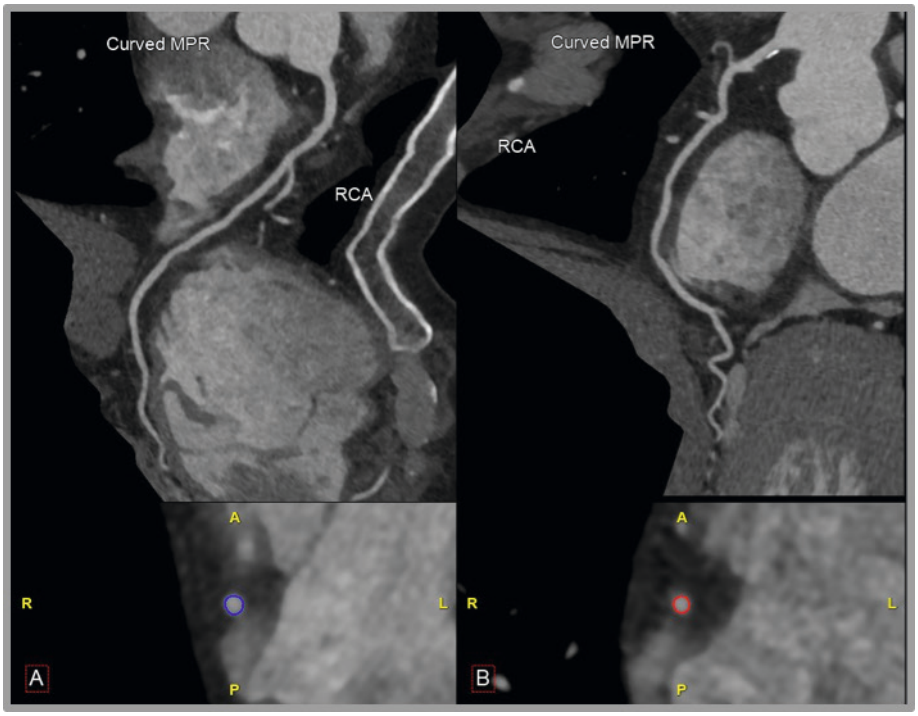
Remember that multiplanar reformatted / reconstructed images permit you to look at any CT dataset in three planes: axial, sagittal, and coronal. Double oblique imaging simply refers to manipulating the data from these planes using linked crosshairs. When the crosshairs are moved to a point in one imaging plane they are moved to the same point in the remaining two planes; similarly, when the crosshairs are rotated in one imaging plane the images will change appropriately in the other planes.

To evaluate plaques using double oblique imaging requires two steps. First, the crosshairs are placed at the point of interest in the top left plane and rotated down the axis of the coronary artery in the bottom left-hand image. Second, the crosshairs would be placed and rotated down the axis of the coronary artery in the second imaging plane (bottom left-hand image). The net result is that three images show the coronary artery in three orthogonal planes, enabling the visualization of the vessel along its length in two opposite views and also in cross section (bottom right-hand view).

This technique is very reliable for ensuring that disease is not missed and that plaques are evaluated correctly. However, it does require time to move the crosshairs down the entirety of the vessel and rotate the crosshairs each time in two planes.

Assessing coronary artery plaques

EVALUATING PLAQUES WITH CURVED MULTIPLANAR RECONSTRUCTION



Curved multiplanar reconstruction refers to a technique for evaluating vessels. It is a form of workstation post-processing which identifies the centre line of a vessel and then stitches all of the axial slices together. This enables visualization of the entire length of a vessel in one view. All curved multiplanar reformatted views can be rotated around their axis so the vessel can be looked at from every angle. When used, the axial data should always be reviewed first. Provided that the original dataset is of good quality, curved multiplanar reconstruction (MPR) imaging may be considered to be an optional technique for the evaluation of plaques. Since the extraction of the vessels is almost instantaneous, many cardiac radiologists are in favor of this technique, due to it's speed. Keep in mind, it does represent a post-processing technique using the raw axial CT data and hence is susceptible to artifact.

READING LIST

Chang, SM, Nabi, F, Xu, J, et al. 2015. Value of CACS compared with ETT and myocardial perfusion imaging for predicting long-term cardiac outcome in asymptomatic and symptomatic patients at low risk for coronary disease: clinical implications in a multimodality imaging world. *JACC Cadiovasc Imaging.* **8**: 134–144.

Hartaigh BO, Valenti, V, Cho, I, et al. 2016. 15-Year prognostic utility of coronary artery calcium scoring for all-cause mortality in the elderly. *Atherosclerosis.* **246**: 361–366.

Hecht, HS. 2015. Coronary Artery Calcium Scanning: past, present, and future. *JACC Cadiovasc Imaging.* **8**: 579–596.

Hecht, HS, Achenbach, S, Kondo, T, et al. 2015. High-Risk Plaque Features on Coronary CT Angiography. *JACC Cadiovasc Imaging.* **8**: 1336–1339.

Knapper, JT, Khosa, F, Blaha, ML, et al. 2016. Coronary calcium scoring for long-term mortality prediction in patients with and without a family history of coronary disease. *Heart.* **102**: 204–208.

Maurovich-Horvat, P, Ferencik, M, Voros, S, et al. 2014. Comprehensive plaque assessment by coronary CT angiography. *Nat Rev Cardiol.* **11**: 390–402.

Nasir, K, Bittencourt, MS, Blaha, MJ, et al. 2015. Implications of Coronary Artery Calcium Testing Among Statin Candidates According to American College of Cardiology/American Heart Association Cholesterol Management Guidelines: MESA (Multi-Ethnic Study of Atherosclerosis). *J Am Coll Cardiol.* **66**: 1657–1668.

Nasir, K, Shaw, LJ, Budoff, MJ, et al. 2012. Coronary artery calcium scanning should be used for primary prevention: pros and cons. *JACC Cadiovasc Imaging.* **5**: 111–118.

Paixao, AR, Ayers, CR, Sabbagh, A, et al. 2015. Coronary Artery Calcium Improves Risk Classification in Younger Populations. *JACC Cadiovasc Imaging.* **8**: 1285–1293.

Valenti, V, Hartaigh BO, Heo, R, et al. 2015. A 15-Year Warranty Period for Asymptomatic Individuals Without Coronary Artery Calcium: A Prospective Follow-Up of 9,715 Individuals. *JACC Cadiovasc Imaging.* **8**: 900–909.

Voros, S, Rinehardt, S, Qian, Z, et al. 2011. Coronary atherosclerosis imaging by coronary CT angiography: current status, correlation with intravascular interrogation and meta-analysis. *JACC Cadiovasc Imaging.* **4**: 537–548.