

Fluorine-18-Fluorodeoxyglucose Uptake in Pneumonia

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Whole-body PET imaging with ^{18}F -fluorodeoxyglucose (FDG) has been shown to be effective in distinguishing benign and malignant pulmonary disease. Mild elevations in FDG uptake with standardized uptake values (SUVs) less than 2.5 have been reported in benign lesions, including pneumonia. We report a case of presumed bacterial pneumonia with markedly elevated FDG uptake in a patient with a concomitant squamous cell carcinoma in the contralateral lung. SUV's were similar for both lesions (4.9 and 5.4). This case demonstrates an inflammatory etiology for false-positive FDG PET imaging in the evaluation of focal pulmonary abnormalities.

Key Words: fluorine-18-fluorodeoxyglucose; PET; standardized uptake values; pneumonia

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The ability of PET with ^{18}F -fluorodeoxyglucose (FDG) to detect differences in glucose metabolism between malignant and benign tissues is the basis for its use in the practice of clinical oncology. FDG PET is increasingly used to evaluate solitary pulmonary nodules (1-5) and for preoperative staging of lung cancer (6-8). Benign causes of FDG accumulation such as active tuberculosis (9), sarcoidosis (10) and histoplasmosis (4) may be potential causes of false-positives in whole-body PET imaging of chest disease. However, it is believed that FDG uptake in benign processes is of a level that can be distinguished from malignant tissue (11).

We report a case in which significantly increased FDG activity was due to presumed bacterial pneumonia.

CASE REPORT

A 70-yr-old man with a history of cardiac transplantation 10 yr earlier presented with fever. He had no cough, chest pain, sore throat, abdominal pain, diarrhea, dysuria or weight loss and physical examination was normal. Chest radiography showed a focal area of consolidation in the right mid lung. CT of the chest revealed a 2×1.5 cm left hilar soft-tissue mass in addition to consolidation in the posterior segment of the right upper lobe (Fig. 1). No pleural effusions were present. Bronchoscopy demonstrated an exophytic mass in the left upper lobe bronchus. Endobronchial biopsy of the mass revealed moderately differentiated squamous cell carcinoma. Bronchoalveolar lavage of the right lung was performed for cytological and microbiological examinations and did not reveal evidence of malignant cells or an infectious agent. Antibiotic therapy was initiated.

An FDG PET scan was performed with an ECAT ART scanner (Siemens/CTI PET Systems, Knoxville, TN) for presurgical staging. A 10-min transmission scan for attenuation correction was obtained before FDG administration. After intravenous injection of 6.5 mCi FDG, dynamic imaging of the chest and a whole-body emission scan were performed. The PET study revealed a large area of intense FDG uptake in the posterior right upper lobe

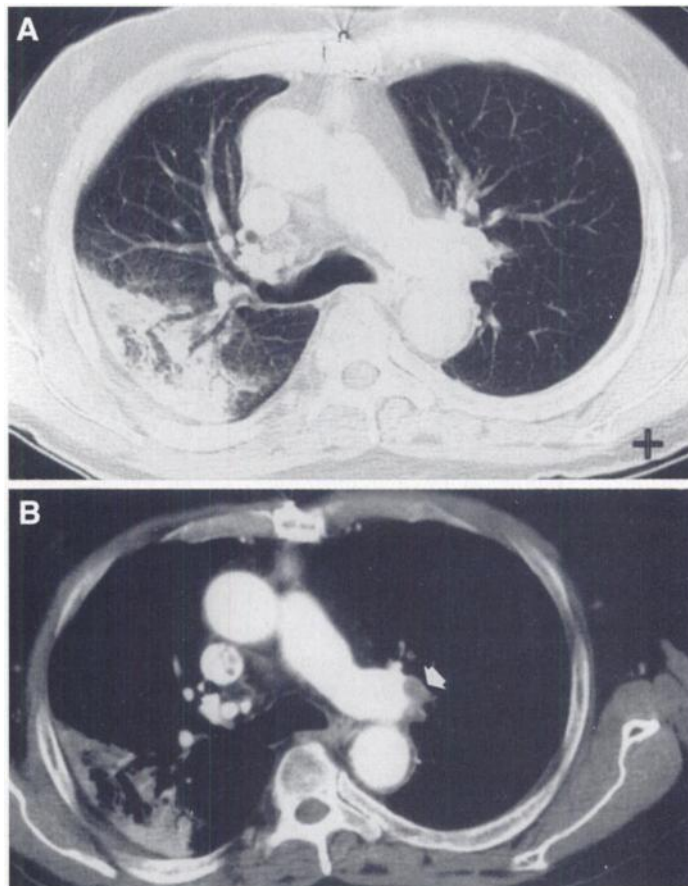


FIGURE 1. (A) CT scan obtained before antibiotic therapy at the level of the right mainstem bronchus shows focal area of consolidation in the posterior segment of the upper right lobe consistent with pneumonic process and (B) left hilar mass (arrow).

corresponding to the infiltrate seen on the CT scan. A significant focus of FDG uptake was also seen in the left hilum, compatible with the patient's known malignancy in this area (Fig. 2).

A standardized uptake value (SUV) was computed by drawing small circular regions of interest over the two areas that showed the most intense FDG uptake on transaxial images. SUVs were calculated as follows:

$$\text{SUV} = \frac{\text{Mean ECAT cps/pixel} \times \text{ECF (mCi/g/ECAT cps/pixel)}}{\text{Injected dose (mCi)/body weight (g)}}, \quad \text{Eq. 1}$$

where ECF is the ECAT calibration factor.

SUVs for the lesion in the right upper lung and the lesion in the left hilum were 4.9 and 5.4, respectively. Since the degree of FDG uptake in the right upper lobe was in the range typical of malignancy, endobronchial examination and bronchial washings were repeated and six transbronchial biopsies were obtained under fluoroscopic guidance in the area of the infiltrate. Surgical pathology and cytology examination showed no evidence of malignancy.

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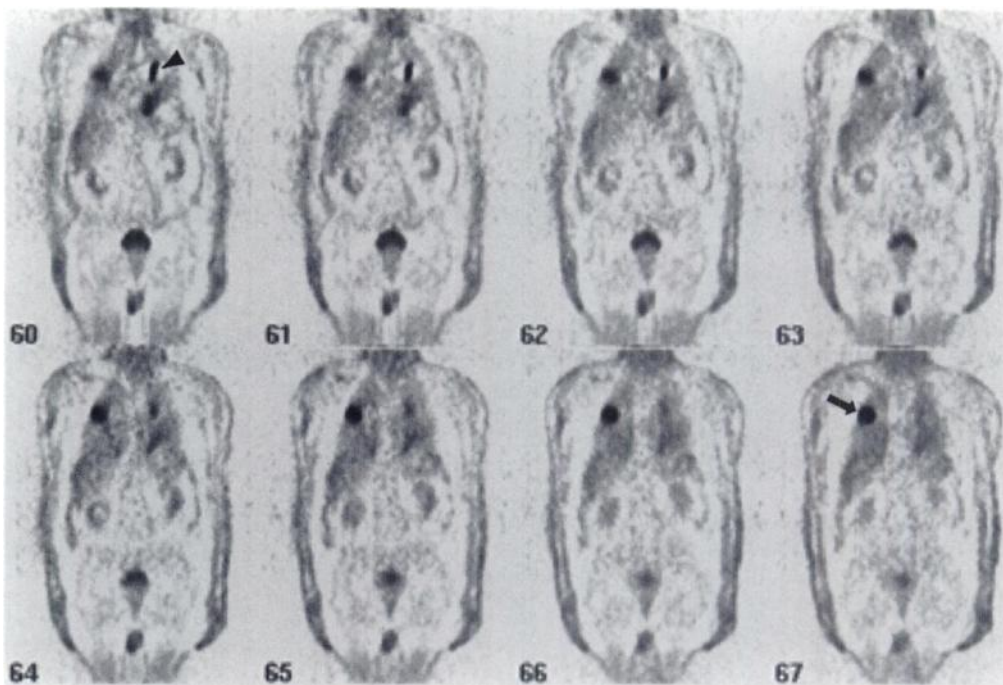


FIGURE 2. Eight sequential coronal whole-body FDG PET images show a large area of increased uptake in the right posterior upper lung (arrow). There is also an area of increased FDG uptake compatible with the patient's known malignancy in the left anterior upper lung (arrowhead). SUVs of lesions were 4.9 and 5.4, respectively.

Gram stain and bronchoalveolar lavage cultures were negative for bacteria, fungi and mycobacterium. Serial chest radiographs demonstrated resolution of the right upper lobe infiltrate during a 4-day course of antibiotic therapy (Fig. 3).

Mediastinoscopy was performed for surgical staging of the left lung tumor. All lymph nodes sampled were found to be free of tumor, and the patient underwent a left lobectomy. The patient underwent definitive resection of the left lung mass. Surgical staging and pathologic correlation confirmed Stage 1 squamous cell carcinoma. The patient received no further treatment.

The patient was followed closely for any recurrence and demonstrated no evidence of disease 9 mo after surgery. Repeat CT examination of the chest performed at this time revealed stable postoperative changes due to median sternotomy, but no acute

pulmonary parenchymal disease or evidence of parenchymal mass (Fig. 4A). Similarly, a repeat PET scan was obtained 11 mo after the first PET study, and it was unremarkable (Fig. 4B).

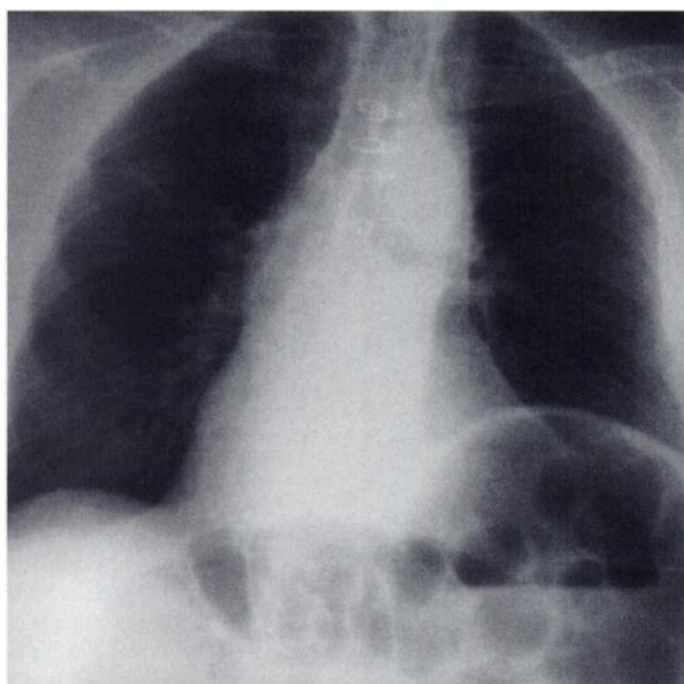


FIGURE 3. Posterior-anterior chest radiograph obtained 6 wk after antibiotic therapy shows near-total resolution of right upper lung consolidation area.

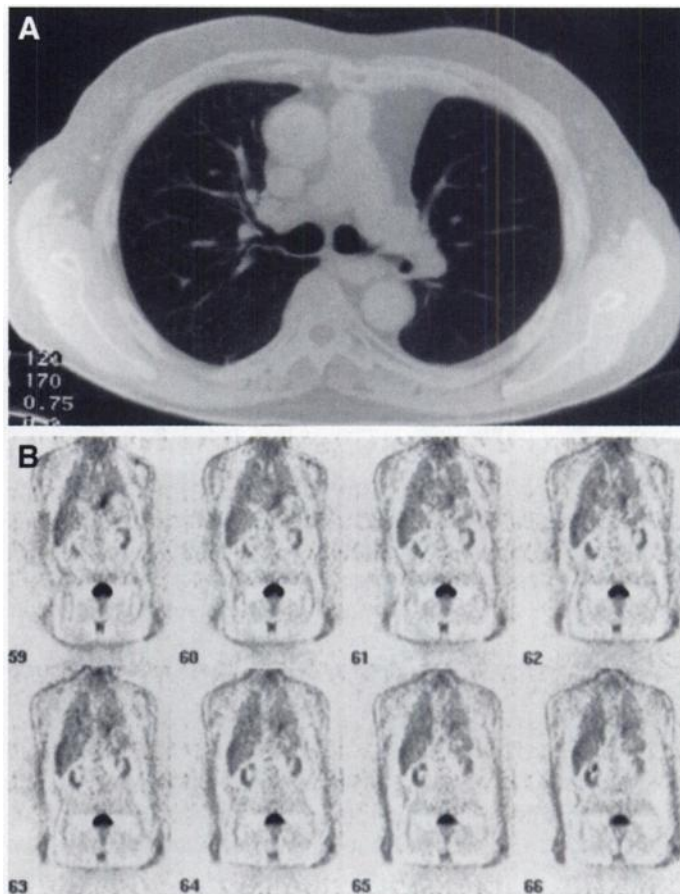


FIGURE 4. Follow-up imaging: (A) CT scan obtained 9 mo after surgery at the level of the right mainstem bronchus shows complete resolution of the right upper lung consolidation area. There also is no evidence of recurrence of previously resected left lung malignancy. (B) Eight sequential coronal whole-body FDG PET images acquired 11 mo after the original PET scan demonstrate no evidence of abnormal FDG uptake.

DISCUSSION

FDG is a tracer of cellular energy metabolism, and increased FDG uptake is not limited to malignant tissue. FDG is taken up not only by viable tumor cells, but also by peritumoral granulation tissue, activated macrophages within the tumor and cells at the periphery of necrotic tumoral tissue (12). Tissue inflammation may manifest increased glycolysis, but the increase in metabolic rate due to inflammatory changes is usually substantially less than that of neoplastic tissue. Inflammation and malignancy generally are differentiated on the basis of SUV (1-3), which allows a numerical comparison of areas of abnormally increased FDG uptake with areas of normal tissue. An SUV threshold of 2.5 has been empirically determined to provide both good sensitivity and specificity in differentiating benign from malignant lesions in evaluating patients with solitary lung nodules (1-3).

Mild elevations in FDG uptake, with SUVs less than 2.5, have been reported in bacterial pneumonia (1,7). However, in this case, the right lung pneumonia demonstrated a markedly elevated SUV of approximately 5, similar to the patient's concurrent malignancy in the contralateral lung.

In the thorax, several benign diseases have been reported to be associated with increased FDG accumulation. False-positive findings, defined by an SUV of greater than 2.5, have been reported in inflammatory and granulomatous processes such as aspergillosis, cryptococcosis, histoplasmosis, tuberculosis, Wegener's granulomatosis, histiocytosis, sarcoidosis and several benign tumors such as neurofibroma, inflammatory pseudotumor, schwannoma and fibrous mesothelioma (13,5).

In our case, bacterial pneumonia was presumed the cause of the increased FDG accumulation in the right upper lobe. Although cultures failed to isolate the organism, the infiltrate resolved with standard antibiotic therapy. It has been shown in a rabbit model that neutrophil activity may be responsible for the increased FDG uptake in pneumonia (14). Intense inflammatory response in pneumococcal pneumonia resulted in air-space accumulation of neutrophils with persistence of associated elevated FDG uptake for up to 3 wk (14).

The increased use of PET to diagnose and stage thoracic malignancy may result in cases in which increased FDG uptake due to pyogenic pulmonary infections may be misinterpreted as malignancy. Such infections may result in SUVs well within the range for malignancy, as demonstrated in this case.

CONCLUSION

The overlap between FDG uptake of malignant lesions and some severe infectious processes such as pneumonia may limit the use of PET as a diagnostic tool in evaluating solitary pulmonary lesions. Caution should be exercised when interpreting FDG PET images in patients with focal abnormalities on chest radiographs.

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Influence of Age and Gender on Quantitative Sacroiliac Joint Scintigraphy

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The value of quantitative sacroiliac joint scintigraphy for detecting sacroiliitis is controversial. Age and gender may contribute to this discordance. In previous reports, the number of control groups has been small and might not exactly reflect the change of sacroiliac/sacral (S1/S) ratios related to different age. In addition, the selection of control subjects was not strict. In most studies, care was not taken to ensure that control subjects did not have a history of back pain or any other relevant conditions. In addition, there was no requirement for a normal radiograph as a condition of inclusion. The aim of our study was to evaluate the consequent changes in S1/S ratios, according to age (in 10-yr intervals) and gender. **Methods:** Over a period of 5 yr, 413 control subjects without a history of back pain, scoliosis, kyphosis, joint pain, arthritis, lesions within the pelvis, chemotherapy or systemic disease such as diabetes or systemic

lupus erythematosus were included in this study. A posterior planar film of the pelvis was obtained to calculate S1/S ratio 3 hr after injection of 740 MBq ^{99m}Tc-methylenediphosphonate. Our data showed that: (a) the change in S1/S ratios related to age was significant in both females and males; (b) the S1/S ratios were higher in males younger than 30 yr and higher in men in the 41-50-yr age group and in females in other groups; (c) the S1/S ratios declined steadily with increasing age in females, whereas there were two plateaus in men aged 21-40 yr and 41-70 yr; (d) there were significant differences of S1/S ratios between the genders in certain age groups; and (e) no differences were found between left S1/S ratios and right S1/S ratios. **Conclusion:** The influence of age and gender on S1/S ratios are substantial, and it is essential for each department to establish its own values for S1/S ratios based on gender and age (in 10-yr intervals).

Key Words: sacroiliitis; sacroiliac joint scintigraphy; age; gender

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