Case Report

Technetium-99m-sestamibi Redistribution after Exercise Stress Test Identified by a Novel Cardiac Gamma Camera: Two Case Reports

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ABSTRACT

Single photon emission computer tomography (SPECT) myocardial perfusion imaging (MPI) employing technetium-99m (Tc-99m)-based imaging tracers is the mainstay of nuclear cardiology for the detection of myocardial ischemia. Current guidelines for same day rest/stress Tc-99m-sestamibi SPECT MPI recommend image acquisition 15–60 minutes after the stress testing. A novel sensitive SPECT imaging technique, D-SPECT, allows fast acquisition of images and captures rapid changes in radiotracer distribution. Here we report 2 cases of SPECT MPI in patients with angiographically confirmed coronary artery disease (CAD) where Tc-99m-sestamibi exhibited marked redistribution between early (6–8 min) and late (60–70 min) post-stress imaging leading to an underestimation of the extent and severity of ischemia on late images. These observations suggest that early imaging maybe more sensitive for CAD detection. Fast SPECT imaging techniques, such as D-SPECT, will facilitate similar studies in the future as they will allow fast image acquisition at several time points after the stress test.

Background

Single photon emission computer tomography (SPECT) myocardial perfusion imaging (MPI) employing technetium-99m (Tc-99m)-based imaging tracers is the mainstay of current nuclear cardiology practice providing both high sensitivity and specificity for the detection of myocardial ischemia.[1] Tc-99m-sestamibi injected at rest and peak stress is trapped within viable cardiomyocytes and its distribution observed with an Anger scintillation camera 15–60 minutes after tracer injection has been assumed to reflect the status of regional myocardial perfusion (MP) at the time of radionuclide injection. Here we report 2 cases of SPECT MPI in patients with angiographically confirmed coronary artery disease (CAD) where Tc-99m-sestamibi exhibited marked redistribution between early (6–8 min) and late (60–70 min) post-stress imaging, suggesting that early imaging may be more sensitive for CAD detection.

Case 1

A 45-year-old man with known CAD and concomitant diabetes, hypertension, obesity, hypercholesterolemia, and tobacco use presented to the hospital with signs of acute coronary syndrome. He admitted stopping his medications and using cocaine prior to hospitalization. The patient was referred for urgent coronary catheterization, which revealed total occlusion of the left anterior descending coronary artery (LAD), 99% occlusion of the left circumflex coronary artery (LCX), and 50% occlusion of the right coronary artery (RCA; Figure 1A,B). LCX was identified as the culprit artery and the patient underwent stenting of this vessel with a bare-metal stent. The patient was discharged the following day on Imdur, atenolol, aspirin, plavix, lisinopril, simvastatin, and metformin.

In order to evaluate the presence and magnitude of residual ischemia, the patient underwent a rest/stress Tc-99m-sestamibi SPECT MPI (518 MBq [14 mCi] Tc-99m-sestamibi at rest and 1295 MBq [35 mCi] Tc-99m-sestamibi at stress). The patient exercised on a standard Bruce protocol for 7:16 minutes and did not show any ischemic changes on the electrocardiogram (ECG). The clinical response to exercise was abnormal due to significant dyspnea causing termination of exercise. Image acquisition was performed by 2 different SPECT methods: standard dual-head Anger camera (A-SPECT; ECAM, Siemens, Hoffman Estates, IL) 45 minutes post-stress and a novel fast SPECT camera (D-SPECT; Spectrum Dynamics, Caesarea, Israel) 8 and 70 minutes post-stress. A-SPECT images were acquired in a supine position in 60 projections over a 180-degree arc and 32 seconds/projection. Images were

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reconstructed using a standard filtered back-projection algorithm. No attenuation or scatter correction was applied. D-SPECT images were acquired in a semi-reclined position with 9 detector columns rotating around the patient's chest and reconstructed with a proprietary Broadview reconstruction algorithm.[2]

A-SPECT imaging performed 45 minutes after the stress test demonstrated mild ischemia in the apical left ventricle (LV) segments and the apex (summed stress score (SSS) = 7, summed difference score (SDS) = 6; Figure 1C). These findings were comparable to those observed on the D-SPECT images 70 minutes after the stress test (Figure 2A). Interestingly, D-SPECT images acquired 8 minutes after peak stress identified significantly more extensive and severe ischemia throughout the mid LAD territory (Figure 2B). In addition, these images showed a medium-sized area of reversible ischemia in the distribution of the posterior descending artery (PDA) which was not obvious on the A-SPECT or 70-minute D-SPECT images (Figures 1C and 2A, respectively). Importantly, early post-stress D-SPECT images were consistent with the findings seen on coronary angiography (Figure 1A,B).

Case 2

A 60-year-old man with hypercholesterolemia who had undergone percutaneous coronary intervention (PCI) for an LCX stenosis 9 months earlier was admitted with recurrent, non-exertional chest pain lasting for 3 days prior to admission. ECG and cardiac enzymes were normal and the patient was referred for coronary CT angiography, which revealed a 50% to 69% narrowing of the proximal LAD, a 70% to 89% narrowing of the proximal LCX, and the widely patent mid-LCX stent (Figure 3A,B,C).

SPECT MPI was performed to determine whether the proximal LAD or the proximal LCX was likely to be the culprit vessel. The patient exercised on a standard Bruce protocol, developing substernal chest discomfort at 8 minutes. A 925 MBq (25 mCi) of Tc-99m-sestamibi was injected at 8:15 minutes, shortly after chest discomfort developed, and the test was terminated at 9:50 minutes after the onset of exercise. Stress ECG did not reveal any signs of ischemia. D-SPECT imaging was performed 6 minutes and 60 minutes post-stress with acquisition times of 2 minutes. Post-stress A-SPECT imaging was performed for 16 minutes, beginning 30 minutes after radiotracer injection. Image acquisition and processing for both cameras were performed as in Case 1, with the exception that iterative reconstruction was employed for A-SPECT.

A-SPECT imaging performed 30 minutes after the stress test demonstrated mild ischemia in the anterior wall (SDS = 4) which could not be attributed with certainty to the LAD or the LCX territory (Figure 3D). D-SPECT images acquired 60 minutes post-stress showed similar findings, but the defect appeared to be more in the anterolateral wall, suggesting an LCX lesion (Figure 4A). However, when D-SPECT images acquired 6 minutes post-stress were compared to rest images (Figure 4B), there was a moderately large region of LCX ischemia (SDS = 10) not present on later post-stress images (Figures 3D, 4A). Importantly, as in Case 1, these findings were consistent with those seen on subsequent coronary angiography (not shown), which revealed an 80% "hazy" stenosis in the LCX ostium and an 80% mid LCX stenosis. In addition, the mid LAD revealed a 70% stenosis, while the RCA demonstrated luminal irregularities.

Discussion

Rest/stress SPECTMPI is a well-established technique which has been extensively validated in clinical studies for the evaluation of known or suspected CAD. The current guidelines for same day rest/stress Tc-99m-sestamibi SPECT MPI recommend acquisition of images 15–60 minutes after the stress testing.[1] The recommendations of the time delay for imaging after stress testing were based on the optimization of image quality, assuming a stable distribution of Tc-99m-sestamibi over time with minimal redistribution. However, these case reports challenge the assumption of "stability" of radiotracer distribution over time, which in these cases led to a significant underestimation of the extent and severity of underlying disease. High quality "early" imaging in these patients was possible due to the increased sensitivity of D-SPECT, thereby allowing fast acquisition of stress images (2 min) and, thus, capturing apparently rapid changes in radiotracer distribution.

Existing literature describes prior findings similar to ours. Taillefer et al[3] showed that myocardial perfusion SPECT images acquired 15 minutes after the stress test identify more ischemic segments than images acquired 60 minutes later. Likewise, images acquired 60 minutes after stress showed ischemic segments that were not present on the images acquired 3 hours later.[4] Franceschi et al[5] also suggested that delayed MP images should be interpreted with caution as they might underestimate the extent of ischemic defects. Of note, the quality of early images was comparable to the quality of delayed ones. Several studies also suggested that the magnitude of stress-induced functional changes (transient decrease in ejection fraction, changes in end-diastolic and end-systolic volumes, and the degree of transient ischemic dilation) may be more pronounced on myocardial perfusion images acquired early after stress.[6,7] Even though all of these studies were relatively small and some did not show statistically significant differences between early and delayed imaging, they suggested that earlier imaging might improve the sensitivity of CAD detection, especially in cases where ischemic defects are mild. Earlier imaging, should it prove useful, will also be more cost-effective and will increase the turnover of patients in a busy nuclear cardiology department, decreasing the workload at the same time.

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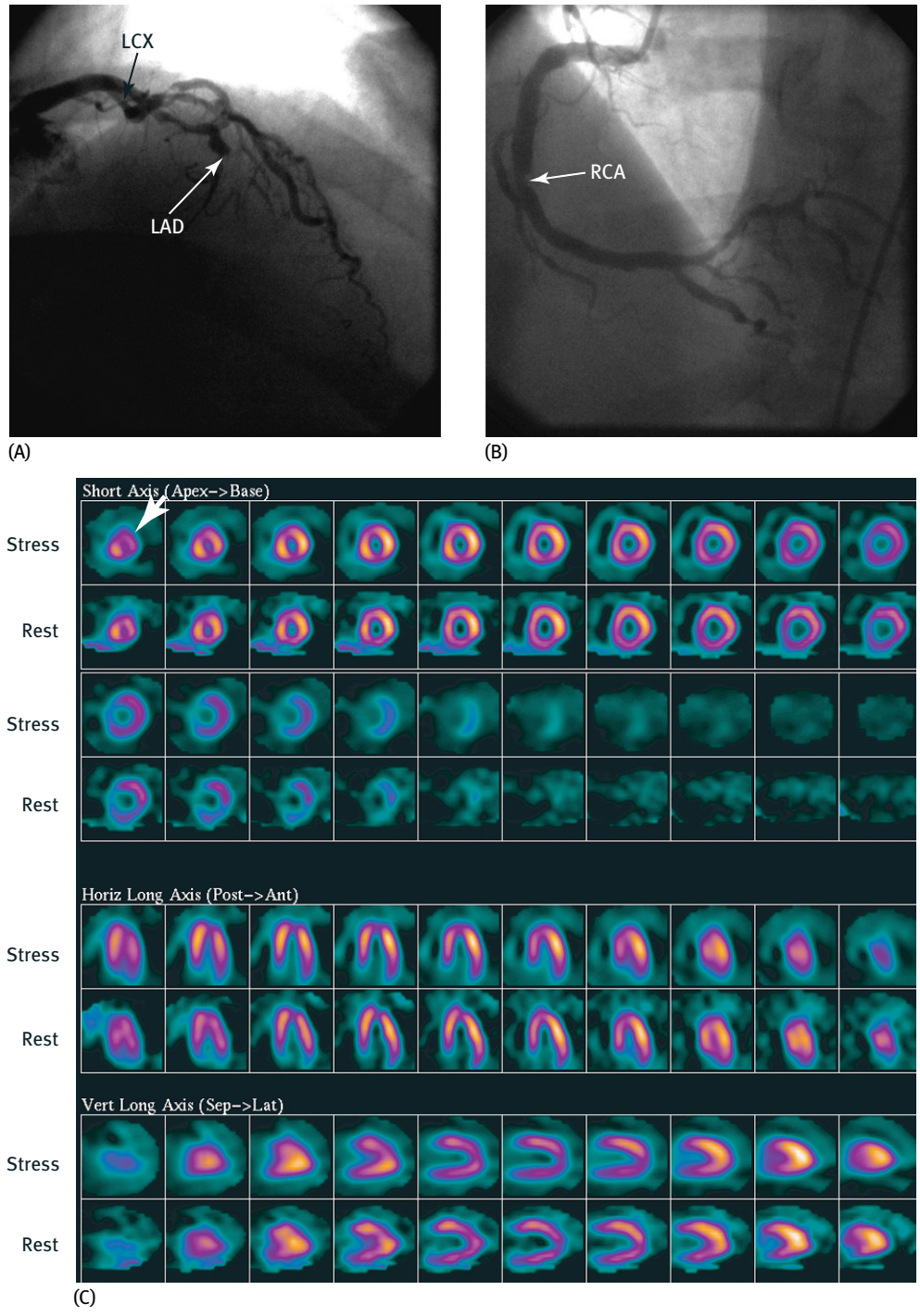

Figure 1. (A) Coronary angiogram at admission demonstrating total occlusion (white arrow) of the left anterior descending coronary artery (LAD) and a 99% occlusion (black arrow) of the proximal left circumflex coronary artery (LCX); (B) a 50% occlusion (white arrow) of the right coronary artery (RCA) in its middle part; (C) Tc-99m-sestamibi SPECT MPI performed with the A-SPECT camera 45 minutes after stress showing exercise-induced perfusion defect (white arrow) in the apical segments of the left ventricle and the apex.

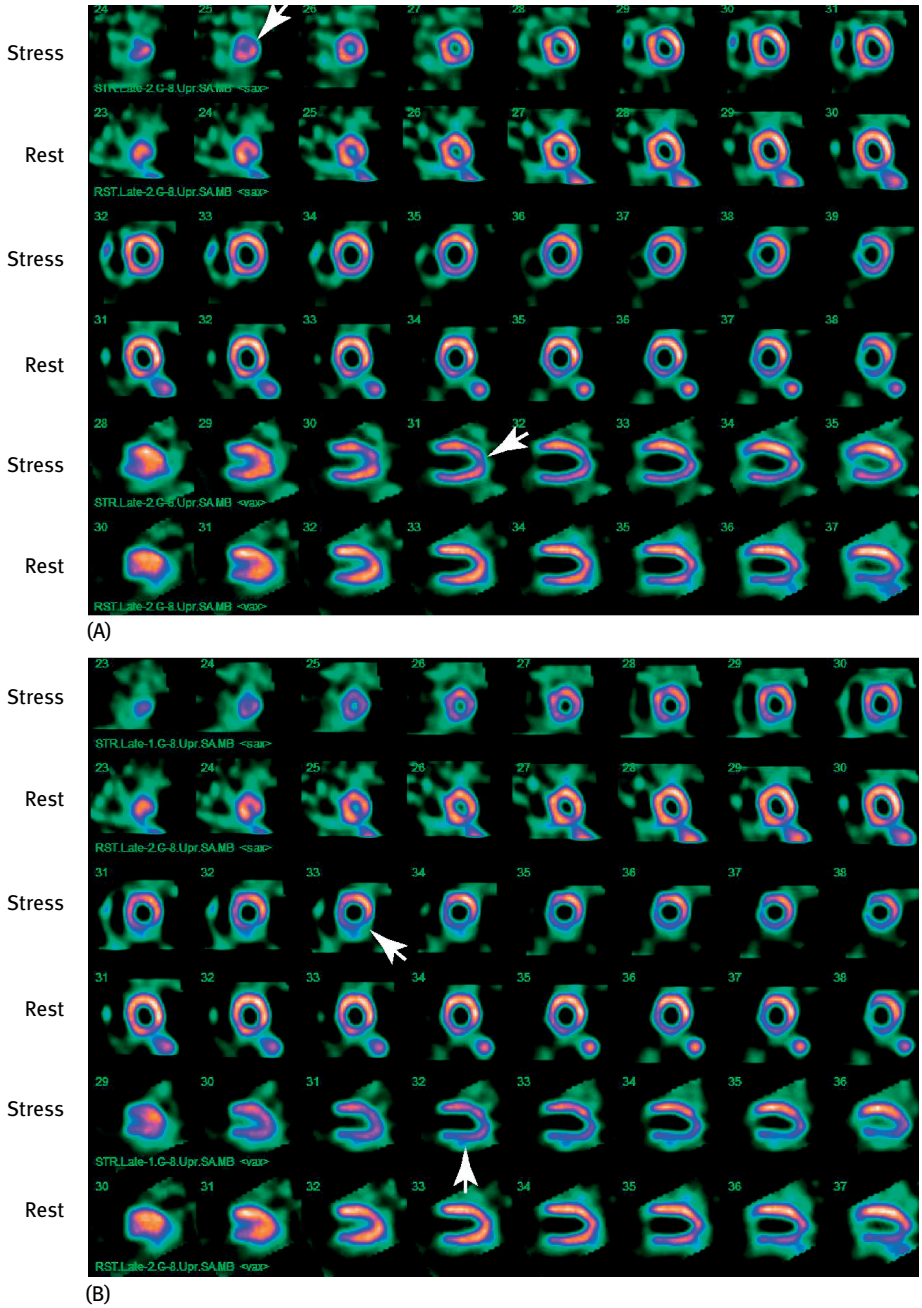

Figure 2. Tc-99m-sestamibi SPECT MPI performed with the D-SPECT camera: (A) 70 minutes post-stress showing perfusion defects (white arrows) in the apical segments of the left ventricle and the apex; (B) 8 minutes post-stress showing exercise-induced perfusion defects (white arrows) in the apical segments of the left ventricle and the apex as well as in the inferolateral and inferior walls of the left ventricle. The latter defects are not present at rest and on images acquired 70 minutes post-stress.

Should we, perhaps, reconsider our current imaging guidelines in favor of earlier imaging? To answer this question, we need further studies estimating diagnostic and prognostic utility of such findings and the frequency of such cases in the general population. Fast SPECT imaging techniques, such as D-SPECT, will greatly facilitate these studies as they will allow fast image acquisition at several time points after the stress test.

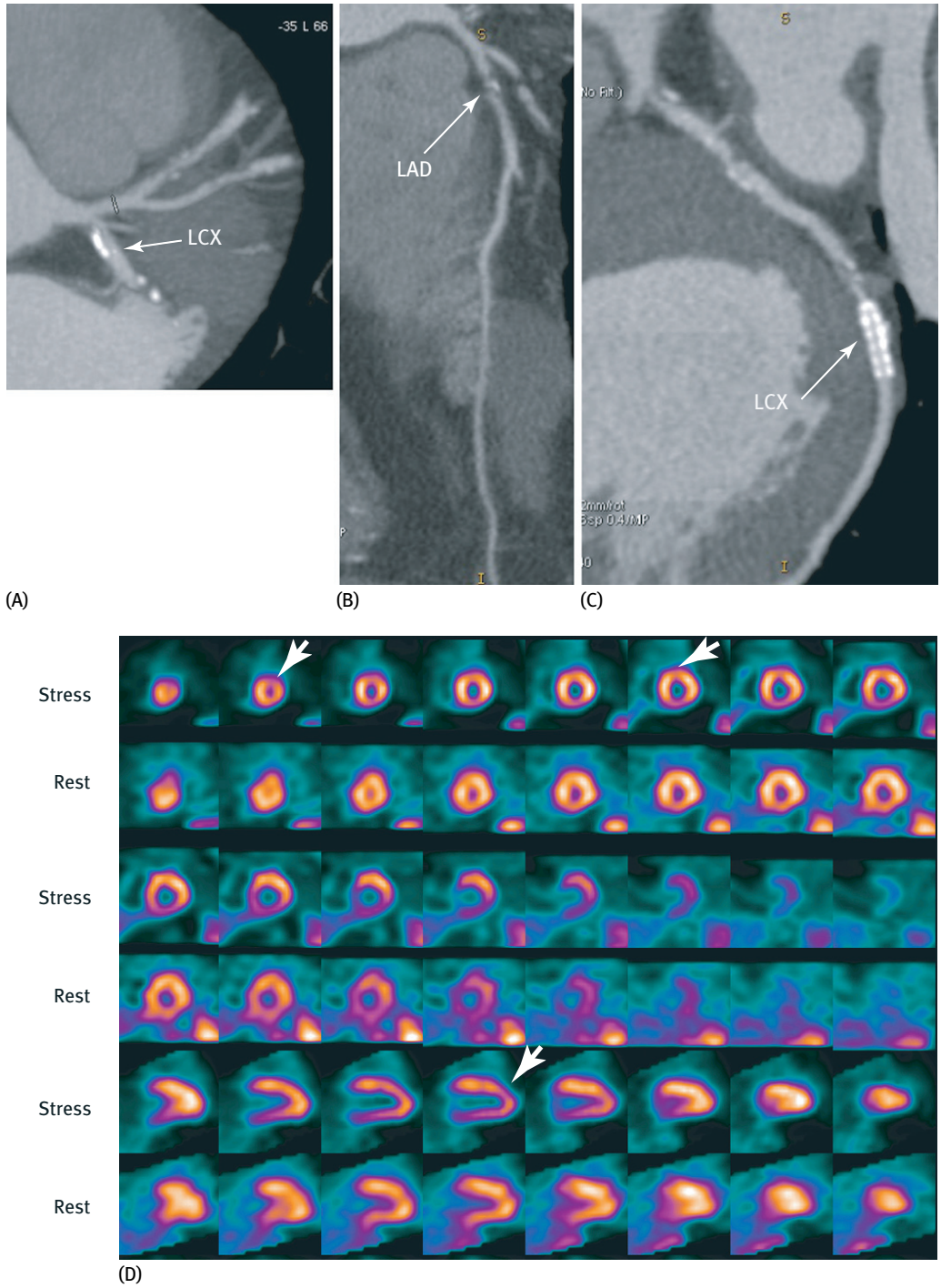

Figure 3. (A) Coronary CT angiography showing 70%-89% narrowing (white arrow) of the proximal left circumflex coronary artery (LCX); (B) 50%-69% narrowing (white arrow) of the proximal left anterior descending coronary artery (LAD); (C) patent mid-LCX stent (white arrow); (D) Tc-99m-sestamibi SPECT MPI performed with an A-SPECT camera 30 minutes post-stress showing exercise-induced perfusion defect (white arrows) in the anterior wall of the left ventricle extending mid to apex.

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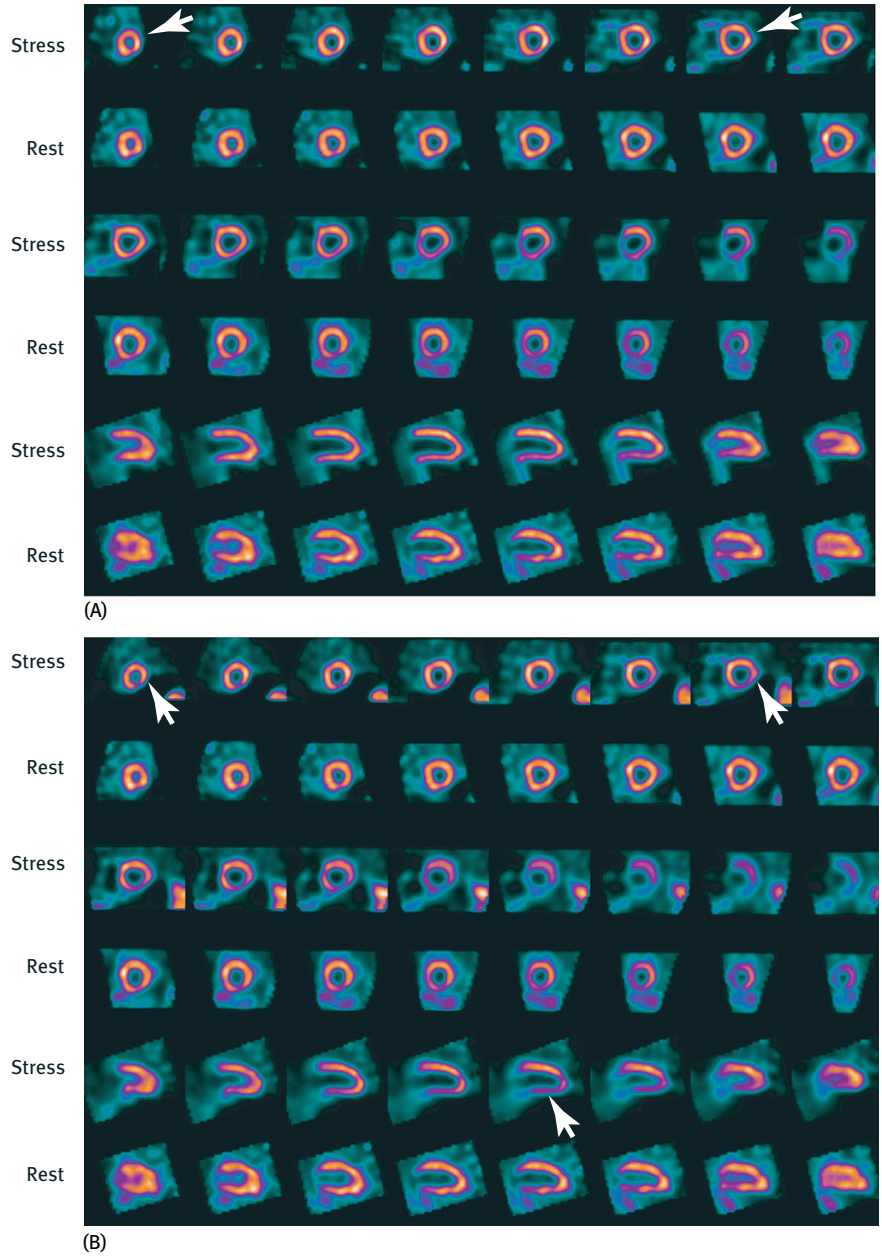

Figure 4. Tc-99m-sestamibi SPECT MPI performed with the D-SPECT camera (A) 60 minutes post-stress showing perfusion defects (white arrows) in the anterior and anterolateral walls of the left ventricle extending mid to apex; (B) 6 minutes post-stress showing perfusion defects (white arrows) in the lateral and inferolateral walls of the left ventricle.

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