Giant Cell Tumor Pulmonary Metastases Mimic Primary Malignant Pulmonary Nodules on ^{18}F -FDG PET/CT

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Abstract A 59-year-old man with a 30-year history of multiple recurrences of a giant cell tumor (GCT) of the left knee was referred for an ^{18}F -FDG PET/CT to evaluate a solitary pulmonary nodule. The nodule was mildly FDG-avid, raising suspicion of malignancy. It was excised and histologically proven to be a GCT pulmonary metastasis. A follow-up PET/CT done 2 years later revealed a new, larger lung mass that was more intensely FDG-avid, but of the same histology. This rare report highlights a pitfall in the evaluation of solitary pulmonary lesions by ^{18}F -FDG PET/CT in patients with GCT of the bone.

Keywords Giant cell tumor · GCT · Pulmonary metastases · FDG · PET/CT

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Introduction

Giant cell tumor (GCT) of the bone is a benign but locally aggressive tumor that accounts for 5% of all bone tumors, including 20% of benign bone tumors. It occurs most frequently in young adults between 20 and 40 years of age, with no sex predilection. About 3% of patients with benign GCTs of the bone develop pulmonary metastases [1–4].

Although ^{18}F -FDG PET/CT cannot reliably differentiate a benign GCT of the bone from a malignant bone tumor, PET/CT has been used to assess GCT in very specific situations, including: the evaluation of ^{18}F -FDG kinetics and gene expression in GCTs, detection of multifocal GCTs, and staging of sarcomatous degeneration of GCTs [5–10]. ^{18}F -FDG uptake in pulmonary metastases from a benign GCT of the bone has not been previously described in the literature. We present the imaging characteristics of GCT pulmonary metastases mimicking a primary lung malignancy in a patient with a history of recurrent GCTs, as seen on initial and follow-up ^{18}F -FDG PET/CT.

Case Report

A 59-year-old man was referred for an ^{18}F -FDG PET/CT for evaluation of a solitary pulmonary nodule discovered incidentally on a chest x-ray. Thirty years ago he had been treated for a benign GCT of the left distal femur with curettage and autografting. Six years ago, the tumor recurred locally and was treated with curettage, cementing and phenol. Four years ago it recurred in adjacent soft tissues of the left knee, however this time with a more aggressive histology, which was treated with distal femoral resection, prosthesis placement and two cycles of adriamycin and cisplatin chemotherapy.

Fig. 1 ^{18}F -FDG PET/CT maximum intensity projection (MIP) images with (a) anterior, (b) left lateral and (c) lower extremity views show a small, mildly FDG-avid nodule in the left upper lung (arrows), and mild FDG uptake surrounding the left knee prosthesis

An ^{18}F -FDG PET/CT (Discovery ST, GE Healthcare, Canada) was performed. The patient fasted overnight prior to the examination and waited in a quiet, dark room the morning of the exam. Oral contrast (900 cc of barium) was administered. An ^{18}F -FDG emission scan extending from the head to the mid-thigh was obtained 60 min after intravenous injection of 0.22 mCi/kg of ^{18}F -FDG. A second emission scan extending from the pelvis to the feet was obtained 112 min post ^{18}F -FDG injection. The emission scans were acquired for 5 min per field of view, each covering 14.9 cm, at an axial sampling thickness of 3.75 mm/slice. The 16-slice helical CT acquisition was performed prior to a full-ring dedicated PET scan of the same axial range. The CT component was operated with an X-ray tube voltage peak of 140 kVp, 80 mA (whole body), 70 mA (legs), a 1.75:1 pitch, a slice thickness of 3.75 mm and a rotational speed of 0.8 s/ rotation. The patient was allowed to breathe normally during the PET and CT acquisitions. PET images were reconstructed with CT-derived attenuation correction using ordered subset expectation maximization software (20 subsets, 2 iterations). Only the maximum standardized uptake value (SUV_{max}) was reported, corrected for body weight.

The ^{18}F -FDG PET/CT maximum intensity projection (MIP) images (Fig. 1) showed a small mildly FDG-avid nodule in the left upper lung and mild diffuse uptake surrounding the left knee prosthesis (which was not considered suspicious).

Fig. 2 Transaxial views of the thorax with (a) CT, (b) ^{18}F -FDG PET and (c) PET/CT fusion images show a 1-cm nodule in the left upper lung posteriorly (arrow) with SUV_{max} 2.9

The 1-cm left upper lung nodule was located posteriorly with a SUV_{max} of 2.9, raising a suspicion of malignancy (Fig. 2). An excisional biopsy was performed, and the histology was consistent with a GCT pulmonary metastasis.

The patient was followed regularly with CT scans of the thorax, and a follow-up ^{18}F -FDG PET/CT was performed 2 years after the initial PET/CT to evaluate a new growing mass in the left lower lung. MIP images of the follow-up PET/CT (Fig. 3) showed a new, larger and more intensely FDG-avid mass in the left lower lung (arrow), measuring 3.5 cm $\times$ 1.5 cm with SUV_{max} of 4.9 (Fig. 4), again raising a strong suspicion of malignancy. This mass was excised, and histological evaluation revealed another GCT pulmonary metastasis (Fig. 5). Despite the appearance of pleural involvement, the lung metastasis was completely encased by a rim of normal lung tissue. There were no other FDG-avid abnormalities in the remainder of the scan. There was persistent mild diffuse FDG uptake surrounding the left knee prosthesis, which was unchanged compared to the previous PET/CT.

Discussion

GCT of the bone occurs almost exclusively at the metaphysis-epiphyseal junction. The most frequent locations include: the distal femur, proximal tibia, distal radius and sacrum. About 3% of patients with GCT of the bone develop pulmonary

Fig. 3 MIP images of the follow-up ^{18}F -FDG PET/CT done 2 years after the initial PET/CT with (a) anterior, (b) left lateral and (c) lower extremity views show a new lung mass in the left lower lung posteriorly (arrow). There is mild FDG uptake surrounding the left knee prosthesis

Fig. 4 Transaxial views of the thorax with (a) CT, (b) ^{18}F -FDG PET and (c) PET/CT fusion images show a 3.5×1.5 -cm mass in the left lower lung with SUV_{max} 4.9

Fig. 5 a Hematoxylin and eosin-stained sections ($\times 100$ magnification) of the 3.5-cm lung mass identified on the follow-up PET/CT. Atypical mononuclear cells with enlarged nuclei and prominent nucleoli admixed with numerous osteoclast type giant cells, consistent with

GCT metastasis. b Hematoxylin and eosin ($\times 400$ magnification). Highly atypical mononuclear histiocytic cells with epithelioid morphology and evidence of mitotic activity, confirming the aggressive nature of the GCT pulmonary metastasis

metastases, and the lung is known to be the most common site for metastasis. Mean age at presentation with pulmonary metastases is 30 years, males and females are affected equally, and the mean interval to developing a pulmonary metastasis is about 3.8 years. The natural history of lung metastases is unpredictable. They may show spontaneous regression, remain stable, or show slow or rapid progression [1–4]. Our patient developed two separate GCT pulmonary metastases over the course of 2 years.

Among benign bone tumors, GCTs show significantly elevated glucose metabolism and ^{18}F -FDG uptake, but cannot be reliably distinguished from malignant bone tumors based on SUV_{max} alone [5–7]. In this case, the PET/CT incidentally identified a GCT pulmonary metastasis that showed mild ^{18}F -FDG uptake. Another GCT pulmonary metastasis was identified on the follow-up PET/CT, which had grown rapidly to a 3.5-cm mass and showed more intense ^{18}F -FDG uptake. On both PET/CT studies, the GCT pulmonary metastases raised a strong suspicion of a primary lung malignancy. The SUV_{max} values of both lesions (2.9 and 4.9) were above the cutoff SUV_{max} values of 2.0–2.5, which have been suggested in the literature to differentiate benign from malignant pulmonary nodules [11–13]. The rapid appearance and growth of the second pulmonary mass only added to the suspicion of malignancy.

In conclusion, PET/CT readers should be aware that GCT pulmonary metastases can grow significantly on follow-up studies and can also show significant ^{18}F -FDG uptake, mimicking primary malignant pulmonary lesions. This represents a potential pitfall in the evaluation of pulmonary nodules and masses by ^{18}F -FDG PET/CT in patients with a prior history of GCT of the bone.

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