Masked Ischemia on Myocardial Perfusion Imaging: A Case Example

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Introduction: Electrocardiography (ECG)-gated single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) for the diagnosis and prognosis of coronary artery disease (CAD) is the most commonly performed imaging procedure in nuclear cardiology.

Case Presentation: A 67-year-old man underwent exercise electrocardiography (ECG)-gated single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) for evaluating his mild dyspnea on exertion (New York Heart Association class I). Images showed inducible ischemia of severe intensity in the interior walls and moderate intensity in the apicoseptal and anteroseptal segments, but exercise stress to induce coronary hyperemia revealed marked ST-segment depressions in low heart rates and the patient complained of only mild dyspnea during these ECG changes. He subsequently underwent coronary angiography, which revealed left main and severe three-vessel disease. This discrepancy between the SPECT perfusion images and the extent of coronary artery disease in this case represents the masking of one ischemic territory (left system) by another more severely ischemic territory (right system).

Discussion: The reason is that we assess the relative and not absolute differences of the tracer uptake in this imaging modality. There may be other findings on MPI images which could help us overcome this pitfall, including detecting wall motion abnormalities, lung uptake of the tracer, or transient ischemic dilation. Another important issue is the ECG changes during exercise stress testing, which could point to a more extensive coronary artery disease than the one detected on MPI images alone.

*Keywords:*Coronary Artery Disease; Single-Photon Emission-Computed Tomography; Myocardial Perfusion Imaging; Coronary Angiography; Myocardial Ischemia

1. Introduction

Electrocardiography (ECG)-gated single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI) for the diagnosis and prognosis of coronary artery disease (CAD) is the most commonly performed imaging procedure in nuclear cardiology. This imaging modality could be performed by various perfusion tracers and protocols. Exercise or pharmacologic stress is necessary to induce coronary hyperemia. The accuracy of MPI for the detection of regional myocardial ischemia is dependent on multiple factors (1). In this case presentation, we aimed to describe an important pitfall in image interpretation and the various potential strategies to overcome it.

2. Case Presentation

A 67-year-old male patient was referred to our department with a chief complaint of dyspnea during strenuous activities (New York Heart Association class I). He had a history of hypertension and sudden cardiac death in his younger brother. Baseline ECG was normal.

Echocardiography revealed a good left ventricular (LV) systolic function (ejection fraction [EF] = 60%) with no regional wall motion abnormalities, LV hypertrophy, or significant valvular dysfunction. Laboratory tests showed dyslipidemia.

The patient underwent Tc99m-Sestamibi exercise/rest gated myocardial perfusion SPECT using a 2-day protocol. He exercised on a treadmill under a standard Bruce protocol. Baseline heart rate (HR) and blood pressure (BP) were 75 beats/min and 120/80 mmHg, respectively. At stage 3 of the Bruce protocol (HR of 112 beats/min and BP of 140/95 mmHg), 740 MBq of 99mTc-Sestamibi was injected as a compact bolus and exercise terminated due to ST-segment depressions at multiple leads of more than 2 mm (Figure 1). Imaging was performed 15 minutes after exercise in supine position. The resting gated SPECT was performed 90 minutes after a 740 MBq 99mTc-Sestamibi injection on the following day. Imaging was performed using a dual-head variable angle gamma camera (ADAC, Forte; Philips) equipped with low-energy high-resolution collimators. The SPECT imaging studies were performed using a 20% window

centered on the 140-keV peak as well as using a circular 180° acquisition for 32 projections (25 s/ projection). Gating was performed at 8 frames per cardiac cycle. The images were stored in a 64 × 64 matrix on computer, reconstructed by filtered back projection using a Butterworth filter (cut-off value was 0.35 cycle/cm for gated data but 0.55 cycle/cm for un-gated data, order = 5). No attenuation or scatter correction was used. Visual interpretation was performed using short-axis, vertical, and horizontal long-axis tomograms. Semi-quantitative analysis was performed using QPS (quantitative perfusion SPECT) software based on a 17-segment 5 scoring system. QGS (quantitative gated SPECT) was used for the calculation of the LVEF using gated images.

During the exercise test, the patient developed marked horizontal ST-segment depressions in multiple leads at low heart rates (Figure 1) but his functional capacity was good and he complained of only mild dyspnea. Gated SPECT images revealed inducible ischemia in the inferior segments (severe) as well as anteroseptal and apicoseptal segments (moderate) (Figure 2). The summed stress score (SSS), summed rest score (SRS), and summed difference score (SDS) were 19, 7, and 12, respectively. The LVEF using the post-stress gated images was 63%, while it was 59% in the rest gated images. No remarkable wall motion abnormality was noticed in post-stress as well as rest gated images. So, there was no evidence of stress-induced myocardial stunning. No transient ischemic dilation (TID) of the LV or lung uptake was observed.

Coronary angiography showed significant (60%) left main and severe three-vessel disease. The left anterior descending artery had severe stenosis (90-95%) at the proximal portion and also after the first diagonal branch as well as at the proximal portion of this well-developed diagonal branch (Figures 3 and 4). The left circumflex had two significant stenoses (up to 80%) at the distal portion (Figure 4), and the right coronary artery was cut off at the mid portion (Figure 5) with retrograde filling via the left coronary system and good distal run-off (Figure 4). The patient underwent coronary artery bypass grafting.
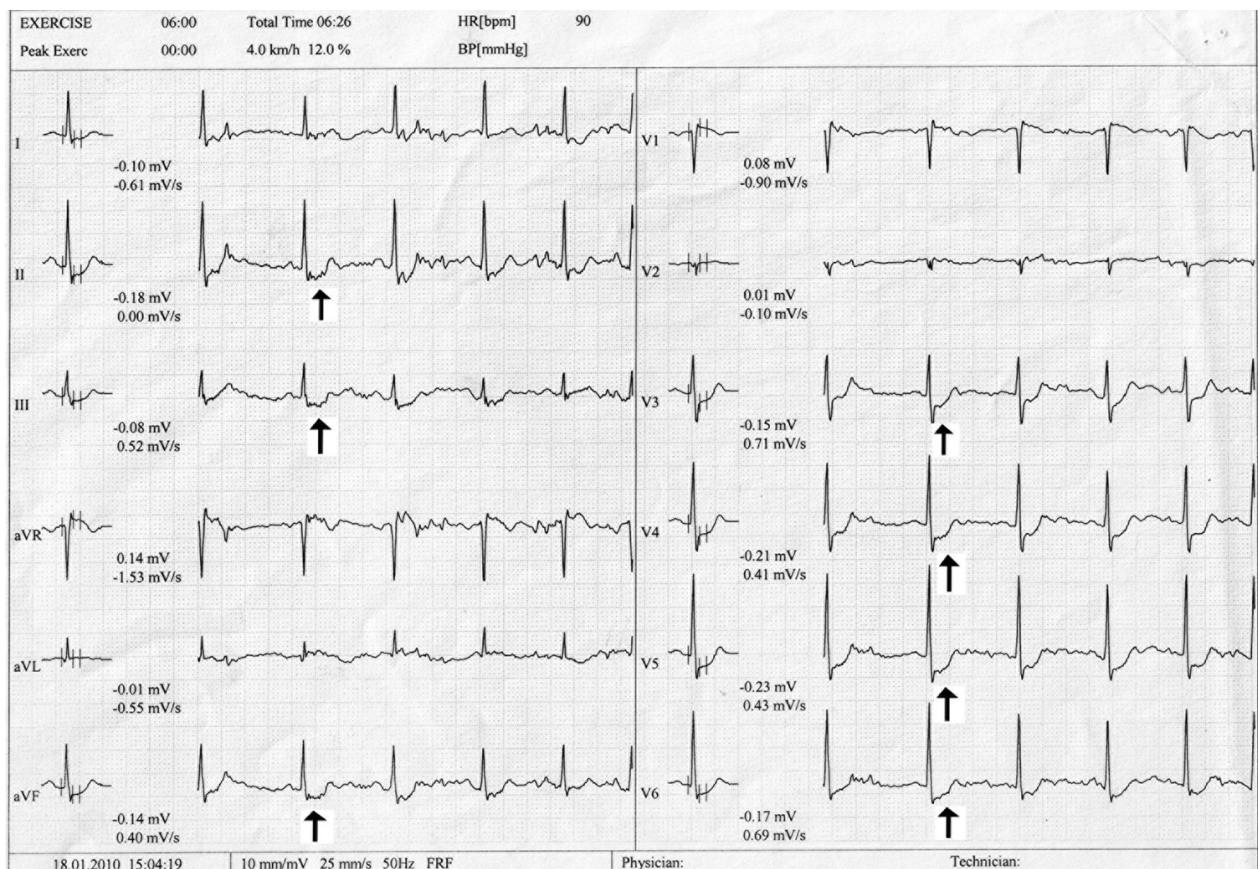

Figure 1. Exercise Stress Test, Revealing Marked (more than 2 mm) Horizontal ST-Segment Depressions in Multiple Leads (D2, D3, aVF, and V3-V6) at Low Heart Rates (arrows)
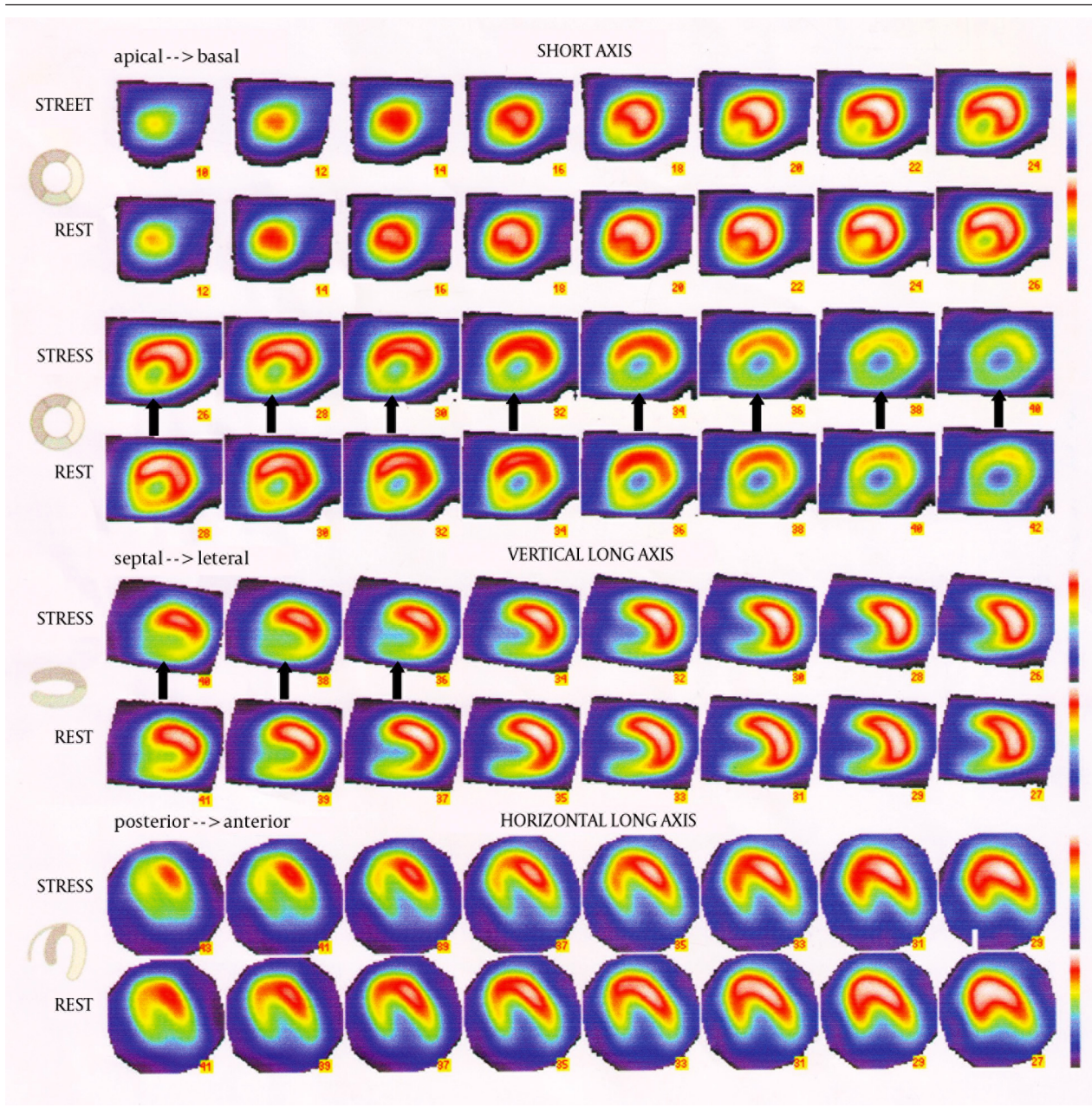
Figure 2. ECG-Gated Single-Photon Emission Computed Tomography Myocardial Perfusion Imaging, Showing Severe Inducible Perfusion Defects of Mainly the Inferior Walls of the Left Ventricle (arrows)

3. Discussion

Nowadays, SPECT MPI is the most commonly performed diagnostic imaging procedure in cardiology practice. With SPECT imaging, relative but not absolute regional differences of the tracer uptake throughout the myocardium can be detected and quantified (1). SPECT MPI is limited by this relative nature of the perfusion information. For example, if all vascular territories are hypoperfused in the presence of three-vessel CAD, the least hypoperfused areas appear normal (masked ischemia) and the true extent of CAD may be underestimated. Even worse, when the magnitude of perfusion abnormality is relatively equal in all areas, the images may look normal (balanced ischemia). The presence of wall motion abnormalities on post-stress gated SPECT imaging may be helpful in the detection of these patterns (2). Moreover, there are additional abnormal findings on SPECT images that provide information beyond the perfusion pattern alone, including lung uptake of the tracer and TID of the LV (3, 4).
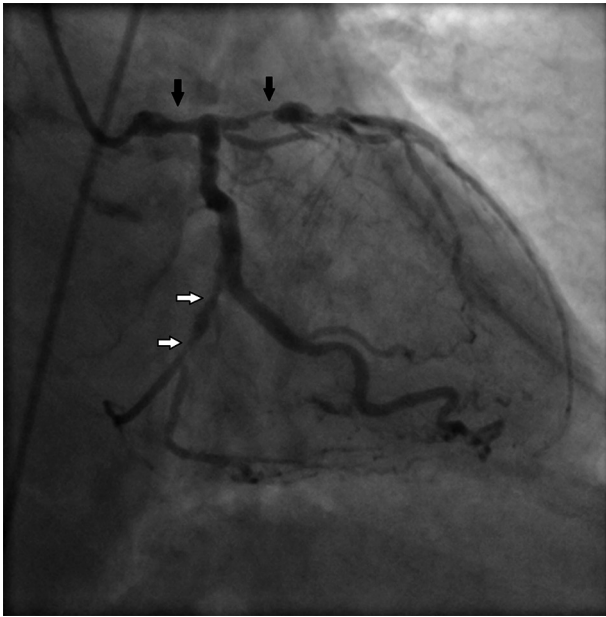
Figure 3. Coronary Angiography in the Right Anterior Oblique Caudal Projection, Showing Significant (60%) Left Main Disease, Severe Stenosis (90-95%) of the Proximal Left Anterior Descending Artery (black arrows) and Two Significant Stenoses (up to 80%) at the Distal Left Circumflex Artery (white arrows)

Figure 4. Coronary Angiography in the Right Anterior Oblique Cranial Projection, Showing Severe Stenosis (90-95%) of the Left Anterior Descending Artery after the First Diagonal Branch as well as at the Proximal Portion of this Well-Developed Diagonal Branch (black arrows)

The distal right coronary artery fills via the left coronary system with good run-off (white arrow).
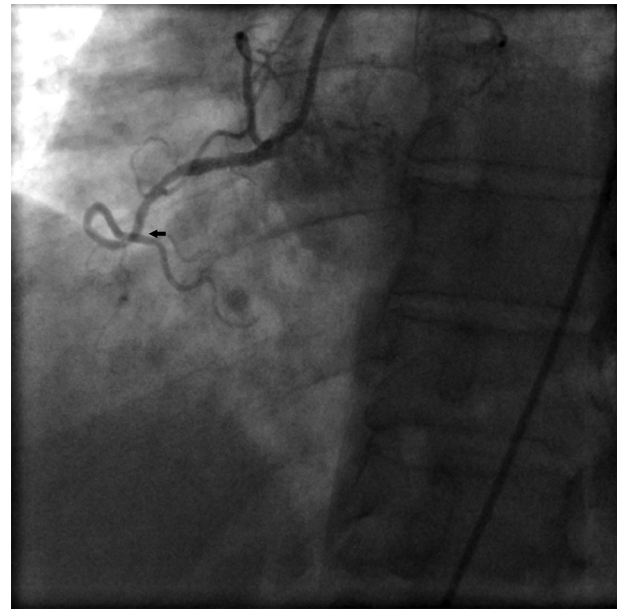

Figure 5. Coronary Angiography in the Straight Left Anterior Oblique Projection, Showing that the Right Coronary Artery is Cut off at Mid Portion (arrow)

Patients with substantial lung tracer uptake after stress often have severe multi-vessel disease, but it could be missed with Tc-99m tracers because of the more delayed onset of imaging compared with thallium-201 tracers. This is because of minimal splanchnic or background activity after thallium-201 stress injection and the redistribution properties of thallium-201, which mandate that imaging begin relatively early after stress. Thus, lung uptake may be more apparent with thallium-201 rather than Tc-99m-based tracers (1). TID during stress is another sign associated with extensive and severe CAD in angiography (5). Incorporating the exercise stress findings (presence and extent of ST-segment changes, hypotension, and functional capacity) is also useful in enhancing the diagnosis of left main or three-vessel CAD, and the development of greater than 2 mm of ST depression or hypotension on the ECG treadmill testing increases the likelihood of left main or three-vessel CAD (6, 7).

In our patient, more severe abnormality in the right coronary artery territory masked less degree of abnormality in the left coronary system in an unbalanced fashion. This emphasizes one of the limitations of SPECT MPI, which is based on detecting perfusion heterogeneity. Other potential imaging findings to detect extensive CAD, including wall motion abnormalities, lung uptake, and TID, were not apparent in the imaging study, but the presence of about 2 mm of horizontal ST-segment depressions in low HRs (90/min) guided us to determine his coronary anatomy in spite of his good functional capacity and mild symptoms. In addition, exercise for inducing hyperemia

provides additional objective information (ST-segment changes, blood pressure response, and functional capacity) and should be preferred over pharmacologic stress testing whenever it is possible (3). Last but not least is the fact that the severity of patients' symptoms does not correlate with the extent of myocardial ischemia per se.

This case shows how clinical data (age, multiple risk factors, and history of sudden cardiac death in younger brother), and exercise-induced ECG changes could alter the post-test probability of extensive and severe multivessel disease. In interpreting SPECT MPI, it is important to be aware of its potential limitations and artifacts and to incorporate the clinical data and objective findings in exercise stress testing for decision-making in performing further diagnostic studies and revascularization.

Acknowledgements

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