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Myocardial Perfusion Analysis
Comprehensive Patient Management in One Examination

ONE
Aquilion
dynamic volume CT

Case Study Brochure
Rigshospitalet



TOSHIBA MEDICAL SYSTEMS CORPORATION

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ONE
Aquilion

Myocardial Perfusion Analysis

Comprehensive Patient Management in One Examination

Introduction

Rigshospitalet in Copenhagen, Denmark, is a 1,100 bed hospital that has provided healthcare services to Danish citizens and foreign nationals for more than 250 years. It was the first hospital in Denmark to provide free treatment to patients who were unable to pay for their care.

The Radiology Department includes 40 physicians and 100 radiographers who perform a wide range of examinations for the entire spectrum of patients, from neonates to the elderly.

The CT Department performs more than 30,000 CT scans per year covering all types of examinations, with an emphasis on cardiac CT. In 2009, an Aquilion ONE™ scanner was installed in our department, where it is mainly used for cardiac examinations, including a wide variety of research projects.

The myocardial perfusion analysis software for the Aquilion ONE was installed in December 2009. Since then, we have performed more than 70 myocardial perfusion examinations to improve the characterization of cardiac disease in selected patient populations. CT myocardial perfusion examinations performed both at rest and during pharmacological stress permit the comprehensive assessment of the effects of coronary artery stenosis on blood flow to the myocardium. However, not every cardiac patient needs to undergo a stress perfusion scan, and an important part of our current work is to identify the patient population that requires this additional examination.

We are proud to be part of the CORE320 multicenter trial to validate this technique.

The cases presented in this brochure are clinical examples of patients in whom we would routinely perform myocardial perfusion examinations to thoroughly characterize their coronary artery disease.



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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.

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Myocardial Perfusion Analysis

The unique ability of the Aquilion ONE to acquire the entire heart in a single temporally uniform volume allows quantitative myocardial perfusion analysis to be performed using the same data as for coronary CTA. A similar acquisition during pharmacological stress permits the comprehensive evaluation of myocardial perfusion in ONE examination.

Comprehensive functional and morphological cardiac analysis with the Aquilion ONE can reduce the need for patients to undergo multiple examinations, saving both time and money and providing the additional benefit of an overall reduction in exposure dose.

Workflow

In order to accurately evaluate myocardial perfusion, images acquired at rest and during stress are required. Stress images demonstrate stress-induced perfusion defects. Rest images are compared with the stress images to assess the reversibility of defects. If a defect is seen both at rest and during stress, it is likely to be an infarct. Stress imaging in CT is achieved pharmacologically using either adenosine or dipyridamole because exercise stress is impractical.

The rest scan should be performed first to ensure the highest quality CT angiogram. This scan also provides the rest perfusion data.

Following injection of the stress agent, the CT perfusion scan is performed.

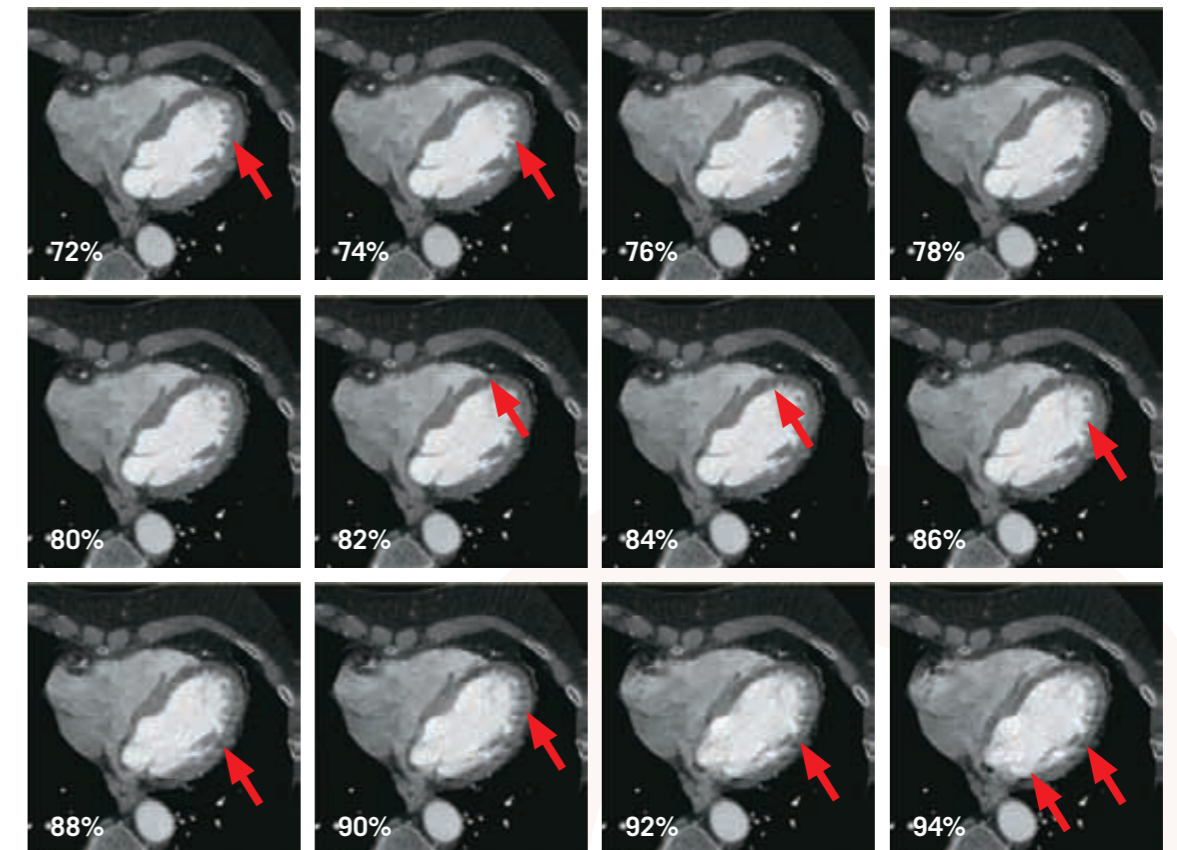


Reconstruction

The cardiac phase automatically selected for coronary CTA may not be the best motion-free phase of the left ventricle. Motion artifacts can mimic or hide perfusion defects, and it is therefore important to select the best motion-free phase of the left ventricle both at rest and during stress for myocardial perfusion analysis. Therefore, the scan is programmed to cover the late diastolic phase to ensure the best motion-free phase can be reconstructed.

Clinical Example:

The following stress CTP images show a range of reconstructions during diastole. Motion artifacts can be seen in many phases, but the best motion-free phases of the left ventricular myocardium are found at 76% to 80% of the cardiac cycle.



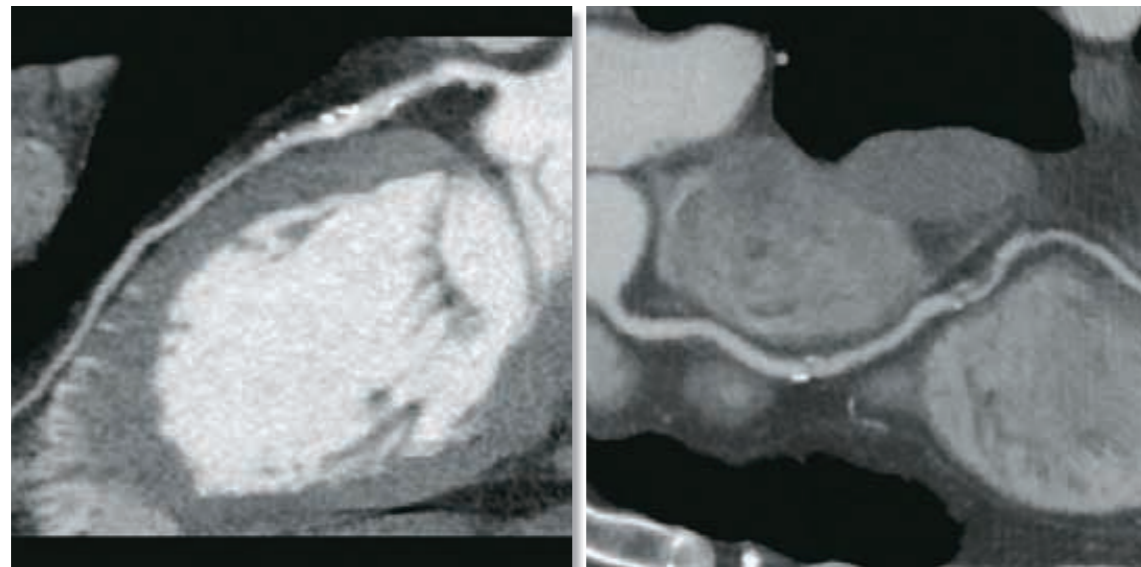
Multivessel Disease

Patient History

This 53-year-old man presented with stable angina. Coronary CT angiography and a stress CT perfusion scan were performed.

Findings

CT Angiogram

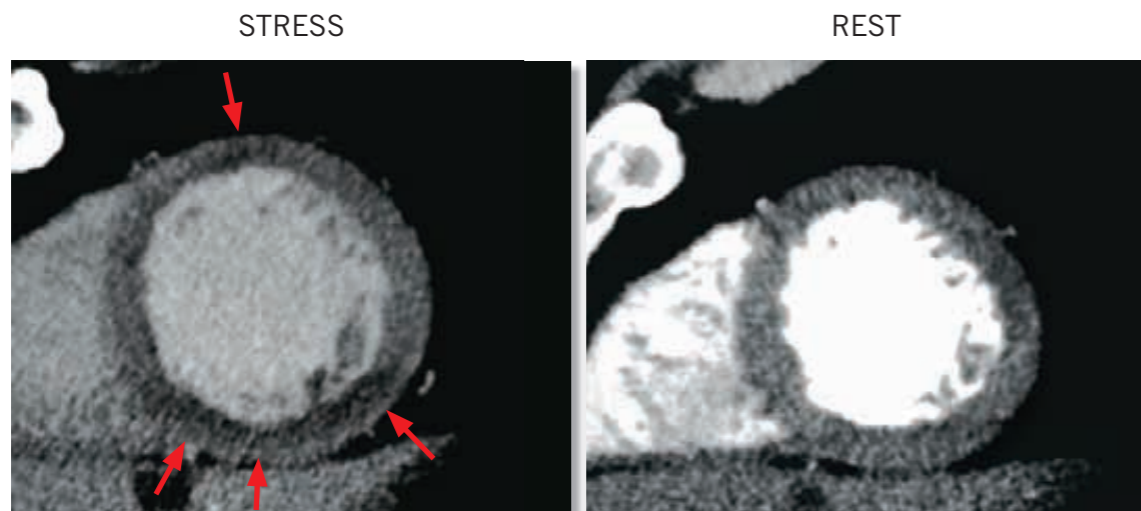


LAD

RCA

The CT angiogram demonstrates widespread vascular disease. Significant stenoses are seen in the left main trunk and the midportion of the LAD. There is a large plaque in the distal RCA associated with a short segmental stenosis of greater than 70%.

CT Perfusion



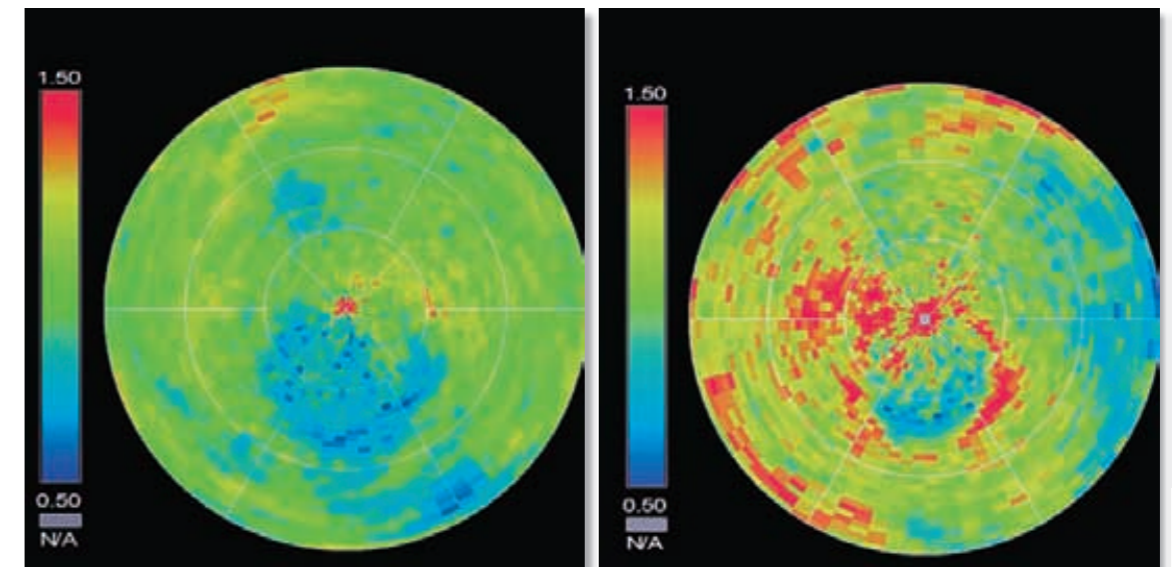
STRESS

REST

The rest CTA scan shows normal perfusion of the myocardium. However, during stress, two hypoperfused regions are demonstrated in both the anterior and inferior walls, corresponding to the vascular territories of the LAD and RCA.

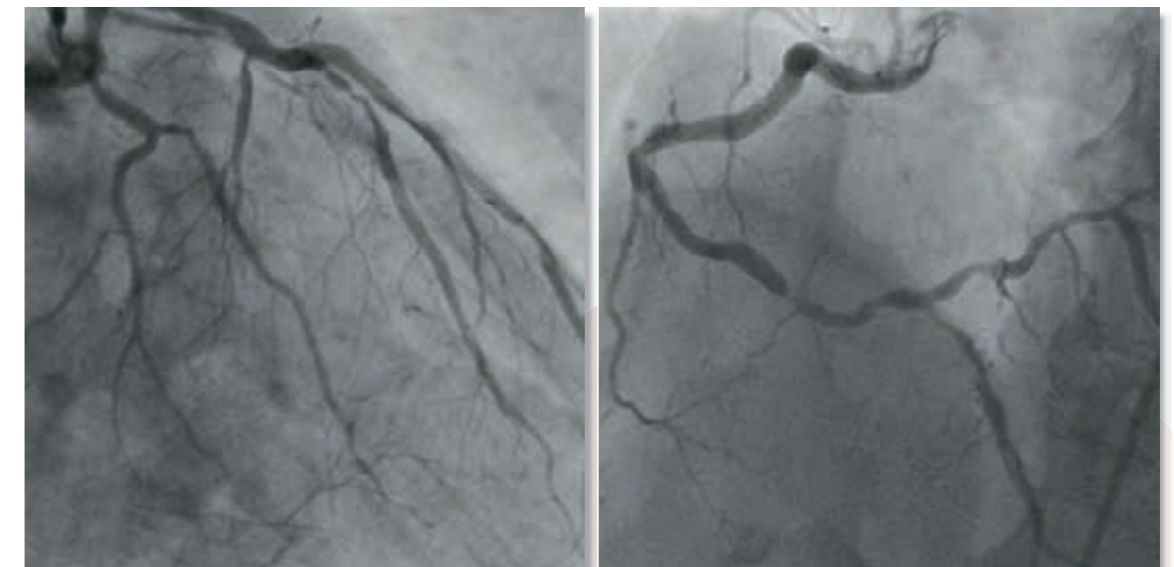
STRESS

REST



The TPR polar maps confirm both the anterior and inferior wall deficits seen in the stress scan. Analysis of the rest scan with TPR demonstrates a small area of hypoperfusion in the mid-ventricular inferior wall, indicating a small infarction.

Catheter Angiography



LAD/D1

RCA

A 90% stenosis is seen in the mid LAD. The Fractional Flow Reserve (FFR) measurement of the LAD lesion was 0.63 during stress. The stenosis in the distal RCA was judged to be on the order of 95% based on qualitative assessment.

Conclusion/Treatment

Significant stenoses of the mid LAD and distal RCA were demonstrated in the CTA scan and confirmed by catheter angiography. The stress perfusion results provided additional evidence that these stenoses were compromising blood flow to the myocardium.

The patient was scheduled for bypass surgery.

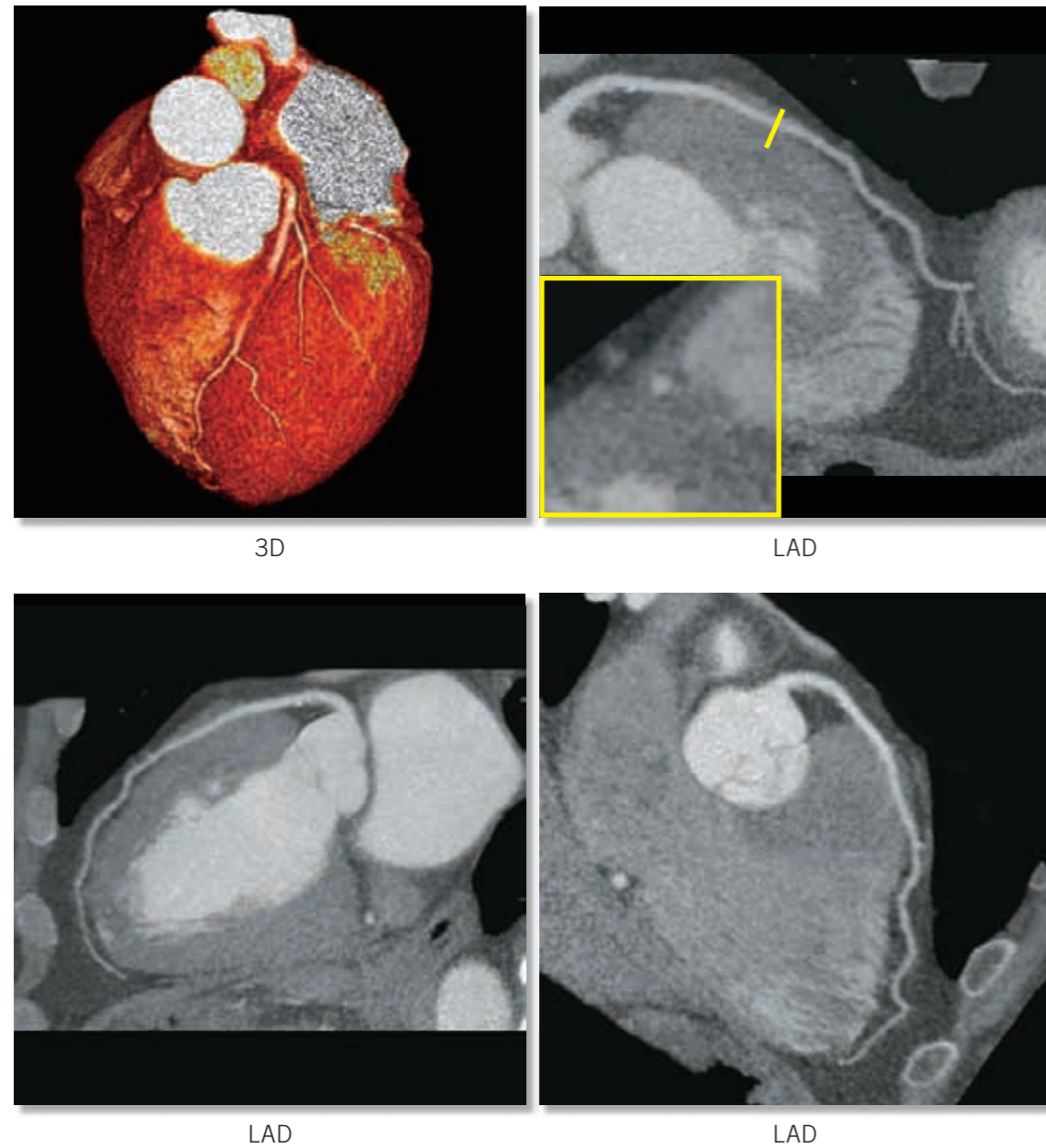
Myocardial Bridging

Patient History

This 61-year-old man presented with chest pain. A CT scan was requested to rule out coronary artery disease.

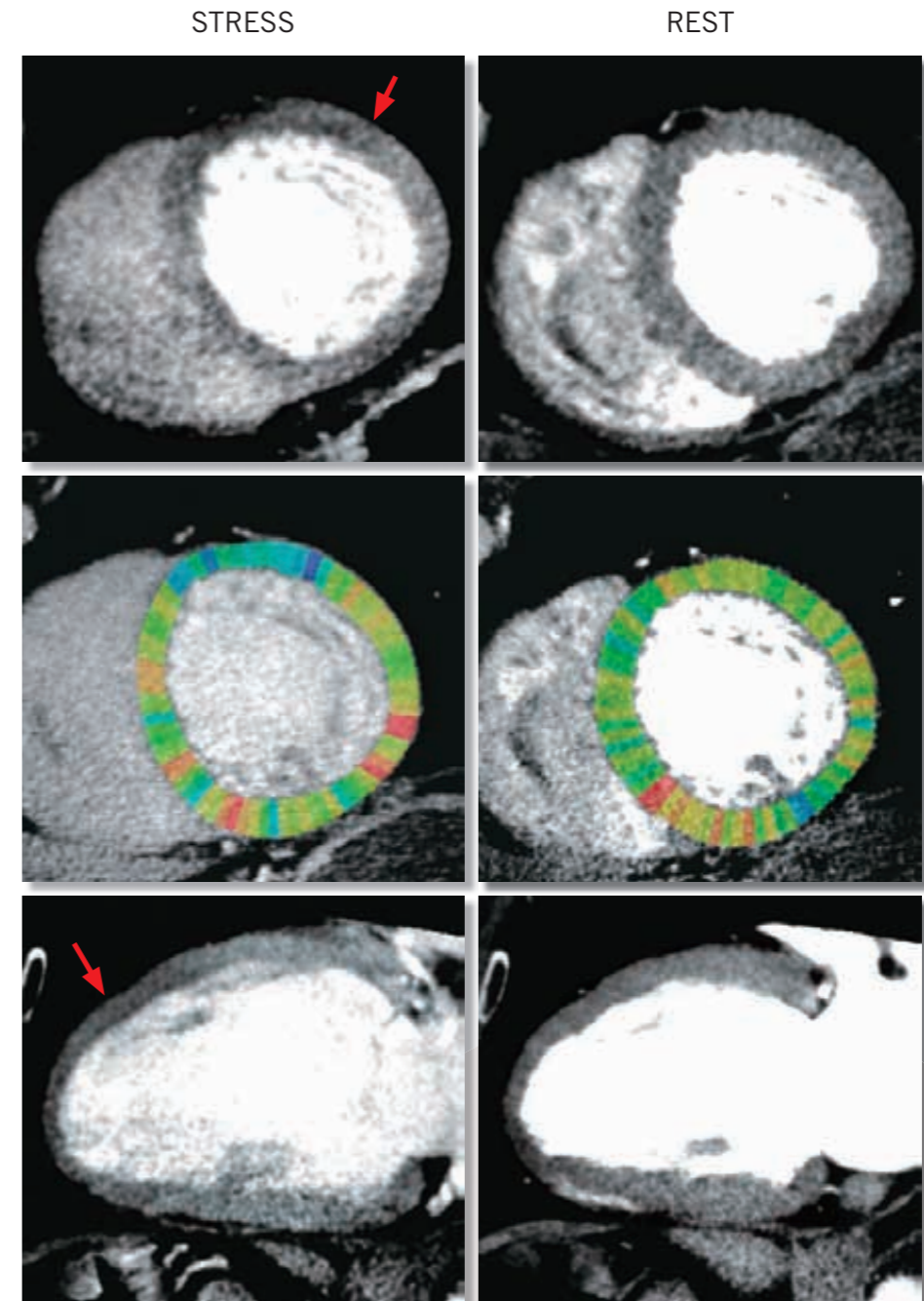
Findings

CT Angiogram



Myocardial bridging of the midportion of the LAD is demonstrated in the curved MPR images. A stress perfusion scan was subsequently performed to evaluate the hemodynamic significance of this finding.

CT Perfusion



A small perfusion deficit is observed in the anterior wall of the left ventricle, corresponding to the vascular territory supplied by the LAD. This lesion is only seen during stress. Applying a fusion overlay of the TPR polar maps emphasizes the presence of the defect.

Conclusion/Treatment

The stress CT perfusion scan indicated inducible myocardial ischemia in the vascular territory of the LAD, possibly due to functional narrowing in the area of myocardial bridging.

Since the CTA and stress perfusion scans were performed with a small exposure window in diastole, the caliber of the LAD could not be observed during cardiac contraction.

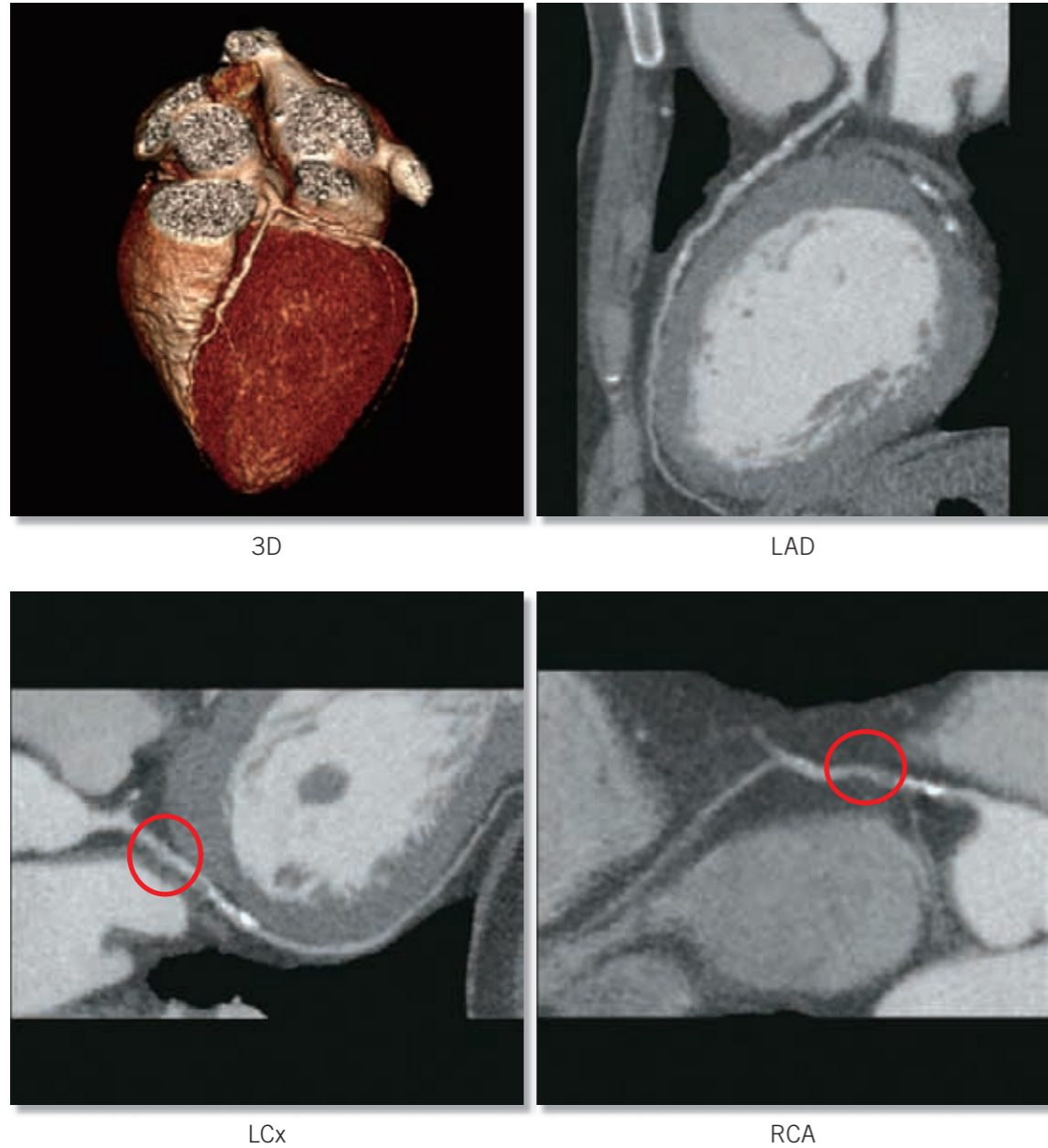
Diffuse Disease

Patient History

This 47-year-old man presented with unstable angina. A CT angiogram and a stress CT perfusion scan were requested to rule out coronary artery disease.

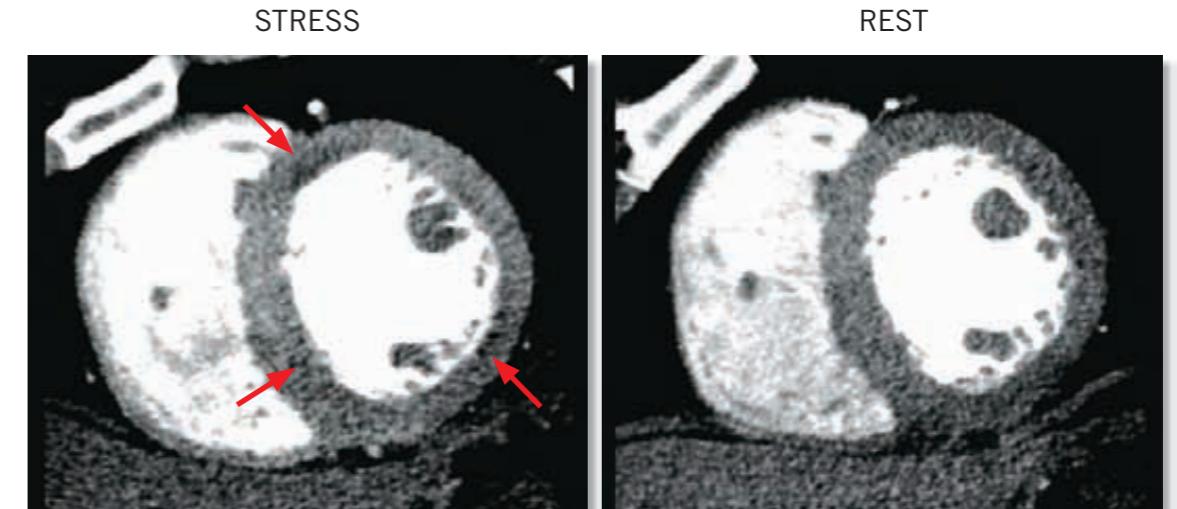
Findings

CT Angiogram



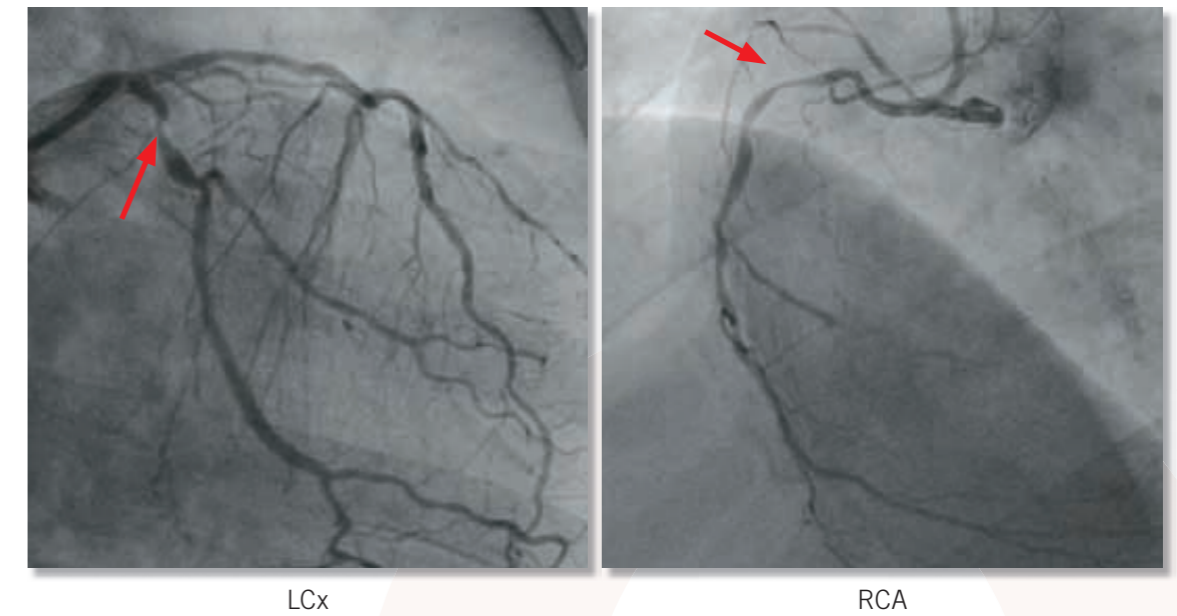
Severe stenoses in the proximal LCx and RCA are seen in the CT angiogram. Diffuse plaque is demonstrated in the LAD.

CT Perfusion



Perfusion deficits are observed in the lateral and inferoseptal walls during stress. A smaller defect is seen in the anterior wall. The rest images demonstrate a small defect in the inferior wall, indicating that some portion of this defect is fixed.

Catheter Angiography



Angiography confirms the presence of a 90% stenosis in the proximal LCx and a 70% stenosis of the proximal RCA. No stenosis is seen in the LAD.

Conclusion/Treatment

Stenoses were seen in the proximal LCx and RCA. The stress perfusion scans demonstrated defects in these vascular territories, indicating that the stenoses were hemodynamically significant. Balloon angioplasty was performed for both lesions.

Stem Cell Therapy

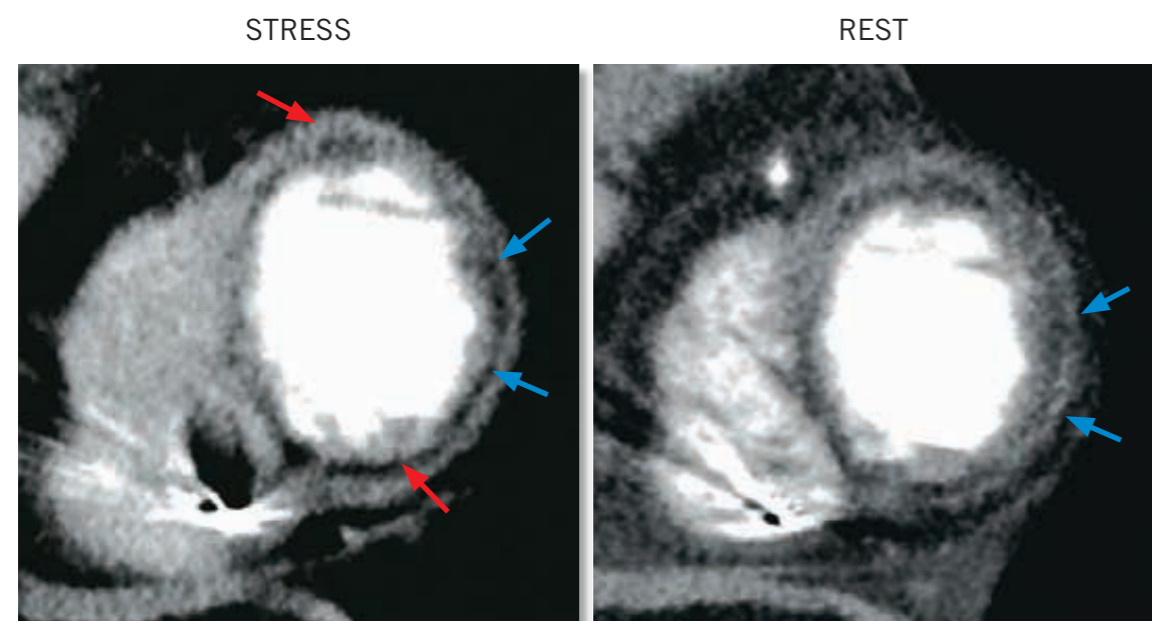
Patient History

This 58-year-old man presented with chest pain. The patient had a history of two previous myocardial infarctions as a result of stenoses in the LAD and LCx which were treated with stents and a LIMA bypass graft. The patient also had an implanted pacemaker.

Perfusion imaging by CT was requested to evaluate the thickness of the left ventricular wall and to identify areas of reversible myocardial ischemia prior to stem cell therapy.

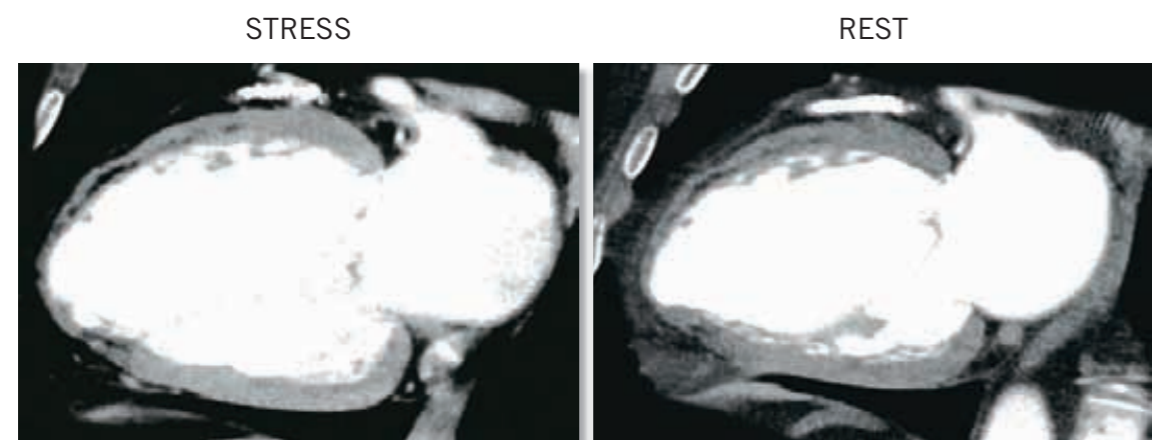
Findings

CT Perfusion

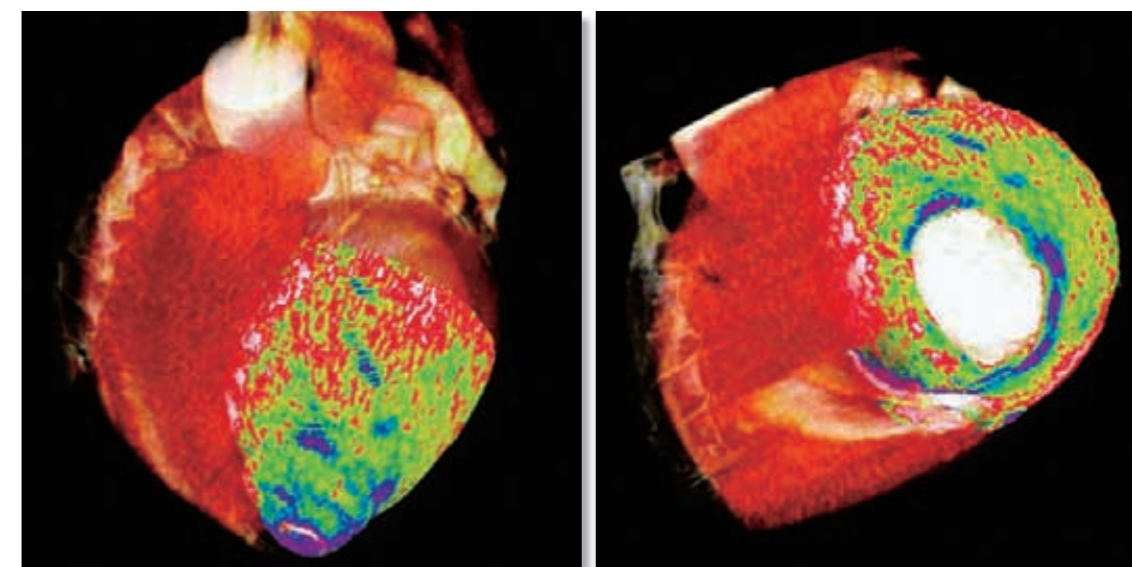


Myocardial infarction is confirmed in the anterior, lateral, and inferior walls (red arrows), shown clearly as low-attenuation areas in the rest and stress images. The defect in the inferolateral basal wall is larger in the stress images than in the rest images, indicating a reversible defect (blue arrows).

The septal wall is partially obscured by artifacts from the pacemaker and was therefore excluded from evaluation.

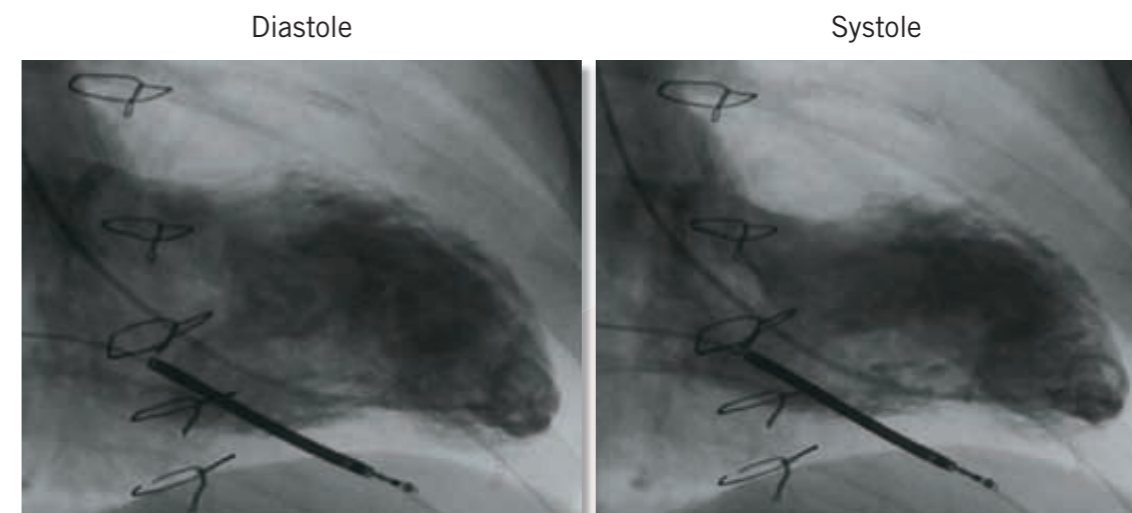


The infarct in the anterior wall is demonstrated in these horizontal long-axis images. Thinning of the myocardium is observed at the apex and anterior walls.



Fusion of the TPR polar map and the anatomical cardiac 3D image clearly demonstrates the relationships between the perfusion defects and the coronary vessels. The fusion image makes it easy to appreciate the specific coronary vessel supplying each segment of the myocardium. When clipping is performed, the deficits in the anterior and lateral walls can be easily evaluated.

Catheter Angiography



Ventriculography was performed, demonstrating reduced wall motion in the inferolateral basal wall. The global ejection fraction was calculated to be 40%.

Conclusion/Treatment

Extensive myocardial infarction involving a large portion of the left ventricle was observed. A reversible defect was seen in the inferolateral basal wall. This patient was treated with the injection of stem cells into this area of the myocardium. A follow-up scan will be performed to assess the effectiveness of this treatment.

CT perfusion could be performed despite the presence of a pacemaker, although the septal wall was excluded from analysis.

Single Vessel Disease

Patient History

This 83-year-old woman presented with stable angina. A CT scan including stress perfusion was requested for further investigation.

Findings

CT Angiogram

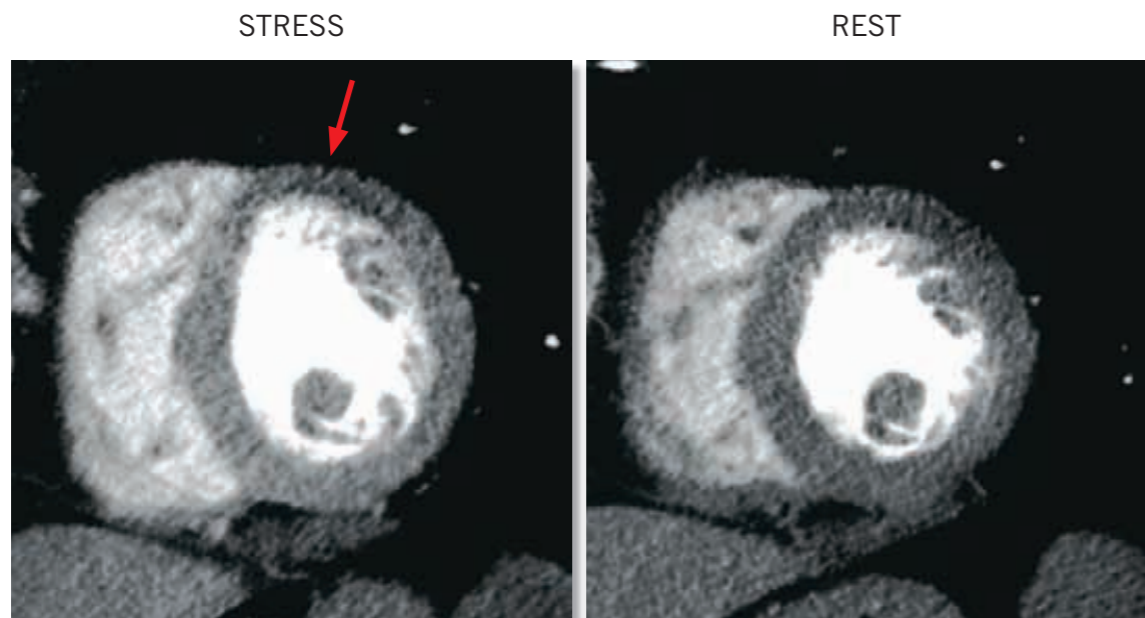


3D

LAD

Calcified plaque is demonstrated in the proximal portions of the LAD, causing significant stenosis at this level. There is a focal stenosis of greater than 90% in the midportion of the LAD (arrow).

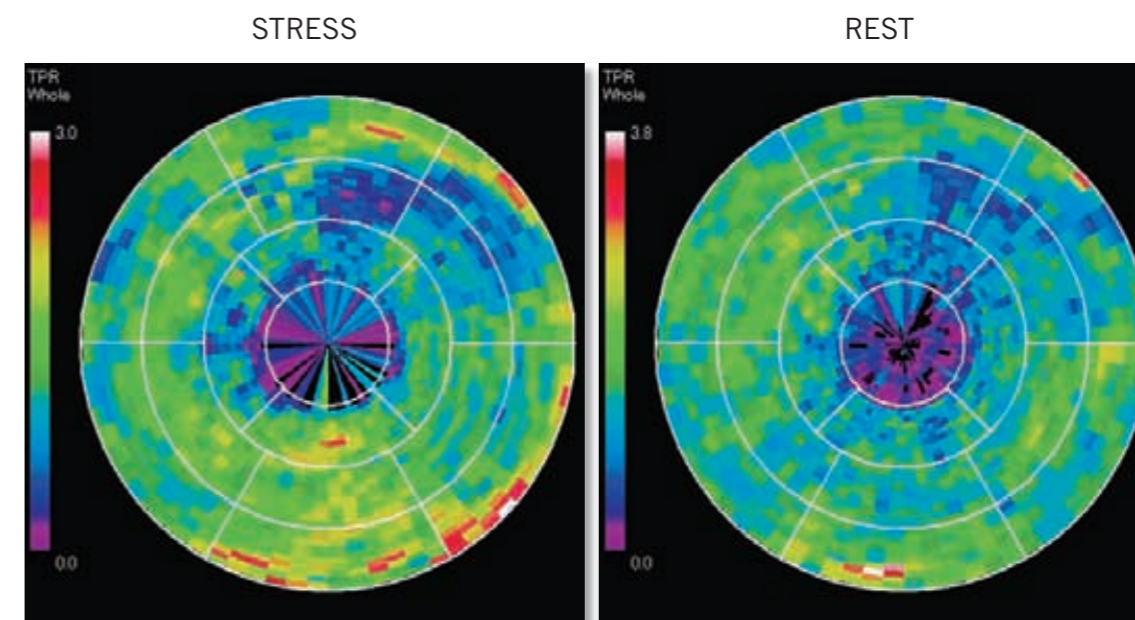
CT Perfusion



STRESS

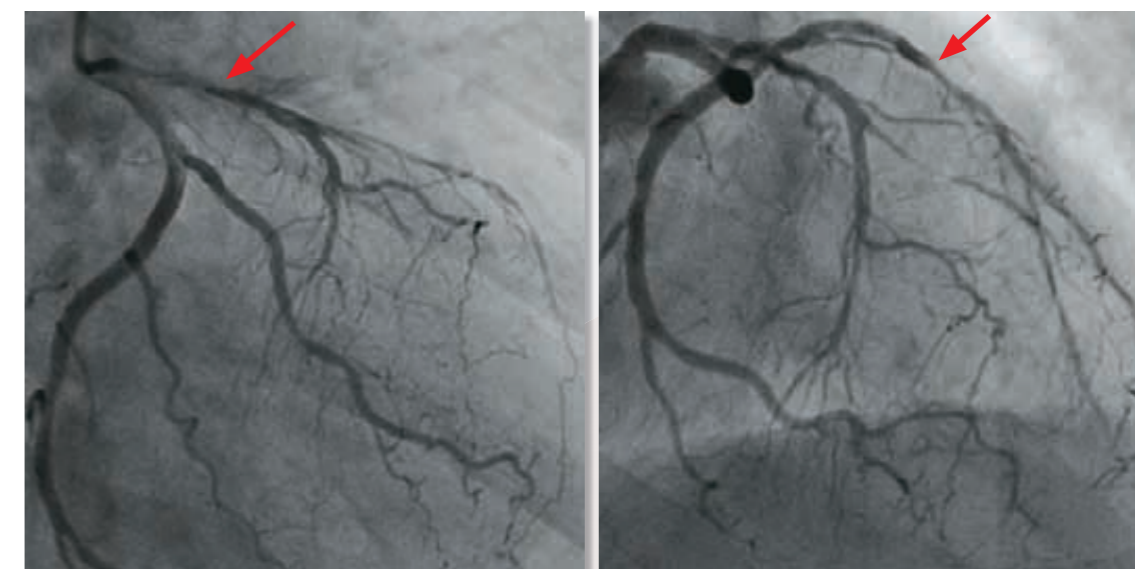
REST

The stress CT perfusion scan demonstrates a deficit in the anterior wall that corresponds to the vascular territory supplied by the LAD. Low attenuation in this region is also seen in the rest CTA.



The stress transmural perfusion ratio (TPR) map confirms the presence of the anterior wall defect. The defect is also present in the rest TPR maps, but it is smaller, indicating a partially reversible defect.

Catheter Angiography



There is a 70% stenosis in the proximal LAD and a 99% stenosis in the mid LAD.

Conclusion/Treatment

Catheter angiography confirmed the presence of a 70% stenosis in the proximal LAD and a 99% stenosis of the mid LAD. Both lesions were stented with Cypher drug-eluting stents.

The CT perfusion images confirmed compromised blood supply to the affected myocardium caused by the LAD stenoses.

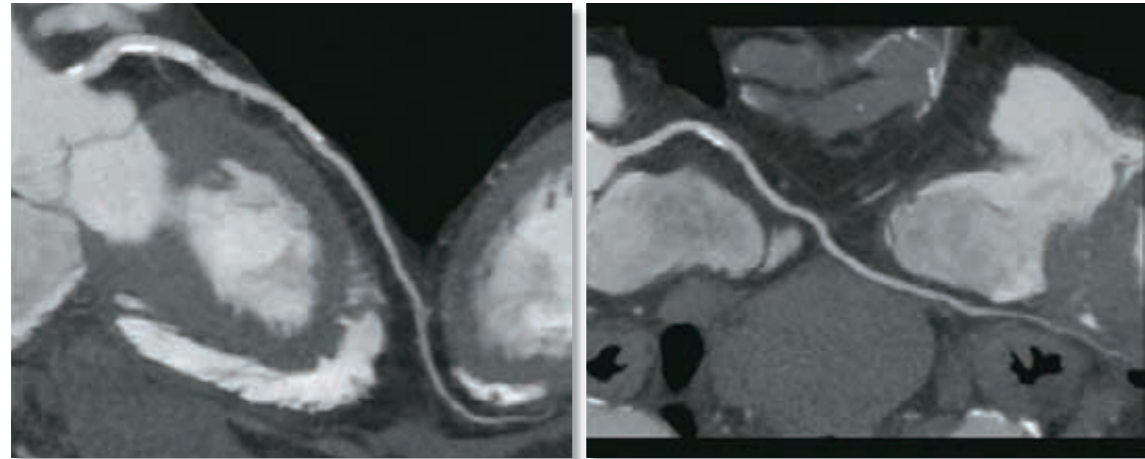
Myocardial Ischemia

Patient History

This 80-year-old woman presented with unstable angina and shortness of breath. A CT scan was requested to rule out coronary artery disease.

Findings

CT Angiogram



LAD

RCA

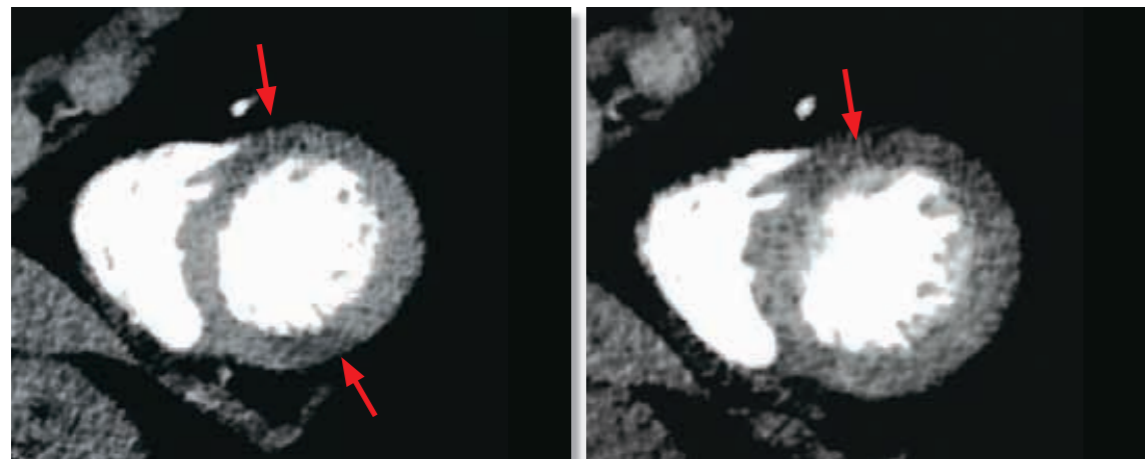
A mixed lesion is demonstrated in the proximal portion of the LAD, causing a stenosis that was determined to be greater than 70%. There is a calcified plaque in the proximal RCA associated with some luminal narrowing, although this was not thought to be significant.

A stress perfusion scan was subsequently performed to evaluate the hemodynamic significance of the LAD stenosis.

CT Perfusion

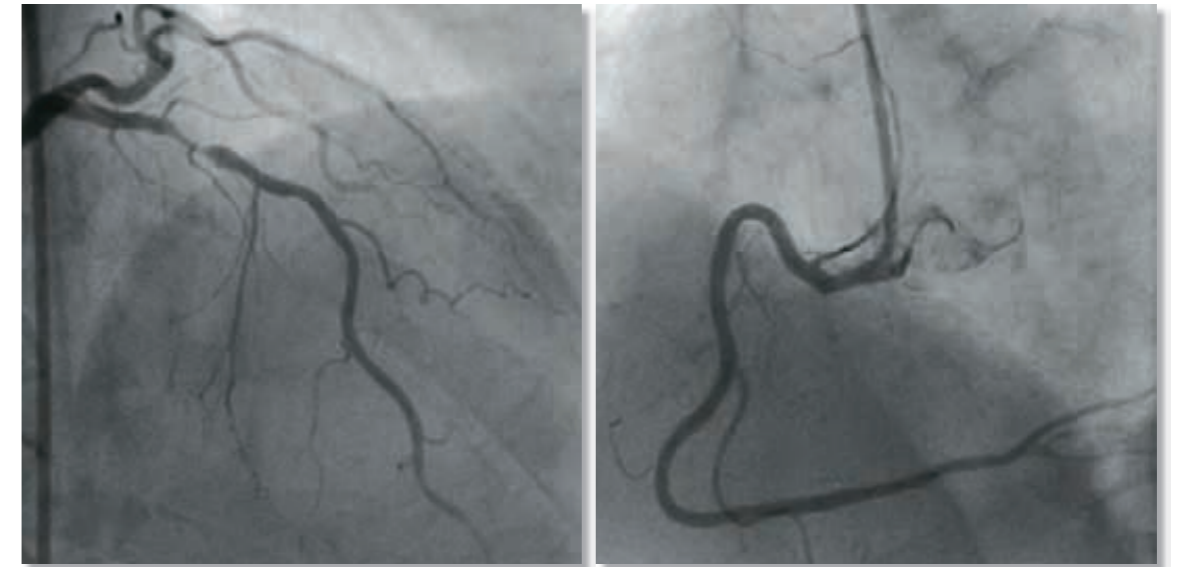
STRESS

REST



In the rest and stress short-axis images, a low-density area is clearly demonstrated in the anterior wall. The location of the deficit corresponds to the vascular territory supplied by the LAD and its branches. The defect is less pronounced in the rest images, indicating partial reversibility and partial infarction. A defect is also seen in the inferolateral wall, corresponding to the vascular territory supplied by the RCA. It is not seen in the rest images, indicating that it is a reversible deficit.

Catheter Angiography



LAD

RCA

Catheter angiography confirmed a severe stenosis in the proximal LAD. This lesion was considered to cause a stenosis of 80%.

In the projections acquired for the RCA, no lesion is observed that would account for the perfusion deficit in the inferolateral wall seen in the myocardial stress perfusion scan.

Conclusion/Treatment

The stenosis of the LAD was confirmed to be hemodynamically significant in the range of 80% by catheter angiography. The associated anterior wall defect was clearly shown in the rest and stress CT perfusion images, but the deficit was less extensive in the rest images, indicating partial reversibility.

The defect in the vascular territory of the RCA seen in the stress perfusion CT scan indicated the presence of a hemodynamically significant stenosis. However, the stenosis was not confirmed by catheter angiography.

Based on the results of these studies, a stent was deployed to treat the lesion in the proximal LAD.

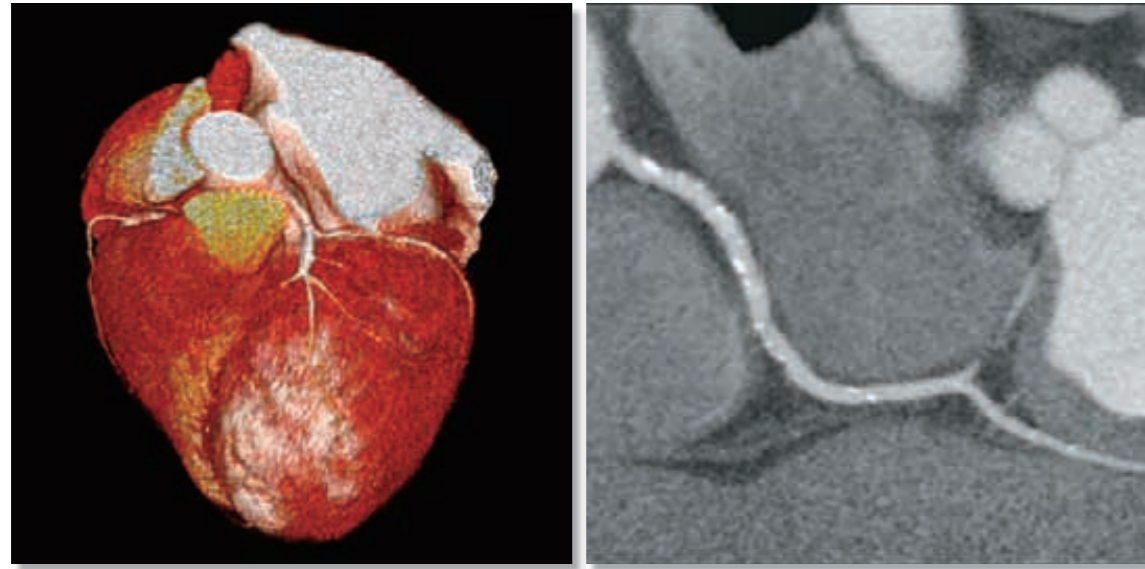
Myocardial Infarction

Patient History

This 73-year-old man presented with cardiomyopathy. A CT scan was requested to rule out coronary artery disease and to evaluate myocardial perfusion.

Findings

CT Angiogram

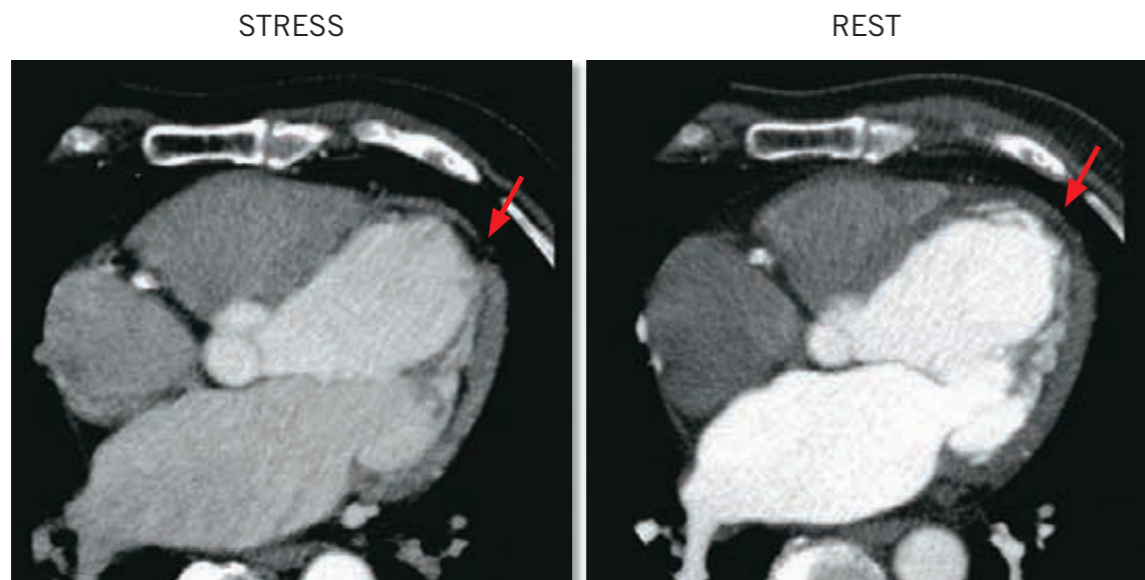


3D

RCA

The LAD is completely occluded from its midportion. Calcification is seen in the apex of the left ventricle. Diffuse calcification is observed along the entire RCA, with a focal stenosis seen in the midportion of the vessel.

CT Perfusion



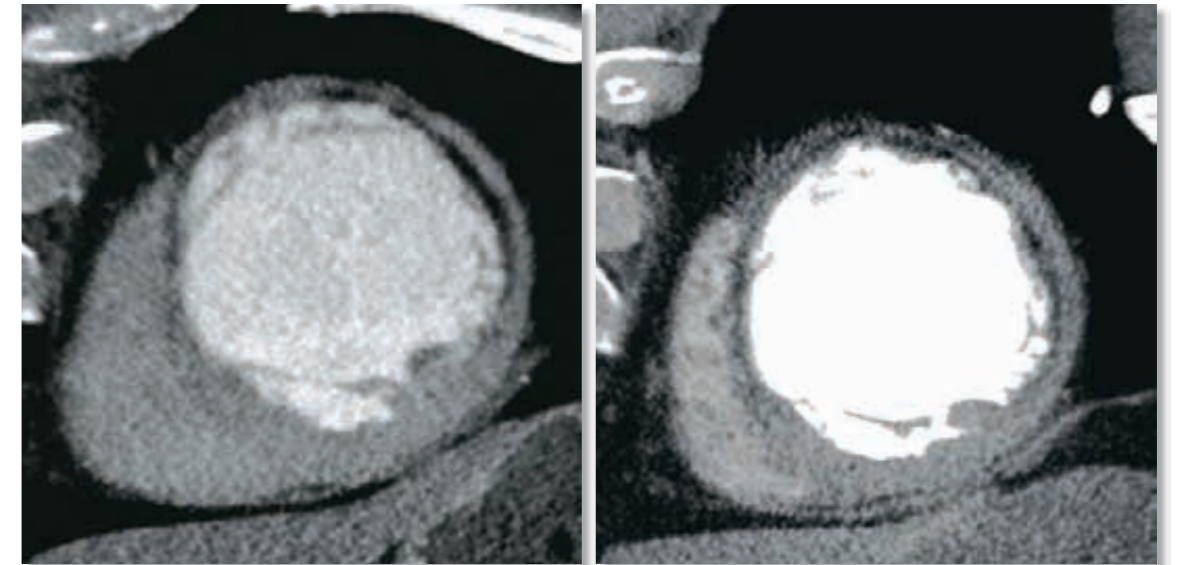
STRESS

REST

A large infarct is seen in the anterolateral wall of the left ventricle, with thinning of the myocardium. During pharmacological stress, the perfusion deficit extends to the epicardial border of the myocardium. This indicates some degree of reversibility of the lesion.

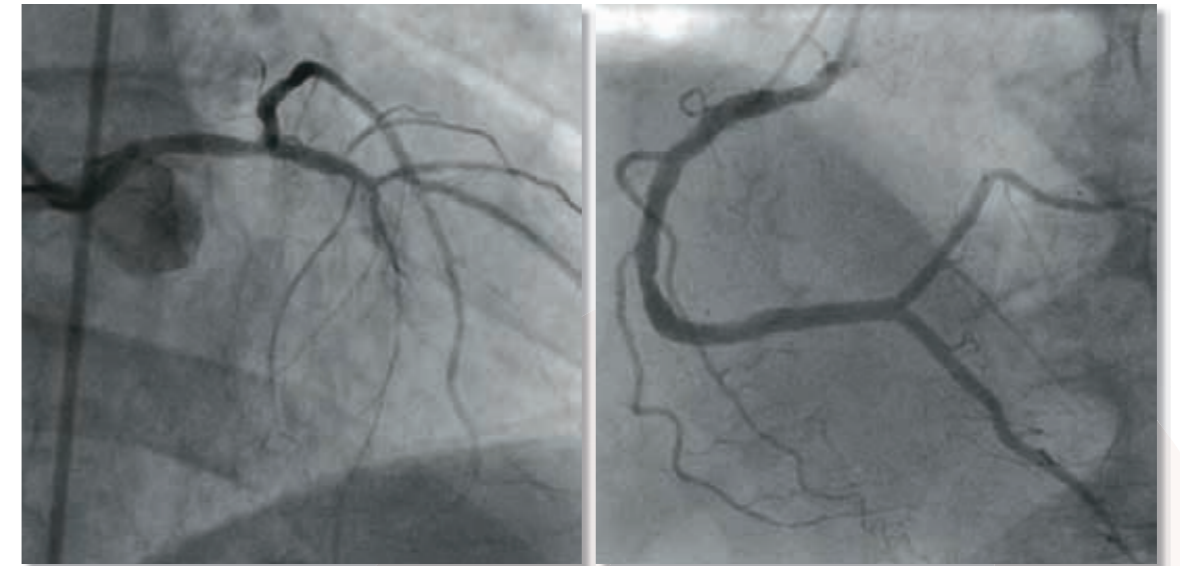
STRESS

REST



The short-axis images demonstrate the extent of the myocardial infarction, which includes the anterior, septal and lateral walls of the left ventricle.

Catheter Angiography



LAD

RCA

Complete occlusion of the LAD is demonstrated in the angiogram. A 50% stenosis of the RCA is also seen.

Conclusion/Treatment

Catheter angiography confirmed complete occlusion of the mid LAD. This occlusion resulted in infarction of the anterior wall, with subsequent calcification. The RCA stenosis was not treated.

The patient was referred for treatment with an implantable cardioverter defibrillator (ICD).