Case Report

False Perfusion Defect on Myocardial Perfusion SPECT Induced by Sternal Tumoral Uptake

Sahar Mirpour[1], Ali Gholamrezanezhad[1,2], Kianoush Ansari-Gilani[1]

[1]Research Institute for Nuclear Medicine, Tehran University of Medical Sciences, [2]Young Researchers' Club, Azad University of Tehran, Iran

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A 61-year-old man with chronic chest pain was referred for a myocardial perfusion scan. Following dipyridamole infusion, ^{99m}Tc-MIBI was injected and the reconstructed images showed decreased activity in the anteroseptal wall, which prompted the supervising physician to review the cinematic data. Reviewing the cinematic images revealed abnormal ^{99m}Tc-MIBI uptake by the ribs, clavicles, and more intensely in the sternum. The next morning, whole-body planar imaging was performed 20 minutes after injection of ^{99m}Tc-MIBI at rest, which again revealed widespread abnormal ^{99m}Tc-MIBI uptake. Subsequently, a skull X-ray showed multiple areas of osteolysis, typical of punched-out lesions. In view of this evidence, the patient underwent bone marrow aspiration, which revealed marked plasmocytosis and confirmed the diagnosis of multiple myeloma. Our case indicates a false positive perfusion defect induced by sternal sestamibi uptake secondary to sternal tumoral involvement. As the sternum is in close proximity to the myocardium, the effects of its unusual radiotracer uptake on the pattern of myocardial perfusion can be significant. The interpretation of a myocardial perfusion scan should not be limited to the heart and, as the ultimate goal is the patient's well-being, any available information should be interpreted.

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Address:
Ali Gholamrezanezhad

Research Institute for Nuclear Medicine
Shariati Hospital
Northern Kargar St.
14114 Tehran, Iran
e-mail:
gholamrezanejhad@razi.tums.ac.ir

There are numerous reports regarding the detection of extracardiac activity in myocardial scintigraphies.[1-7] Extracardiac activity can be an indirect but important indication for a variety of non-cardiac disorders[4-10] that may occasionally mimic cardiac symptoms. Some such disorders are gastric diseases,[6,7] liver and gallbladder diseases,[1] spleen disorders,[1] vertebral pathologies,[1] and pulmonary pathologies.[8] This has led to occasional reports emphasizing the importance of reviewing the cinematic images to detect any possible underlying pathologies incidentally discovered in these imaging procedures,[2,6,8,10] a rule that is easily forgotten by nuclear medicine specialists.[9]

On the other hand, the adverse effects of extracardiac activity on the quality and accuracy of myocardial perfusion SPECT has been emphasized by some authors.[11,12] It seems that significant extracardiac activity can induce false perfusion defects on the final processed views and hence should be avoided.[11,12] All nuclear medicine specialists should be aware of the importance of such extracardiac activity[13-15] and familiar with the possible effects.

Case presentation

A 61-year-old man with a history of chronic non-radiating non-exertional chest pain for a few months was referred to our nuclear medicine department by his cardiologist. A myocardial perfusion scan (MPS) was performed in SPECT mode after a stress protocol of dipyridamole infusion using 925 MBq (25 mCi) ^{99m}Tc-MIBI injection. The reconstructed images showed decreased activity in the anteroseptal wall

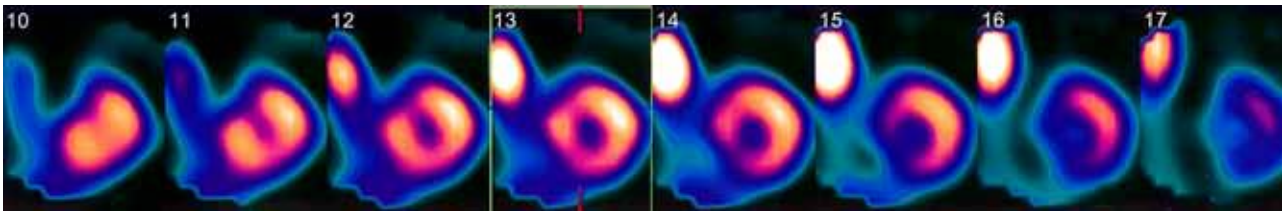

Figure 1. Myocardial perfusion study showing a perfusion defect involving the anteroseptal wall.

(Figure 1) and prompted the supervising nuclear medicine specialist to review the cinematic data.

Reviewing the cinematic images revealed abnormal ^{99m}Tc-MIBI uptake by the ribs and more intensely in the sternum. A thorough physical examination confirmed that the origin of chest pain was musculoskeletal, as the patient suffered from a relatively severe tenderness on palpation and percussion of the chest wall.

As it is routine for our department to perform MPS based on the two-day protocol, the patient presented to the department in the morning of the next day. After informing the patient and recording his consent, the nuclear medicine specialist decided to perform whole-body planar imaging (Figure 2) 20 minutes following IV injection of 925 MBq (25 mCi) ^{99m}Tc-MIBI at rest. This again showed widespread abnormal ^{99m}Tc-MIBI uptake by the ribs, clavicles, pelvis, and more intensely in the sternum. SPECT-mode rest-phase cardiac imaging was performed one hour later, revealing decreased activity in the anteroseptal wall, the same as in the post-stress images. The patient underwent evaluation using dobutamine stress echocardiography, which showed no wall motion abnormality, including in the anteroseptal wall. Since the patient also had no ECG abnormalities, it seemed that the abnormal scintigraphic pattern of the anteroseptal wall was due to an artifact induced by adjacent sternal activity. Even manual manipulation of the region of interest failed to decrease the adverse effect of intense sternal uptake on anteroseptal wall activity. As the heart and sternum are located in the same transverse plane and, in at least some views, they overlap, it was impossible to separate them completely.

Regarding the abnormal findings from the whole-body sestamibi scan, multiple myeloma, leukemia and lymphoma were included in the differential diagnoses and hence, after consultation with the referring physician, further workups were performed. The patient suffered from anemia and showed M-component in serum electrophoresis. However, the urine analysis was negative for Bence-Jones protein. As the patient did not consent to bone marrow aspiration (BMA), a skull X-ray (Figure 3) was performed, showing multiple small areas of osteolysis, with typical characteristics of "salt and pepper" or punched-out lesions. In view of this secondary evidence the patient gave consent for BMA, which revealed marked plasmocytosis.

Figure 2. Whole-body planar imaging revealed abnormal radiotracer uptake by the ribs, clavicles, pelvis, and more intensely in the sternum.

Discussion

All nuclear medicine imaging specialists should be

Figure 3. Skull X-ray showed the characteristic feature of "pepper and salt", the etiology of which was confirmed to be multiple myeloma.

vigilant about improving the specificity of scintigraphic studies by eliminating known sources of false-positive scans; the best way to improve specificity is to detect and eliminate artifacts.[12] It has been confirmed that using filtered back-projection to reconstruct MPS images may generate artifacts caused by the so-called "halo" and "spillover" effects, which can only be partially solved by new imaging techniques.[8] Moreover, it has been frequently reported that myocardial perfusion SPECT can be affected by artifacts related to the extracardiac activity of adjacent structures or by radiotracer uptake by non-target organs;[12] numerous strategies have been implemented in an attempt to solve the problem and to improve image interpretation.[16-19] Therefore, it has been recommended that extracardiac activities should be restricted to a minimum in order to have an examination of good diagnostic quality.[8] To achieve this goal, it is essential as the first step in the interpretative process to view the raw projection data of each study.[8] It has been emphasized that the reconstruction of SPECT images after removing areas of extracardiac accumulation can reduce their influence on the final reconstructed views and is an appropriate method for improving the quality of cardiac images.[20]

Although there is just one report of incidentally discovered sternal metastasis in MPS (mimicking cardiac angina),[21] to the best of our knowledge there is no previous report of a false positive perfusion defect induced by sternal sestamibi uptake secondary to sternal tumoral involvement. This case again underlines the need for nuclear medicine specialists to review all cinematic images in order to detect any underlying non-cardiac pathologies that might induce false perfusion defects on the final processed views. Based on the study of Pitman et al, these artifacts vary widely, depending on the proximity of the extracardiac activity to the ventricle.[11] As the sternum is in close proximity to the myocardium (Figure 1), the effects of its unusual radiotracer uptake on the pattern of myocardial perfusion can be significant, as is confirmed by our case.

Our case also reveals a relatively infrequent case of malignancy, detected for the first time by a nuclear medicine specialist reviewing cinematic images of MPS. Since radioactive thallium and ^{99m}Tc-sestamibi are tumor-seeking agents, it is not surprising that several tumors in the geriatric population (i.e. the age at which the prevalence of cardiac diseases increases and the demand for MPS increases proportionally) are discovered incidentally after performing MPS.[7] However, given the nonspecific nature of these radiopharmaceuticals, any interpretation should be made with caution.[6] Taking the time to review post-radiotracer injection images offers additional advantages over other imaging modalities,[7] as the overall incidence of such non-cardiac findings (1.13%) in the radiological evaluation of coronary arteries (coronary multi-slice computed tomography)[22] seems to be generally less than in scintigraphic studies (Table 1). Also, if clinically needed, scintigraphic studies can be extended to whole-body imaging for a more extensive evaluation of the patient, as in our case, after the initial detection of an abnormal extracardiac activity. Although the incidence of such non-cardiac abnor-

Table 1. There are significantly conflicting statistics from previous reports concerning the incidence of extracardiac abnormalities on myocardial perfusion scintigraphy.

Study	Major focus	Incidence
Jones et al (2008)[10]	All non-cardiac findings	0.69%
Williams et al (2003)[4]	All non-cardiac findings	1.7%
Reza et al (2005)[11]	All non-cardiac activities	7%
Gedic et al (2007)[24]	All non-cardiac findings	1.2%
Shih et al (2002)[13]	Intra-thoracic and intra-abdominal abnormalities	22.55%
Shih et al (2005)[1]	Intra-abdominal abnormalities	41.3%
Gholamrezanezhad et al (2006)[2]	Gastric wall uptake	1.9%
Côté and Dumont (2004)[8]	Gastric wall uptake	1.6%
Kim et al (2001)[12]	Pulmonary uptake	2.9%

malities is relatively low, with significant discrepancy among previous reports (Table 1), its clinical impact can be significant for some patients, such as our case.[10] Also, in a busy practice the total may reach a remarkable number. For example, Jones et al stated that, although most non-cardiac findings represent previously known pathologies, possibly up to one-fifth of them can constitute clinically new findings.[10]

As there is the opportunity to reveal other pathologic conditions, the interpretation of myocardial perfusion imaging should not be limited to the heart and, as the ultimate goal is the well-being of the patient, any available information should be examined and interpreted.[10] In fact, as numerous other organs are included in the imaging field, such an opportunity to evaluate them should not be simply missed, and the supervising physician must be aware of the physiologic distribution of injected radiotracers in order to recognize abnormal uptake. In agreement with the conclusion of Jones et al, we believe that any non-cardiac finding from an MPS that arouses suspicion of a serious disease warrants direct contact with the referring physician for further evaluation,[10] as extracardiac findings and non-perfusion abnormalities may on occasion account for the patient's symptoms[23] or lead to an alteration in patient management.[24] On the other hand, the under-evaluation of any unusual extracardiac activity and the failure to report such an abnormality can be a source of missed diagnosis of a detectable disorder.

In addition, based on this case, some other minor points should be taken into consideration:

a. Chest discomfort is a physically and emotionally distressing symptom, which often poses a diagnostic dilemma for the physician regarding the underlying etiology and extent of evaluation.[2] The classical features of angina do not distinguish the origin of the pain. However, differentiation between cardiac and non-cardiac origins of pain is extremely important in the subsequent management of the patient. Hence, a thorough clinical and physical examination is essential for all patients, as in this case the referring physician failed to obtain primary evidence of skeletal chest pain and to differentiate it clinically from chest pains of cardiac origin. A comprehensive clinical examination is the mainstay of clinical practice; this is easily forgotten by some physicians.
b. The urine sample of our patient was negative for Bence-Jones protein. Previously, Brigden et al concluded that there are individual patients who will be negative in one sample, but positive in another.[25] Shimizu et al showed that serum free-light chains levels are sometimes elevated in patients with Bence-Jones type myeloma, in spite of negative urinary immunoelectrophoresis.[26] Along similar lines, McLaughlin stated that, on account of the manner in which light chains are metabolized by the kidney, production rates may have to be quite high before the urine is positive for Bence-Jones protein, thus reducing the potential sensitivity of the urine sample.[27] Based on these facts, one cannot assume that all cases of multiple myeloma will excrete Bence-Jones protein in urine.

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