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CASE REPORT

Hot-clot artifact in lung parenchyma on [^{68}Ga]Ga-PSMA-11 PET/CT can mimic prostate cancer metastasis

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ABSTRACT

[^{68}Ga]Ga-PSMA-11 PET/CT scan is an important whole-body imaging tool in oncology and is specifically used for staging and re-staging of prostate cancer, in recent years. Findings of significant focal accumulation of PSMA in the lung parenchyma without corresponding CT abnormalities are challenging and may be a cause for false positive interpretation of metastasis, caused by pulmonary microembolism due to hot-clot artifacts, as previously described in 2-[^{18}F]FDG PET/CT studies. Here we present an unusual case of focal PSMA uptake in lung parenchyma without structural lesions on CT scan, which we believe is due to hot clot because of faulty injection techniques.

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INTRODUCTION

The treatment of prostate cancer (PCa) was revolutionized with the advent of positron emission tomography (PET) imaging using prostate-specific membrane antigen (PSMA). Accordingly, the literature has been flooded with an enormous variety of cases of incidentally detected PSMA uptake in non-prostatic lesions, leading to questioning of the specificity of PSMA-PET results [1, 2]. However, a recent meta-analysis involving 4790 patients undergoing [^{68}Ga]Ga-PSMA-11 PET/CT for various indications showed a per-lesion specificity of 99% [3]. Therefore, the non-prostatic lesions showing PSMA uptake on PET imaging represent an unusual finding that needs to be recognized not only to avoid misdiagnosis but also to enable correct therapy planning. On the other hand, although non-prostatic PSMA uptake might impair the diagnostic performance of PSMA-PET imaging, the receptor expression observed in other malignant tumor cells may broaden its application in diagnostic or even therapeutic approaches of other tumors [4]. The normal biodistribution of PSMA is frequently checked in PET imaging, and physiologic PSMA uptake is usually seen in lacrimal, parotid and submandibular glands, as well as in the small intestine, kidney, liver, spleen and bladder. Mild to moderate uptake can be observed in the nasal and esophageal mucosa; the vocal cords, gallbladder and bile ducts; tracheal and proximal bronchi; mediastinal, axillary and inguinal lymph nodes. Breast uptake (gynecomastia) and sympathetic ganglia, such as B. stellate, as well as ganglia located in the celiac, hypogastric, and presacral regions are often visualized [5-7]. The key features for the differential diagnosis of metastatic disease are also thoroughly highlighted to ensure proper imaging interpretation. PSMA hot clot artifact is a condition that can lead to false positivity that occurs due to the injection technique. Microemboli secondary to erythrocyte agglutination of PSMA can result in transient obstruction of small pulmonary arterioles. In this case, PET images show areas of focal high-intensity PSMA uptake in the lung parenchyma, while CT images do not show corresponding lesion at the same site [8]. Because misdiagnosis of lung metastases can lead to inappropriate staging, it is important to distinguish hot-clot artifacts; if in doubt, rescanning is recommended. In this report, we present an unusual case of incidental focal PSMA uptake in the lungs associated with normal CT scans, which subsequent rescanning revealed to be hot-clot artifacts.

CASE REPORT

First PSMA imaging

A 75-year-old man with prostate adenocarcinoma with a Gleason score of 4+5 and a PSA of 23.4 ng/mL at first scan underwent PET/CT with a suspected diagnosis of right lung metastasis. Whole-body PET/CT images were acquired 60 minutes after PSMA injection using a dedicated full-ring PET/CT scanner (Biograph 6; Siemens Medical Systems, Erlangen, Germany). Unenhanced CT images with a 3 mm slice width were acquired at 130 kV and 90 mA (mean). The PET scan was taken immediately after the CT scan and 57 bed positions were used with a recording time of 3 minutes each. CT-based attenuation corrections were applied to the PET images and reconstruction was performed using an iterative reconstruction algorithm. The scan showed a 7-8 mm nodule in the apical segment of the LLL with increased uptake (which is not located in the basal portion of the lungs, which is the location susceptible for respiratory movement artifacts, SUVmax=12.73). CT images did not show a lesion at the mentioned segment (Figure 1). There were lymph nodes in the para-aortic region (the largest one was 19mm in SAD) with no abnormal uptake. Enlarged lymph nodes with no abnormal uptake were also noted in the common iliac stations. There was one lymph node in the right external iliac station (13 mm at SAD) with SUVmax=38.76. In addition, there were also two internal iliac lymph nodes with SUVmax=7.47. The peripheral part of the right prostate lobe showed a focus of increased uptake (32×24 mm) with SUVmax=57.4. Sclerotic lesions in the sacrum and right pelvic wing were suspicious for metastatic involvement too, with no PSMA avidity.

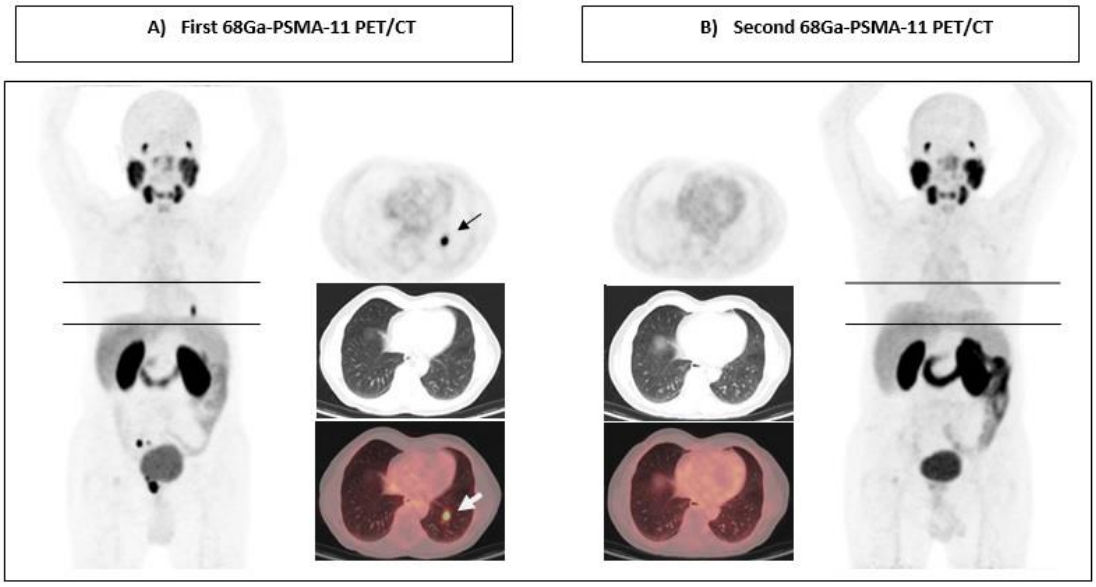

Fig 1. The whole body [^{68}Ga]Ga-PSMA-11 PET/CT scan showed a zone of tracer uptake in the apical segment of the LLL with increased uptake (which is not located in the basal portion of the lungs, which is the location susceptible for respiratory movement artifacts, SUVmax=12.73). CT images did not show a lesion at the mentioned segment (A). Follow up [^{68}Ga]Ga-PSMA-11 PET/CT scan was unremarkable, with resolution of the lung uptake(B)

Whole body bone scan ([^{99m}Tc]Tc-MDP)

The scan demonstrated degenerative changes in the spine, knees. Sclerotic areas are detected in the left pubis, right iliac wing, right side of sacral ala and a smaller focus in the left iliac wing without increased MDP uptake. Sclerotic lesions in pelvic bones were not MDP-avid, corresponding to PSMA non-avid upon the PET scan performed two days previously (Figure 2).

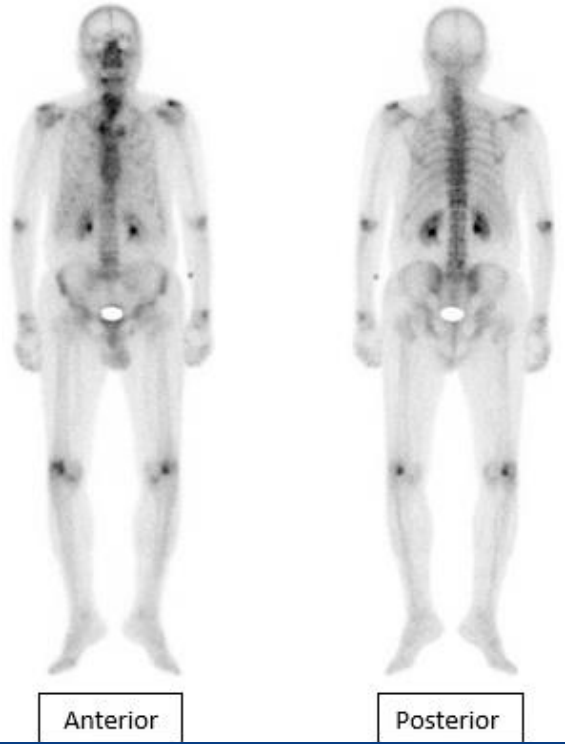

Fig 2. [^{99m}Tc]Tc-MDP whole body bone scan in anterior and posterior view revealing no evidence of bone metastases

Second PSMA imaging

After the initial imaging with [^{68}Ga]Ga-PSMA-11 PET/CT, patient underwent androgen deprivation therapy (ADT) and referred for response evaluation after three months. The scan was repeated with a lower dose CT protocol (110 kV and 50 mA) confined to the thoracic region to reduce the whole-body radiation dose. The previously detected focal hyperactivity in the left lung has been shrunken with no PSMA uptake, proving the PSMA hot-clot and lung metastasis was ruled out (Figure 1). There was mild focal hyperactivity in the peripheral prostate gland with much less intensity comparing the previous PET scan (recent SUVmax=3.92, previous SUVmax=57.4). The previously detected pelvic lymph nodes showed no PSMA avidity at present time, suggestive of complete therapeutic response.

DISCUSSION

PSMA scans have been shown to have a variety of false positive findings including celiac and other sympathetic and parasympathetic ganglions, small intestine, NSCLC, neuroendocrine tumors, Paget's disease of the bone, and reactive lymph nodes [5-7].

In addition to attenuation correction provided by CT imaging, PET/CT scanning allows for anatomical correlation of sites of metabolic activity recognizable on PET images.

The lack of metabolic activity at lesions evident on CT images is common and can be due to various reasons such as low PSMA affinity, response to therapy and small nodule size that falls below the PET resolution threshold or a partial volume effect. On the other hand, focal activity on PET images without a corresponding CT counterpart is a confusing situation. Hot-clot artifact is one of several reasons for such a finding. The underlying mechanism of this artifact is the agglutination of PSMA by erythrocytes during PSMA injection. Microemboli developed due to the adhesion of PSMA to concentrated erythrocytes lead to occlusive plugs in the pulmonary cappilary system leading to the focal PSMA uptake with high metabolic activity on PET images [5], but the CT images do not show a corresponding parenchymal nodule. Microemboli most commonly result from aspiration of blood into the injector, but extravenous or fast injection can also be possible causes. The tiny blood clots lodge in the distal capillary bed of the lung, very similar to macroaggregates of albumin lodged in the lung parenchyma [6]. Misalignment between PET and CT image planes is another reason for reading discrepancies. The lung is the organ that often shows the misalignment of PET and CT images. Misalignment can cause attenuation correction artifacts. PET images without attenuation correction and fusion images can be used to identify these artifacts. Respiratory motion artifacts can occur in the basal lobes of the lungs, the diaphragm, and the upper abdomen. Shallow breathing is recommended to achieve optimal image fusion during PET/CT acquisition [7]. This case presented a focal incidental PSMA uptake on the lung parenchyma with no accompanying anatomic change lesion on the CT images. In addition, non-attenuation corrected PET images showed focal PSMA uptake in the patient. There was no shift compatible with misalignment of anatomical landmarks on the fusion images. The patient's PSMA uptake disappeared on a repeat [^{68}Ga]Ga-PSMA-11 PET/CT scan at the time of the second imaging, proving to be an artificial pulmonary hot spot.

CONCLUSION

There are three important points in diagnosing a PSMA hot-clot artifact:

i) A single or multiple foci of focal pulmonary PSMA uptake with no accompanying CT findings.

ii) A high level of visual and quantitative tracer activity at the involved foci.

iii) Disappearance of the activity following repeat scan [8].

To the best of our knowledge, despite few pulmonary hot spot reports following 2-[^{18}F]FDG studies in the literatures [9, 10], no such findings are reporting PSMA scan. Ha et al. reported three cases in which a patient had five active points [10]. Karantanis et al. found progression of 2-[^{18}F]FDG uptake to more peripheral lung sites on repeat scanning 30 minutes after the initial scan, ruling out a true parenchymal lung lesion [8]. The authors believe that more data are needed to assess the contribution of late scanning in distinguishing true lesions from artifacts on PET/CT imaging. It is important to detect hot-clot artifacts in PET/CT imaging, as incorrect staging can lead to mistreatment in oncology patients. One should pay attention to the injection technique to avoid extravasation or blood aspiration into the injector to avoid such artifacts.

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