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Low-Dose Coronary CTA

The robust solution for all patients

ONE
Aquilion
dynamic volume CT

Case Study Brochure
CT Centre, Mount Elizabeth Hospital



TOSHIBA MEDICAL SYSTEMS CORPORATION

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Introduction

Our radiology practice includes a busy outpatient facility situated in Mount Elizabeth Hospital. In a typical day, we perform up to 50 CT examinations, of which approximately 30% involve patients referred for low-dose coronary CTA. So, every day, five days a week, our practice scans and reports about 15 cardiac studies. All of these studies have been performed using the Aquilion ONE™ CT system since its installation in March 2008.

The most outstanding feature of the Aquilion ONE system is the incredible robustness with which high-quality diagnostic studies can be obtained in the examination of the coronary arteries. This includes patients with arrhythmias, patients who are uncooperative, and even patients with atrial fibrillation. The reasons for this flexibility lie in the unique ability of this system to acquire the entire heart in a single rotation.

Patient care is given the highest priority in our practice, starting at the reception desk and ending with the examination report and images. Both the contrast medium dose and X-ray exposure dose must be kept to a minimum while ensuring that the examination is completed with a high level of quality to permit accurate diagnosis. In the overall patient care setting, we feel that it is important for any additional examinations to be avoided whenever possible. Due to the robustness of this CT system, we rarely encounter failed cardiac cases with nondiagnostic results or cases in which scanning must be repeated.

Excellent image quality with low noise is very important to us because our clients and patients judge us by the quality of our cardiac studies. At the same time, the low exposure dose of our examinations is also very important. So, while we routinely perform low-dose examinations, we do not always push the exposure dose to the lowest possible limits in all patients. For example, we have found that we obtain superior images in patients with coronary artery stents and severe calcification when we use 120 kVp instead of 100 kVp, even though this results in a slightly higher exposure dose. We of course always try to employ ultra-low-dose techniques (sub-millisievert imaging) for very young patients, especially females.

The average exposure dose for the majority of our patients is 2-3 mSv, which we feel presents a low level of risk associated with X-ray exposure while allowing us to obtain diagnostic images in virtually every case. We usually select a prospective scanning window of 70%-80% of the cardiac cycle because, based on our experience with more than 3500 cardiac patients examined using this scanner, it is not uncommon for the heart rate to change suddenly during scanning, and we need the extra data from the 70%-80% exposure to ensure that diagnostic images can be reconstructed.

Another advantage of this scanner is the reliability of the arrhythmia rejection software. It is also not uncommon for ectopic beats and unstable heart rates to occur during scanning, and the robustness and reliability of this software has helped us “rescue” what would otherwise be nondiagnostic scans and avoid the need to perform repeat scanning.

This case study brochure presents some of the routine cases examined at our imaging center on a daily basis.



Dr. Robert Kwok, Medical Director



Dr. John Hoe, Clinical Director

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WARNING: Any reference to x-ray exposure, intravenous contrast dosage, and other medication is intended as a reference guideline only. The guidelines in this document do not substitute for the judgment of a healthcare provider. Each scan requires medical judgment by the healthcare provider about exposing the patient to ionizing radiation. Use the As Low As Reasonably Achievable radiation dose principle to balance factors such as the patient's condition, size and age; region to be imaged; and diagnostic task.

Prospective Volumetric Cardiac CTA

The Aquilion ONE CT system has a detector array that can cover a range of up to 16 cm in a single gantry rotation, allowing the entire heart to be captured in a true volumetric scanning mode without the need for helical scanning. This unique acquisition mode provides the most robust solution for imaging the heart in all patients, providing superior image quality at a low exposure dose.

Prospective CTA scan mode is designed to expose a short period of the R-R interval (generally diastole) and can be used in all patients in whom functional analysis is not required.

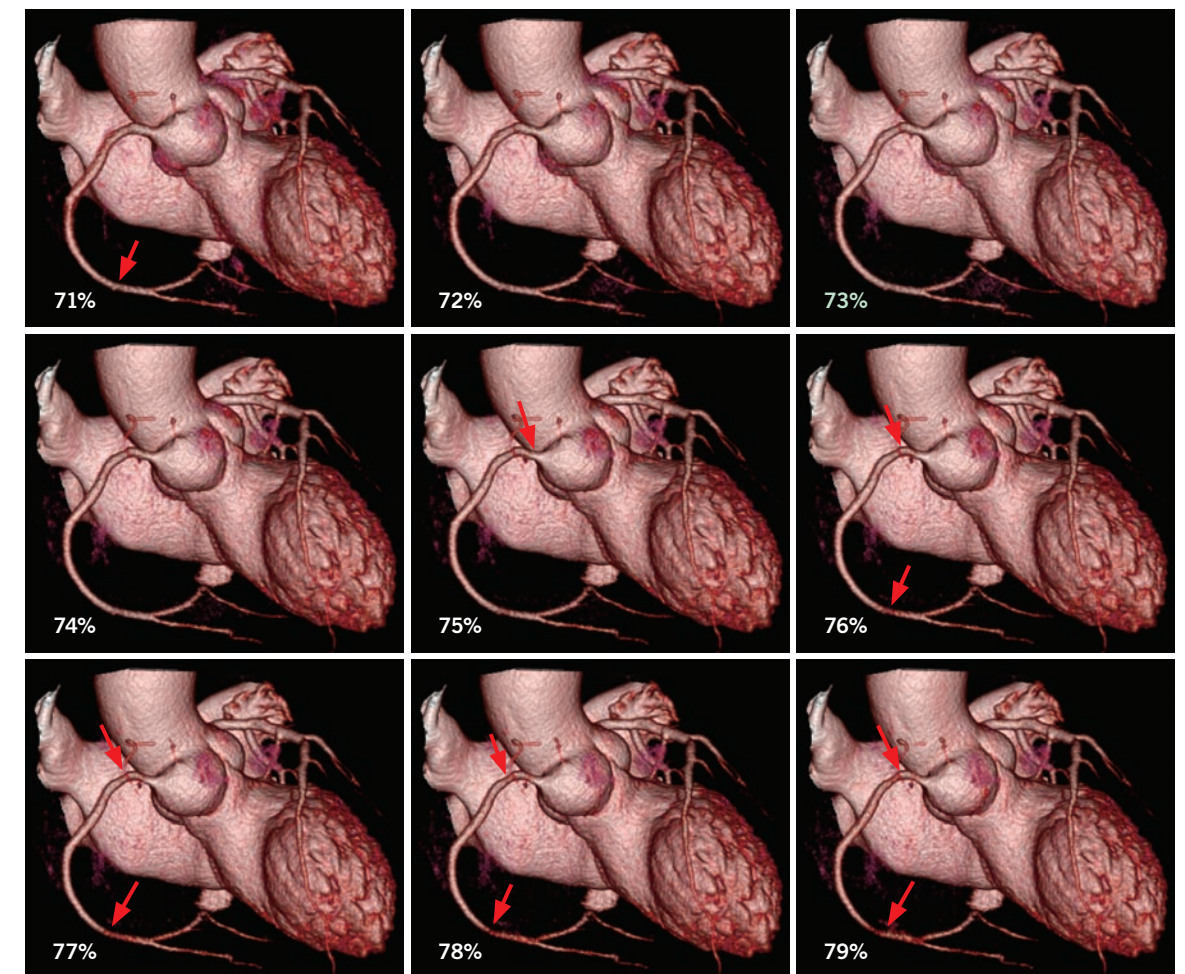
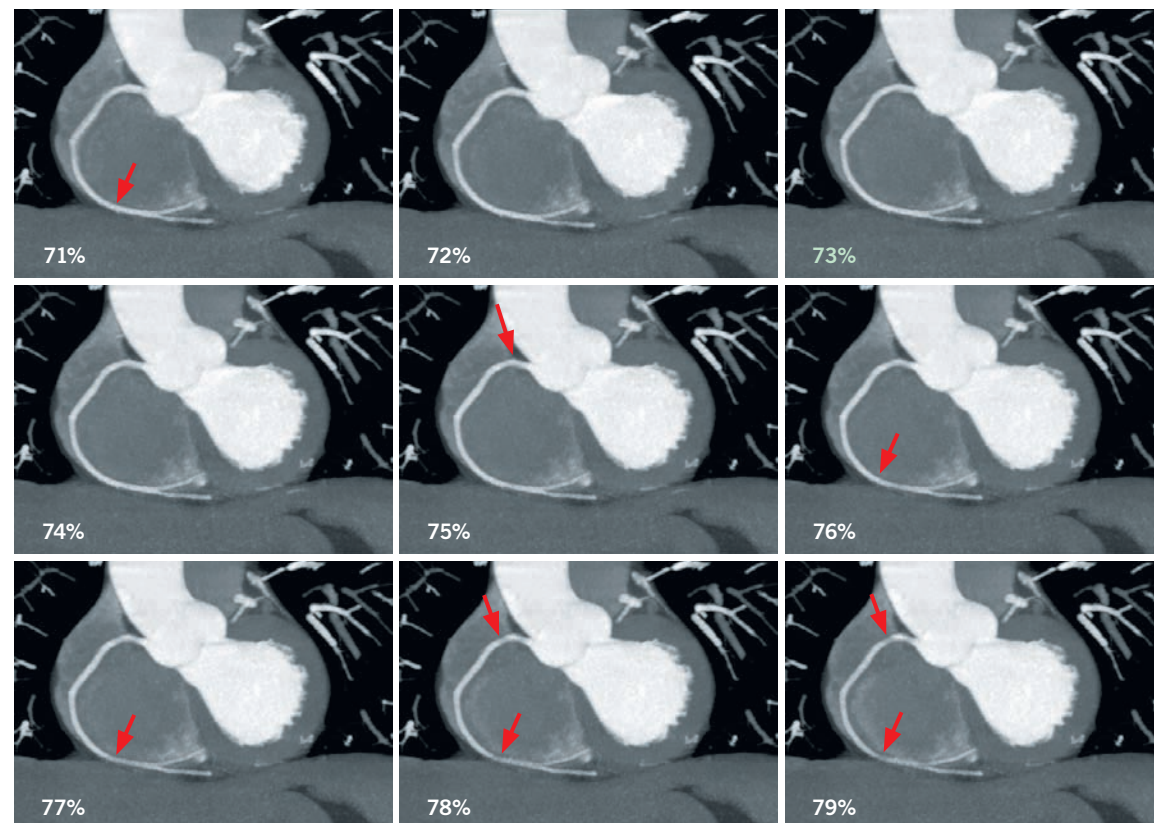
The desired exposure phase is specified as a percentage of the R-R interval, so the actual exposure time varies depending on the patient's heart rate.



Generally, an exposure phase of 70%-80% of the cardiac cycle is selected in this scan mode, permitting the retrospective reconstruction of the best motion-free images and ensuring a high-quality diagnostic study.

Clinical Example:

The following coronary CTA examination was performed with an exposure window of 70%-80% of the cardiac cycle. The patient's heart rate during the exposed beat was 56 bpm. Therefore, the reconstructed images in the range from 71%-79% correspond to a period of only 107 ms in late diastole.



In the above clinical example, a small amount of motion can be seen in the right coronary artery (RCA) during this small window in late diastole. In particular, the caliber of the artery undergoes small changes (red arrows) due to normal physiological motion.

The best motion-free phase demonstrating the RCA is at 73% of the cardiac cycle. Toshiba's phaseXact software is able to calculate and reconstruct the best phase automatically.

If a narrower exposure window were set to cover only a single phase, there would be a real risk that the best motion-free phase might not be available for reconstruction, possibly leading to misdiagnosis.

This small but important physiological movement can be observed in the majority of patients who undergo coronary CTA.

Sub-millisievert Coronary CTA

Patient History

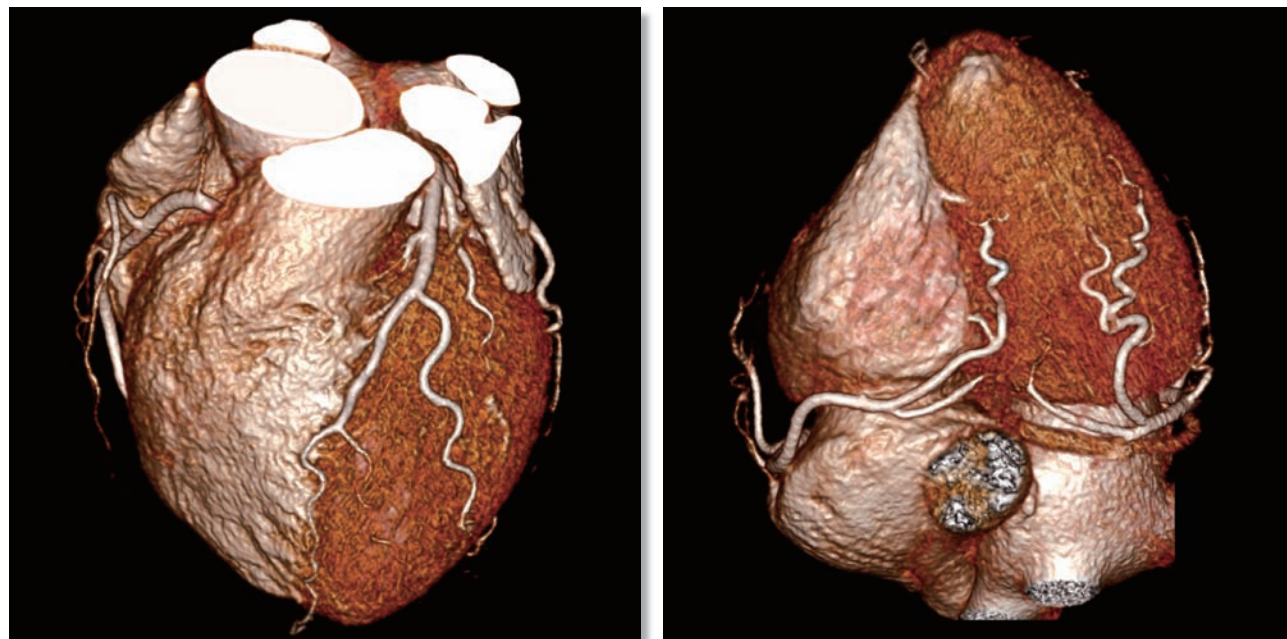
A 54-year-old woman with a BMI of 19 presented with chest pain atypical for angina. Her clinical history included hypercholesterolemia and a family history of coronary artery disease. A CT scan of the coronary arteries was ordered.

Scan Protocol

Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	120 mm
Tube Voltage	80 kV
Tube Current	550 mA
Rotation Time	350 ms
DLPe	57 mGy·cm
Effective Dose	0.8 mSv (k = 0.014)

A single-beat prospective ECG-gated scan at 70%-80% of the cardiac cycle was performed during the administration of iodinated contrast medium.

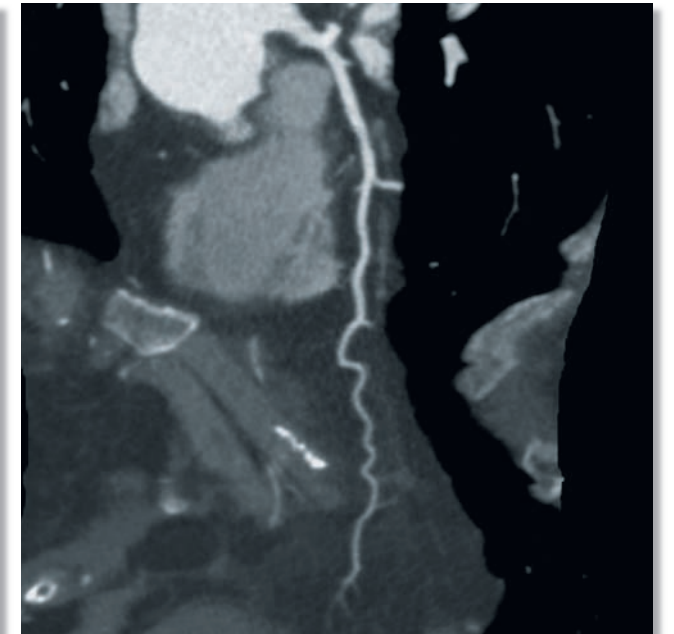
Findings



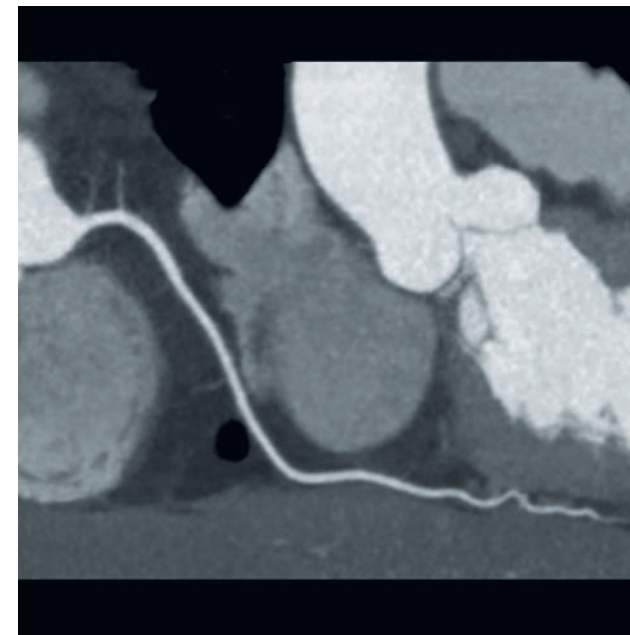
3D VR



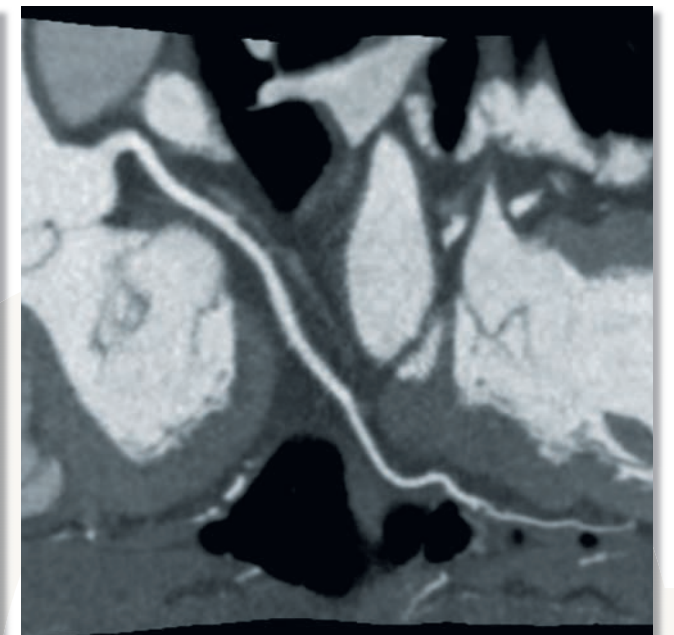
LAD



RCA



Cx



Conclusion

This very-low-dose coronary CTA examination performed with 40 mL of intravenous contrast medium demonstrates completely healthy coronary arteries.

Pulmonary Vein Stenosis

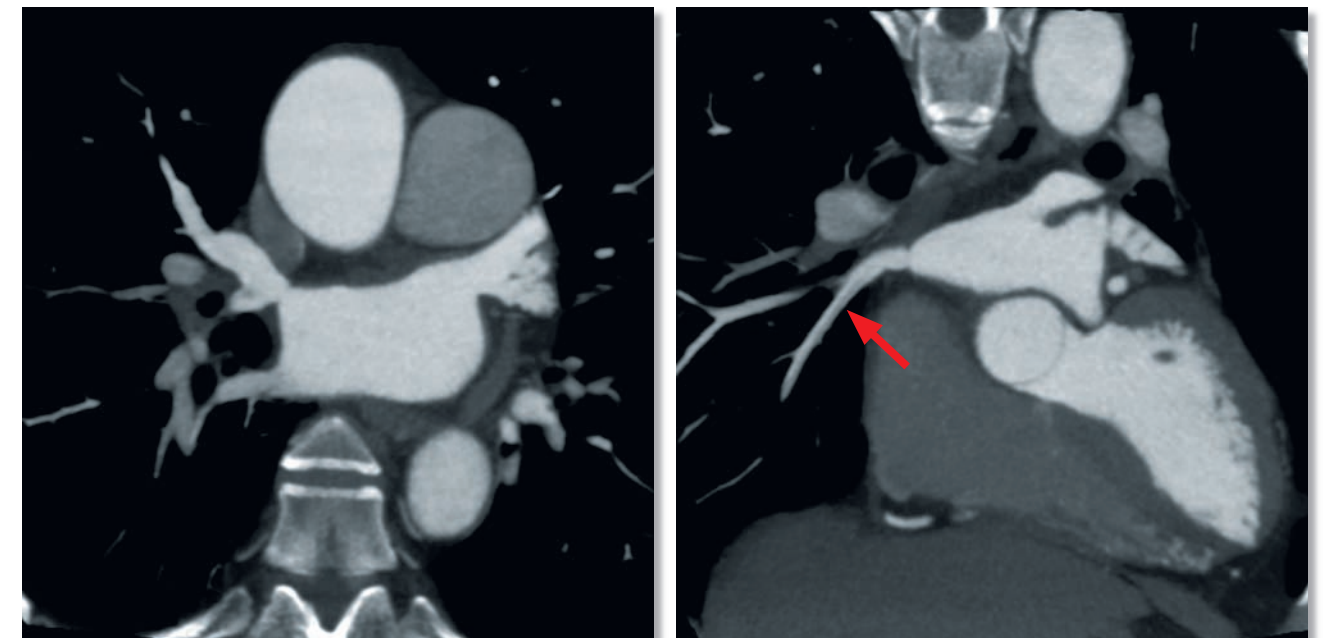
Patient History

A 56-year-old man with a BMI of 26 and a history of prior pulmonary vein ablation therapy was referred for CT. Previous imaging demonstrated a pulmonary vein stenosis. A follow-up CT scan of the pulmonary veins was ordered.

Scan Protocol

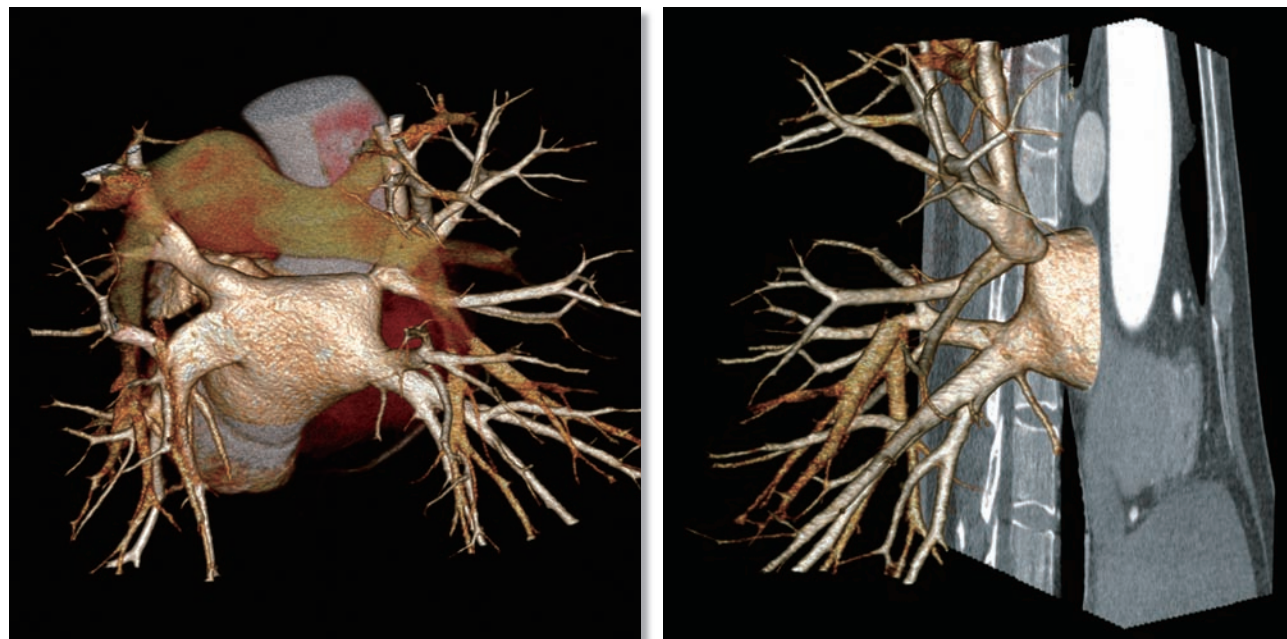
Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	160 mm
Tube Voltage	120 kV
Tube Current	300 mA
Rotation Time	350 ms
DLPe	178.7 mGy·cm
Effective Dose	2.5 mSv (k = 0.014)

A single-beat prospective ECG-gated scan at 70%-80% of the cardiac cycle was performed during the administration of iodinated contrast medium.



The neck of the stenosis shows a web-like appearance. In addition, a long linear pulmonary thrombosis is demonstrated in the pulmonary vein (arrow).

Findings



3D volume-rendered images of the pulmonary veins clearly demonstrate a stenosis at the ostium of the right superior pulmonary vein.

Conclusion

The right superior pulmonary vein shows a web-like appearance at the ostium. The ostium measures 7.9 x 6.6 mm in diameter, showing some residual stenosis but also some improvement as compared to the previous CT scan (not shown here), which was performed prior to intervention and balloon dilatation of the pulmonary vein.

Pulmonary thrombosis is a relatively rare but potentially dangerous complication following radiofrequency ablation therapy.

Multiple Coronary Stenoses

Patient History

A 59-year-old man with a BMI of 24, a family history of CAD, and hypercholesterolemia presented with an abnormal exercise stress test. A CT scan of the coronary arteries was ordered.

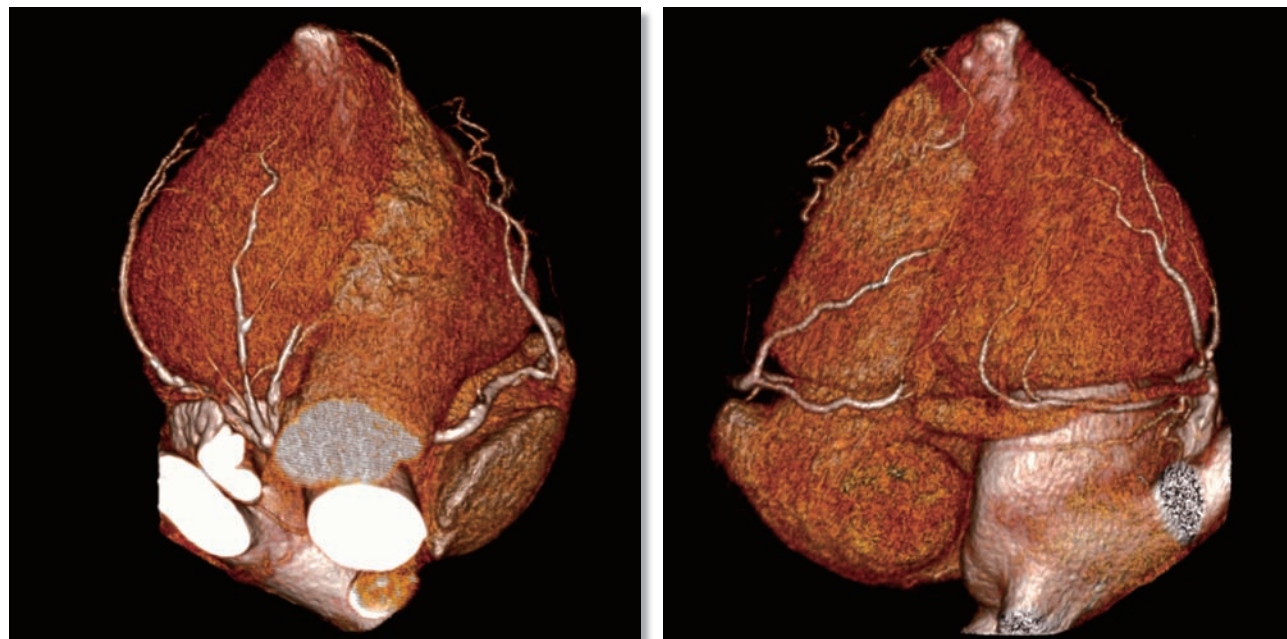
Catheter angiography was performed subsequently.

Scan Protocol

Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	100 kV
Tube Current	580 mA
Rotation Time	350 ms
DLPe	154.34 mGy·cm
Effective Dose	2.16 mSv (k = 0.014)

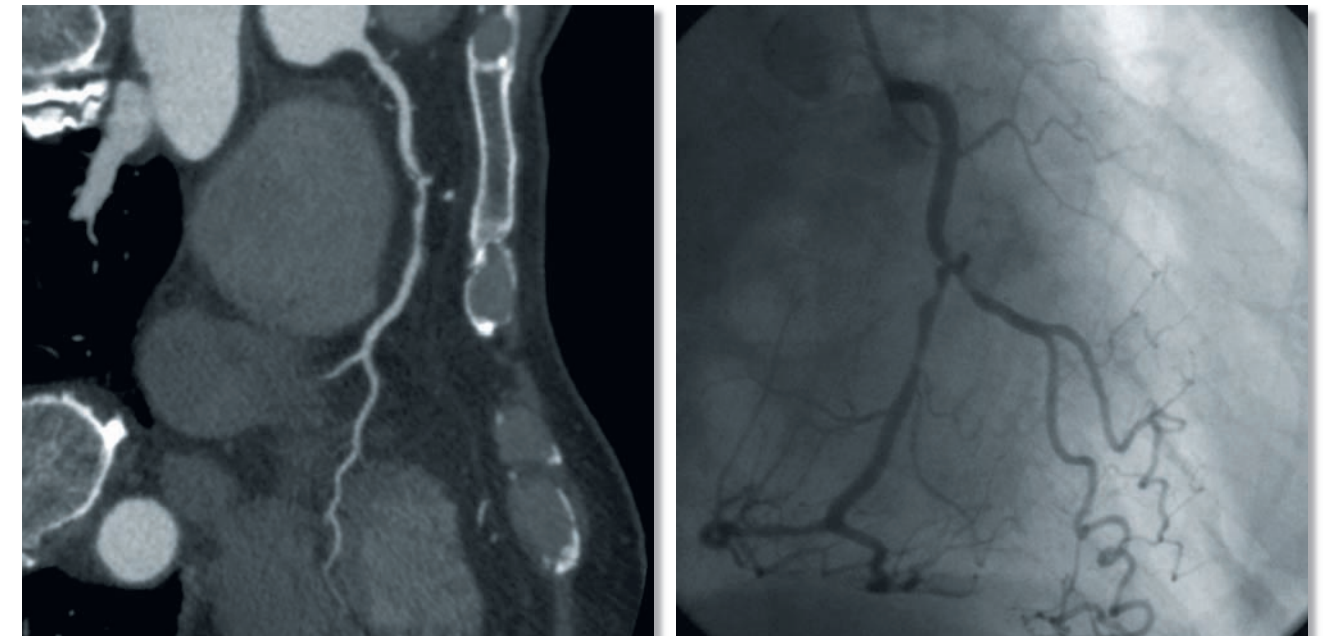
A single-beat prospective ECG-gated scan at 70%-80% of the cardiac cycle was performed during the administration of iodinated contrast medium.

Findings



These 3D volume-rendered images show excellent depiction of the coronary tree.

Right coronary artery (RCA)



Two stenoses are seen in the mid RCA. The CTA examination clearly demonstrates the associated noncalcified plaque formation.

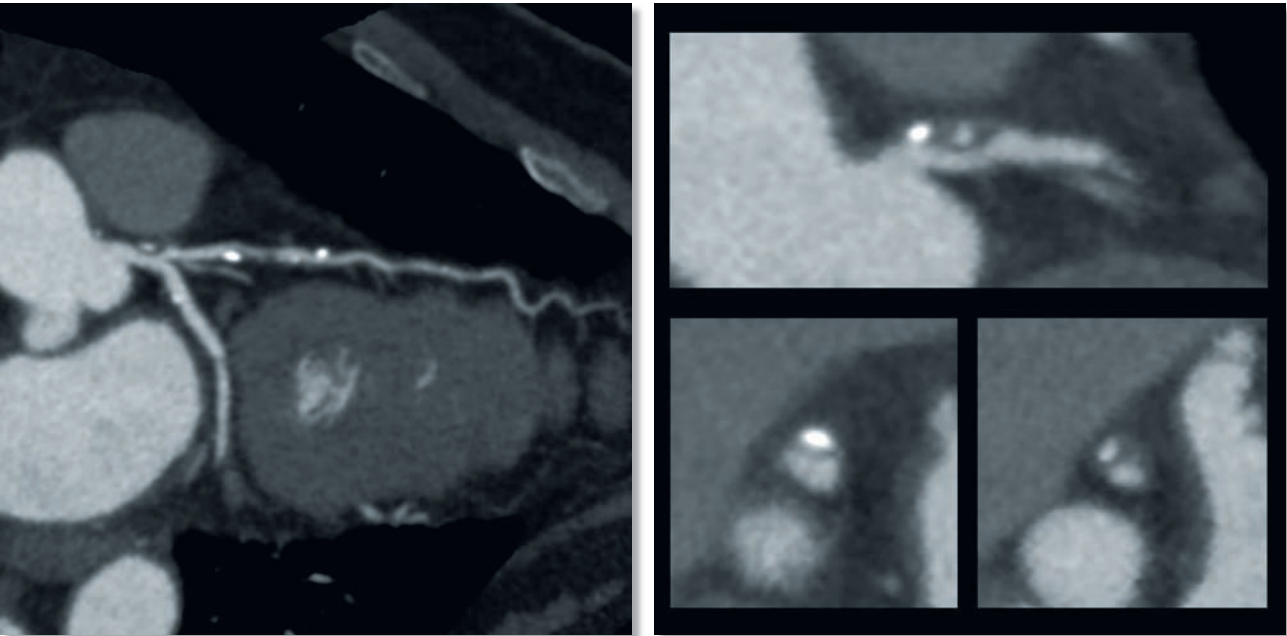
Left anterior descending artery (LAD)



The LAD is small, with severe calcification demonstrated at the origin of the vessel. However, no focal stenosis is demonstrated, as confirmed by catheter angiography.

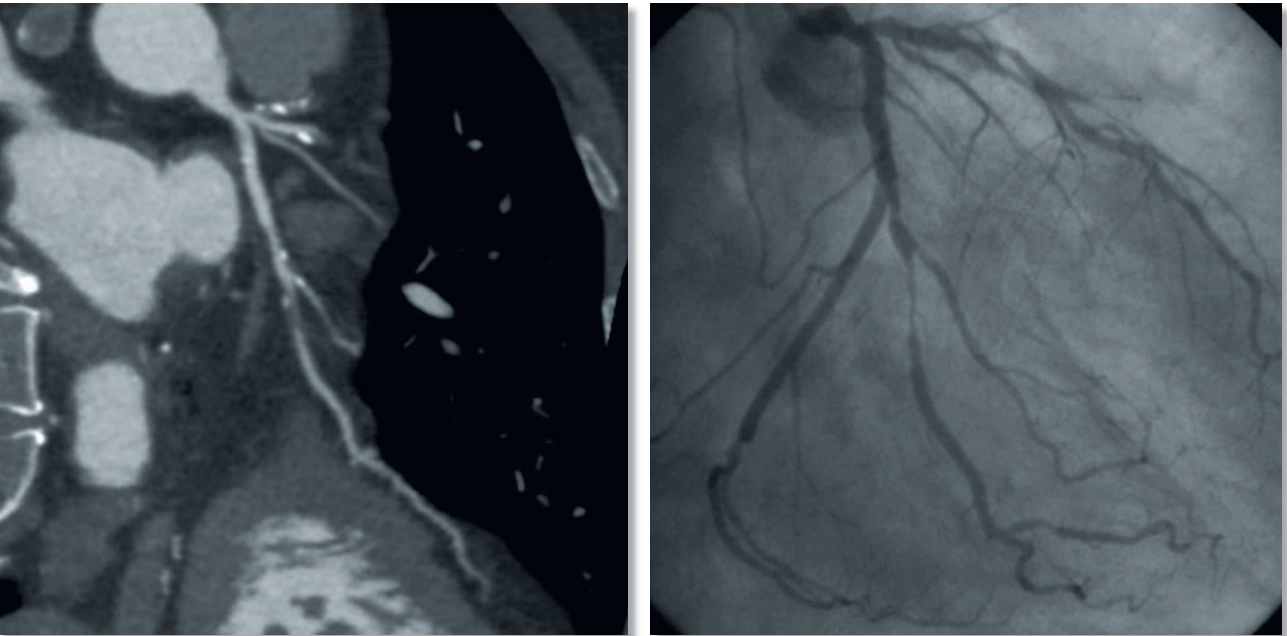
Multiple Coronary Stenoses (continued)

Left main coronary artery (LM) and ramus intermedius (RI)



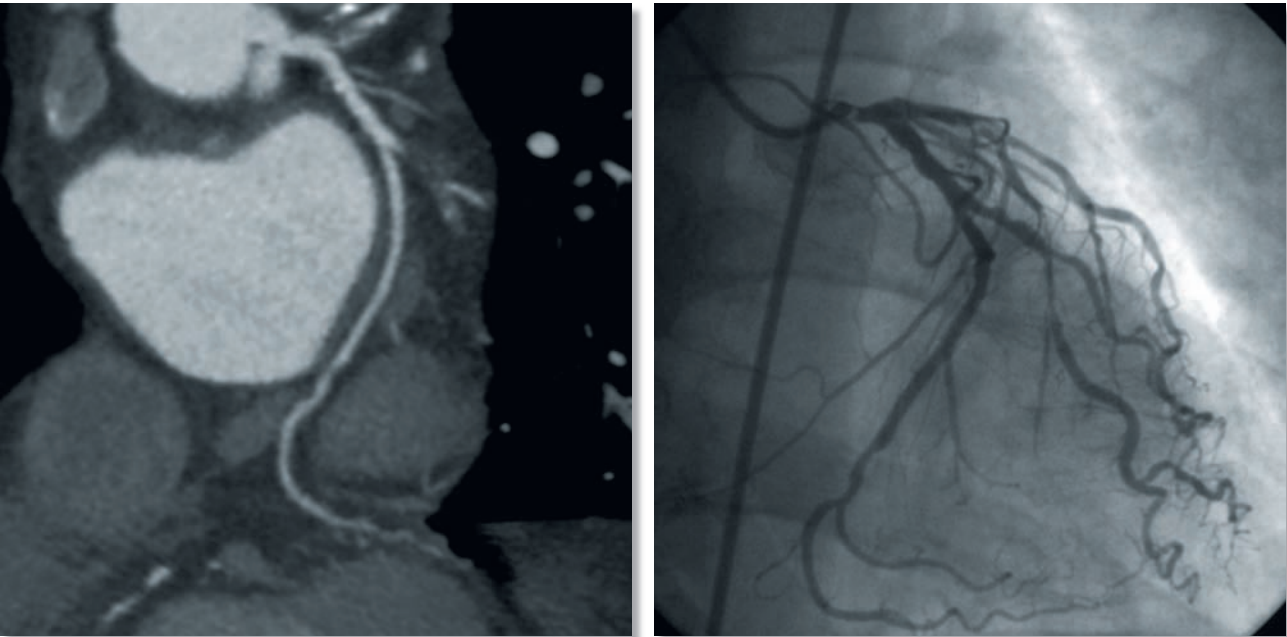
In the distal left main coronary artery, a large ulcerated plaque causing a hemodynamically significant stenosis in excess of 60% is observed in the coronary CTA examination. This lesion is not well demonstrated in the catheter angiogram. The RI shows a short segment of stenosis proximally.

Left obtuse marginal artery (OM)



Near total occlusion of the midportion of the OM branch is demonstrated, showing excellent correlation with the findings of subsequent catheter angiography.

Left circumflex artery (Cx)



Two separate focal stenoses are demonstrated in the distal circumflex artery. Both of these lesions are causing a moderate stenosis of approximately 50%.

Conclusion

This low-dose CTA examination accurately demonstrated multivessel disease, showing good correlation with conventional catheter angiography. In addition, the significant ulcerated plaque in the left main coronary artery was better demonstrated by CT.

The patient was scheduled to undergo coronary artery bypass surgery.

Coronary Stents

Patient History

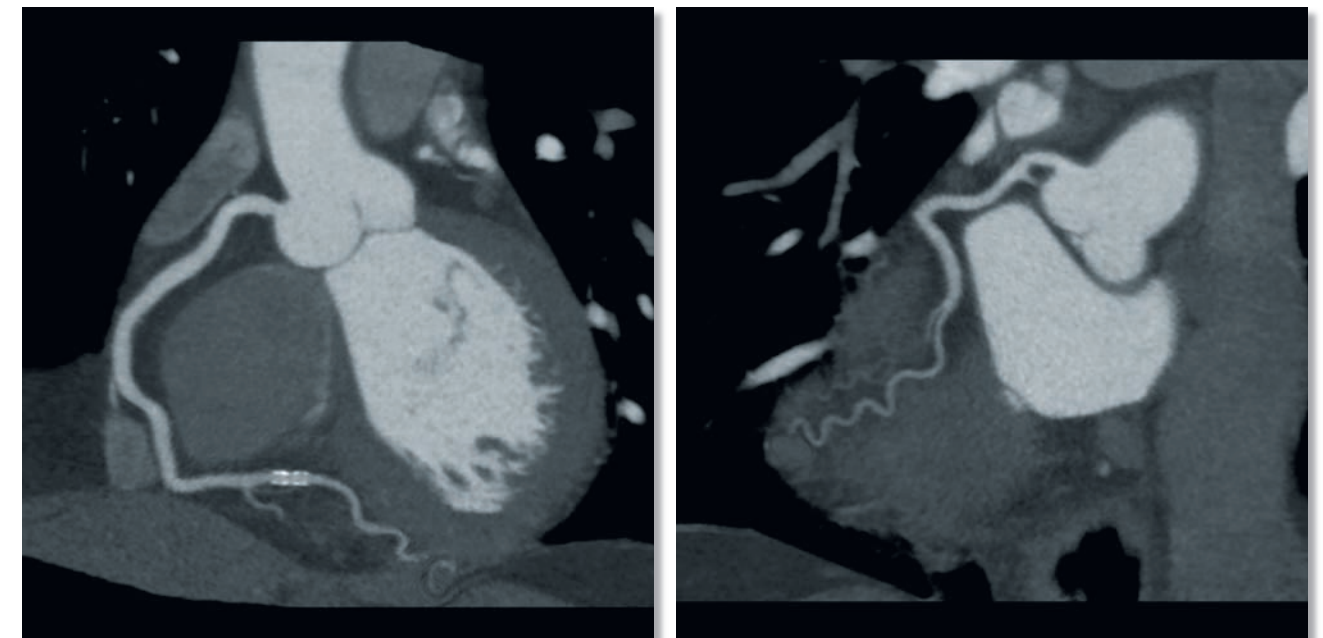
A 49-year-old man presented with chest pain atypical for angina. The patient had undergone placement of two Cypher stents in the LAD and distal RCA 2 years previously.

A CT scan of the coronary arteries was ordered.

Scan Protocol

Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	120 kV
Tube Current	450 mA
Rotation Time	350 ms
DLPe	232.84 mGy-cm
Effective Dose	3.3 mSv (k = 0.014)

A prospective ECG-gated scan was performed at 70%-80% of the cardiac cycle.



The stent in the distal RCA is clearly demonstrated and seen to be patent. The left circumflex artery is normal.

Findings



A 3D volume-rendered image of the heart and a curved reformatted image show a stent in the proximal LAD. The stent is clearly demonstrated and shows no evidence of in-stent restenosis.

Conclusion

The two Cypher stents are well demonstrated in this low-dose volume acquisition. The LAD stent measures 3.0 mm and the smaller stent in the distal RCA measures 2.5 mm. Both stents are clearly patent, with no evidence of in-stent restenosis or neointimal hyperplasia. Note the excellent image resolution of the 2.5 mm stent, even though most reports suggest that stents less than 3 mm in size cannot be clearly depicted by CT.

Volumetric scanning with 0.5 mm detector collimation provides unsurpassed CT images of coronary artery stents. The temporal uniformity of one-rotation volumetric imaging eliminates motion artifacts and the outstanding spatial resolution reduces blooming artifacts, permitting clear depiction of the stent lumen. Volumetric 320-detector row scanning offers significant advantages in evaluating coronary artery stents as compared to multidetector CT.

Vulnerable LAD Plaque

Patient History

A 47-year-old man with a BMI of 27 presented with chest pain atypical for angina. The patient's calcium score was 79.

Scan Protocol

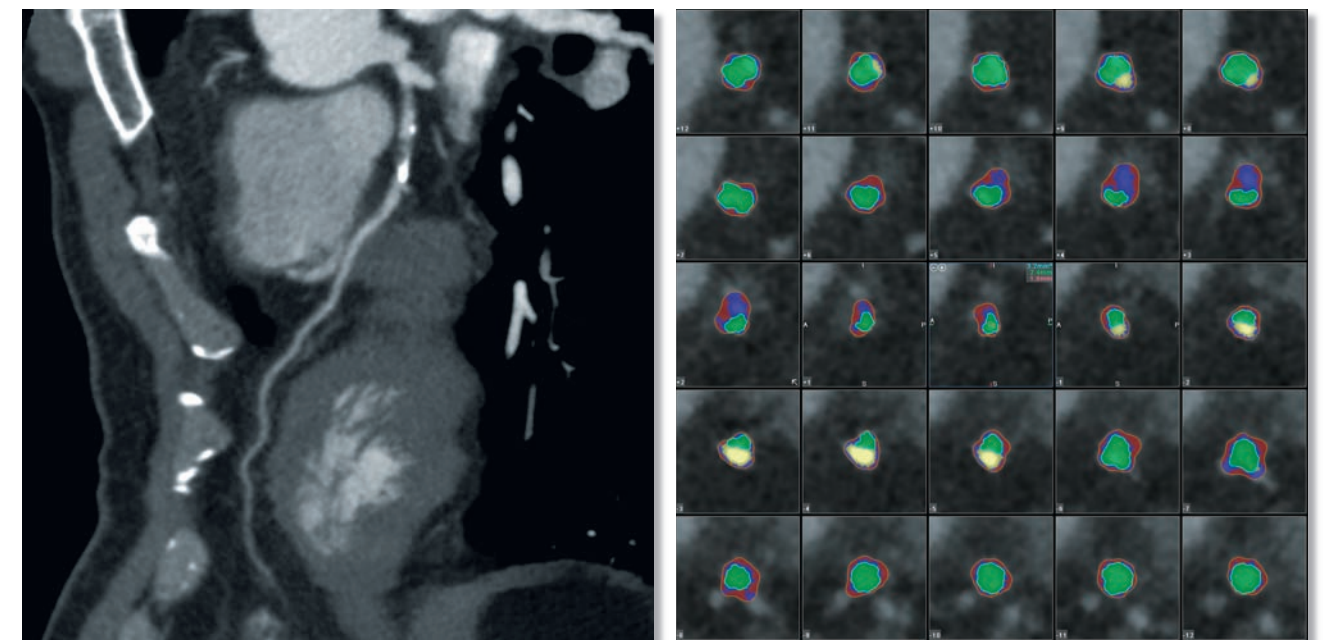
Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	120 kV
Tube Current	520 mA
Rotation Time	350 ms
DLPe	262.26 mGy·cm
Effective Dose	3.67 mSv (k = 0.014)

A single-beat prospective ECG-gated scan at 70%-80% of the cardiac cycle was performed during the administration of iodinated contrast medium.

Findings



A high-grade stenosis is demonstrated in the proximal LAD, as shown in the CPR image.



An eccentric noncalcified plaque is shown at the level of the stenosis. The plaque is of low density and the vessel shows positive remodeling as characterized by ^{SURE}Plaque™ software. A calcified plaque distal to this lesion is responsible for a moderate stenosis of approximately 50%.

Conclusion

A high-grade stenosis is present in the proximal LAD associated with an eccentric low-density plaque. Positive remodeling is clearly demonstrated in the cross-sectional images. The appearance is suggestive of a vulnerable plaque.

Stanford Type A Dissection

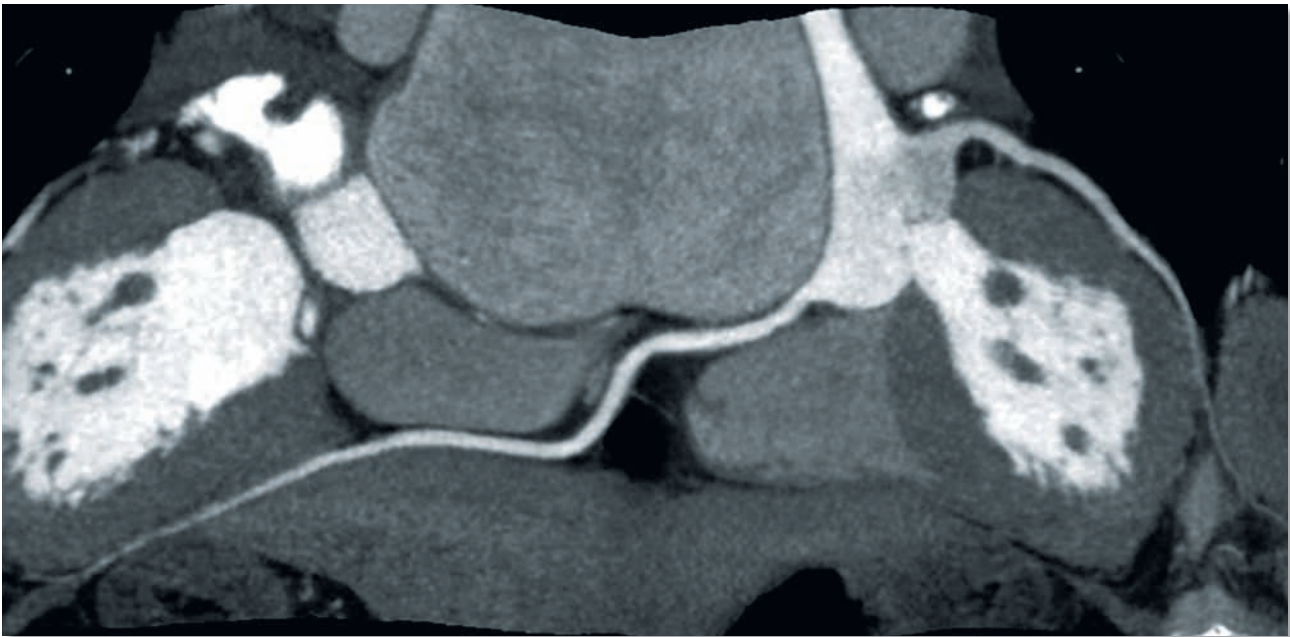
Patient History

A 60-year-old man with a BMI of 26 was referred for a CT coronary angiogram (as an alternative to conventional catheter angiography) to assess the coronary arteries in relation to a known aortic dissection.

Scan Protocol

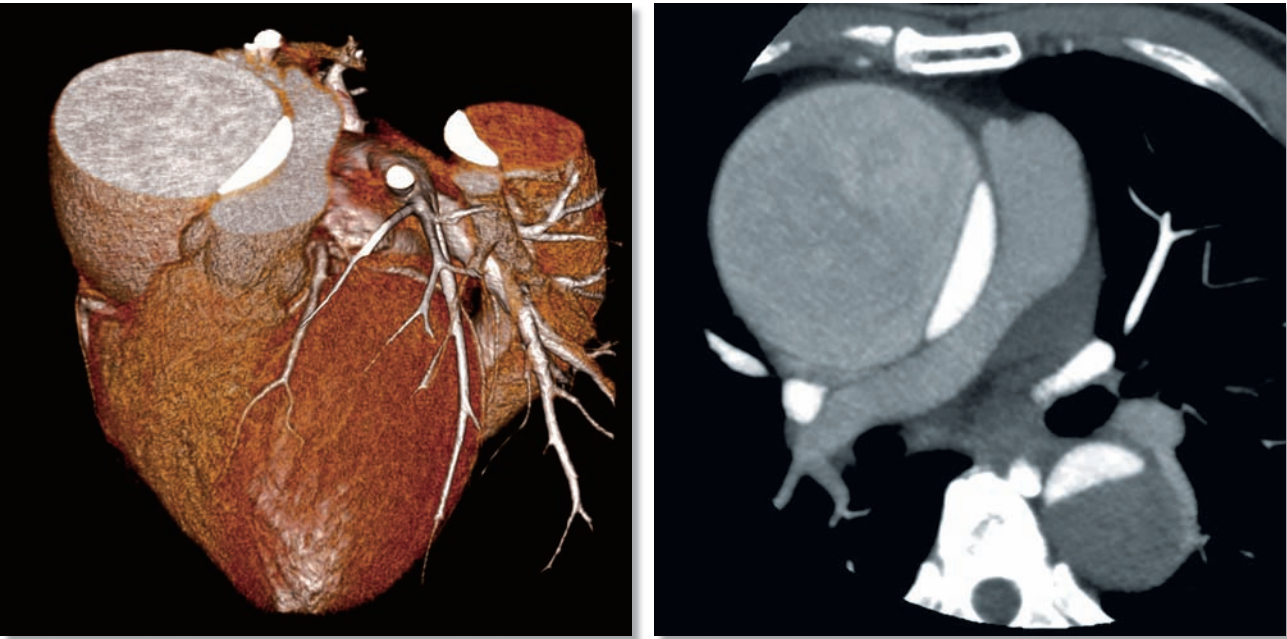
Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	160 mm
Tube Voltage	120 kV
Tube Current	480 mA
Rotation Time	350 ms
DLPe	284.62 mGy·cm
Effective Dose	3.98 mSv (k = 0.014)

A single-beat prospective ECG-gated scan at 70%-80% of the cardiac cycle was performed during the administration of iodinated contrast medium.



The curved MPR of the LAD and RCA shows both vessels arising from the small true lumen.

Findings



Dilatation of the ascending aorta with dissection of the aortic root is clearly demonstrated in the 3D and axial MIP images.

Conclusion

This study demonstrates a Stanford type A dissection involving the ascending aorta. The ascending aorta is grossly dilated, with a diameter of approximately 8.5 cm. The origins of the left main and right coronary arteries arise from the true aortic lumen.

CT permits fast and accurate assessment of the coronary arteries in patients with aortic dissection and is a good alternative to invasive catheter angiography.

LAD and Cx Stents

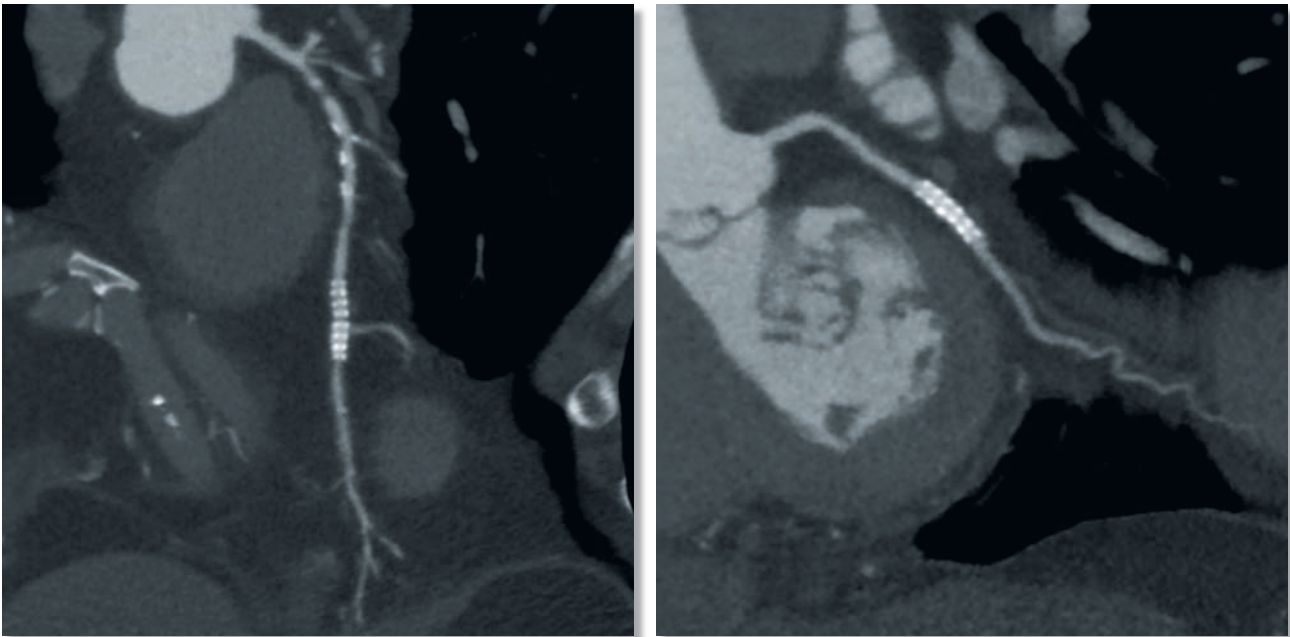
Patient History

A 72-year-old woman with a BMI of 25 and a history of coronary artery disease was referred for follow-up coronary CTA. The patient had previously undergone stent placement in the left anterior descending and circumflex arteries.

Scan Protocol

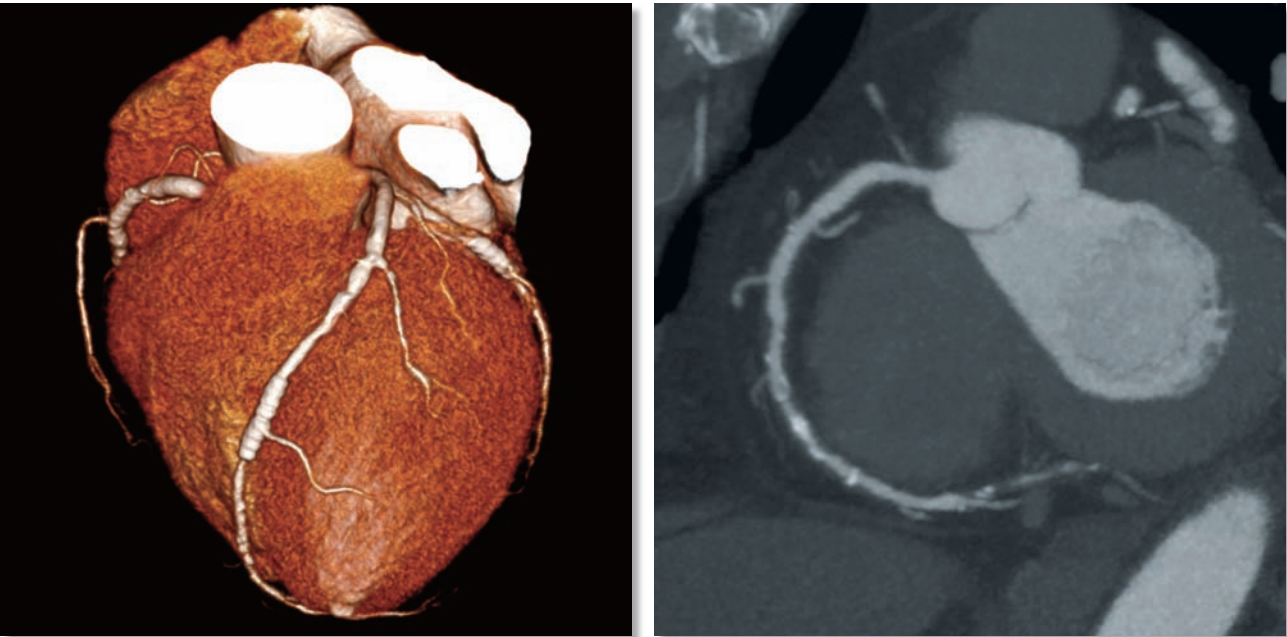
Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	140 mm
Tube Voltage	120 kV
Tube Current	480 mA
Rotation Time	350 ms
DLPe	246.86 mGy-cm
Effective Dose	3.56 mSv (k = 0.014)

A single-beat prospective ECG-gated scan at 70%-80% of the cardiac cycle was performed during the administration of iodinated contrast medium.



The stents in both the LAD and circumflex arteries are shown to be patent. There is no evidence of intimal hyperplasia or in-stent restenosis. There is moderate disease and narrowing of the proximal LAD, with evidence of calcified and noncalcified plaque.

Findings



Moderate disease is demonstrated in the right coronary artery, with focal segments of mild narrowing shown in the mid and distal RCA.

Conclusion

Extensive coronary artery disease is demonstrated in this patient. However, both stents are seen to be patent. The small exposure window acquired in late diastole permits the best motion-free phase to be reconstructed for diagnosis. To ensure optimal visualization of the stents, a 120 kV protocol was selected even though the patient's BMI was 25. This strategy can be employed to ensure fully diagnostic scans in virtually all stent patients.

Coronary CTA in Young Patients

Patient History

A 19-year-old man with a BMI of 21 presented with an abnormal exercise stress test and atypical chest pain. The patient reported a strong family history of coronary artery disease.

Due to the patient's young age, an 80 kV protocol was employed to ensure the lowest possible exposure dose.

Scan Protocol

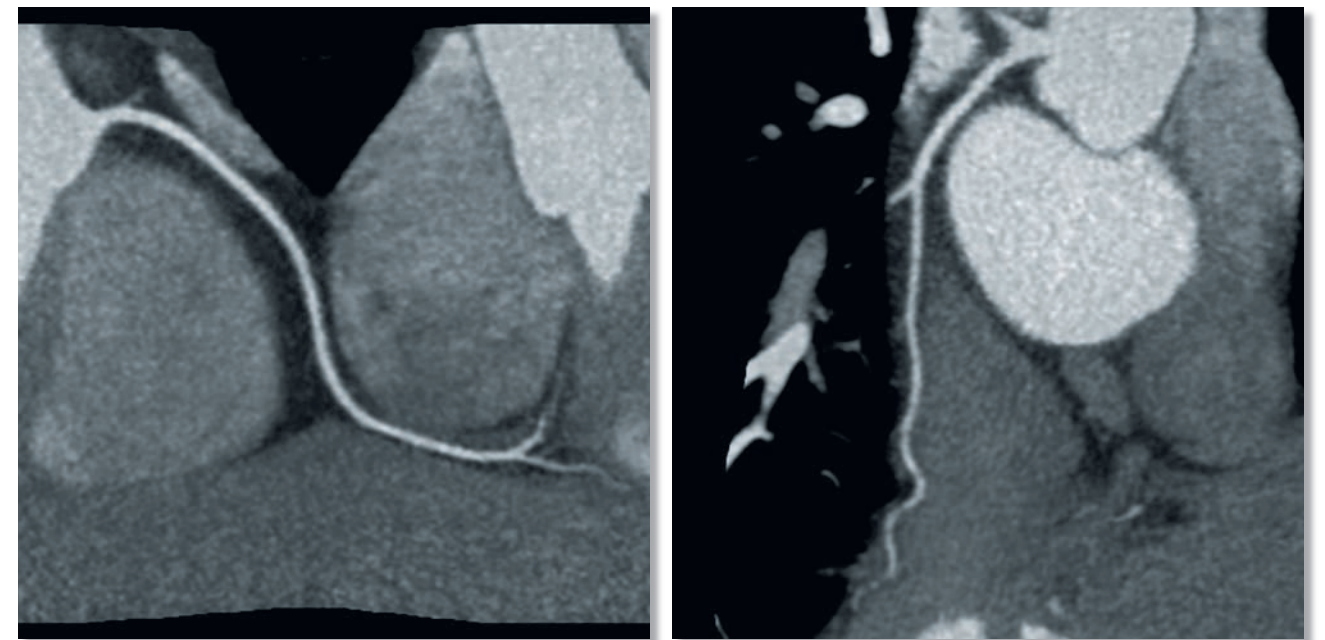
Scan Mode	Volume Scan
Scan Collimation	0.5 mm
Scan Range	128 mm
Tube Voltage	80 kV
Tube Current	550 mA
Rotation Time	350 ms
DLPe	62.43 mGy-cm
Effective Dose	0.87 mSv (k = 0.014)

A single-beat prospective ECG-gated scan at 70%-80% of the cardiac cycle was performed during the administration of iodinated contrast medium.

Findings



The 3D volume-rendered image and curved MPR of the LAD demonstrate normal coronary anatomy with no evidence of disease.



Curved MPRs of the RCA and Cx branches also demonstrate normal, disease-free vessels.

Conclusion

This sub-millisievert coronary CTA study was able to unequivocally rule out coronary artery disease and anomalous coronary artery variants in this young man with chest pain. The dose could have been further reduced by selecting a scan window of only 75%, but a window of 70%-80% was used to ensure a diagnostic scan in the event that the patient's heart rate changed suddenly during scanning, as not infrequently occurs in routine daily practice.

Reducing the tube voltage is also the most effective method for minimizing the exposure dose in patients with a low to normal BMI.