Differential Background Clearance of Fluorodeoxyglucose Activity in Normal Tissues and its Clinical Significance

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KEYWORDS

• Fluorodeoxyglucose • PET • SUV • Distribution time • Background activity • Delayed imaging

KEY POINTS

- The clearance of 2-deoxy-2-[18F]fluoro-D-glucose (FDG) activity in normal tissues varies significantly with extended distribution time.
- Although most tissues have lower standardized uptake value (SUV) on 2-hour/3-hour delayed images, others may have stable or higher FDG activity with longer distribution times.
- The continuously decreased SUV on delayed imaging in some tissues, especially in the liver, indicates that longer distribution time will decrease background activity, increase lesion-to-background ratio, and thus improve imaging quality, whereas the continuously increased SUV from 1to 3 hours in the heart suggest that longer distribution time will improve detection of viable myocardium in a viability study.

INTRODUCTION

The imaging modality of 2-deoxy-2-[18F]fluoro-D-glucose (FDG) PET/computed tomography (CT) has been studied intensively over the past 10 years, because it has evolved into a major form of clinical evaluation. The underlying mechanism of FDG-PET is the differential glycolytic activity in normal versus pathologic tissues. However, intracellular accumulation of FDG is not a specific finding for any pathologic condition, and the standardized uptake value (SUV) of FDG is not a fixed value for any tissues.

Tracer distribution time significantly affects tissue FDG activity on FDG-PET imaging. SUV obtained at an early time point may not be equivalent to the value obtained at a later time point. This possibility limits the direct comparison of two studies performed with different distribution times, and it also has to be considered when using the uptake of the mediastinal/aortic blood pool or the hepatic activity as an internal reference,[1,2]

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because FDG uptake in these reference tissues is similarly affected by tracer distribution time. In addition, delayed or dual-time-point FDG-PET imaging has been proposed in order to follow the uptake of the agent in a dynamic fashion and to enhance the diagnostic accuracy,[3,4] because delayed imaging has been reported to improve the differentiation between benign inflammation and malignancy.[5–8] Knowledge of dynamic FDG uptake in different tissues may help the nuclear medicine physician to decide when to request an additional delayed imaging (eg, an equivocal lesion in a tissue that normally clears background activity over time) or not to request such a delayed imaging.

This article analyzes the background activity clearance of the various tissues by quantifying the FDG uptake at 1 hour, 2 hours, and 3 hours after tracer injection on FDG-PET/CT to evaluate its clinical significance in each tissue type. This article was expanded from our prior study on this topic[9] as more patients were recruited and more data were accumulated.

SUBJECTS AND METHODS

Patients

Fifty nine patients (including 30 patients as previously reported[9]) with suspected lung cancer were prospectively recruited for our study of multiple time point FDG PET/CT scan. The study was approved by our institutional review board (IRB) at the Philadelphia Veterans' Affairs Medical Center. Informed consent was obtained from all 59 patients included in this analysis. All patients had overnight fasting. The blood sugar level was less than 200 mg/dL before the study.

Imaging

Whole-body FDG-PET/CT images were acquired from the skull base to midthighs, at 1 hour, 2 hours, and 3 hours after intravenous injection of 370 to 555 MBq (10–15 mCi) FDG using a dedicated PET/CT scanner (the Biograph 64 hybrid PET/CT imaging systems; Siemens Medical Solutions, Inc). Patients remained fasted until the end of the study and remained resting on a bed between the studies to minimize muscle uptake. A diluted oral contrast (MD-Gastroview, Mallinckrodt Inc) was given to every patient. No intravenous contrast was administered. The images were reconstructed in axial, coronal, and sagittal plans for interpretation.

Data Analysis

All FDG-PET/CT studies were reviewed by a nuclear medicine physician and a radiologist experienced in PET imaging. The maximum SUVs (SUV_{max}) were measured for semiquantitative analysis in patients meeting our criteria: (1) completion of serial whole-body ^{18}F-FDG-PET/CT images at 1 hour, 2 hours, and 3 hours after tracer injection; (2) absence of malignancy in the area of interest; (3) absence of artifacts in the area of interest. A large region of interest (ROI) was drawn to include the major part of an organ without including nearby tissues for the normal tissue activity. For the blood pool activity, the ROI was placed at the lower descending thoracic aorta without including the aortic wall. For the heart, the ROI was placed at the region of the highest FDG activity in the left ventricular (LV) lateral wall. For SUV quantitation, three-dimensional (3D) measurement was used for most tissues, whereas two-dimensional measurement was used for the lungs, liver, spleen, and prostate gland to avoid potential errors induced by inclusion of an unwanted uptake on 3D measurement, such as inflammatory changes in the lung or urine activity near the prostate gland.

For each organ or tissue, only 1 SUV_{max} was obtained for analysis, except for the following conditions: (1) for bone uptake, several sites were selected and SUV_{max} was obtained for each site; (2) for lymph nodes, SUV_{max} was obtained from the largest node in each side of nodes; (3) for brown fat activity, SUV_{max} was obtained from each area of discrete focal uptake.

The SUV_{max} values were analyzed using paired 1-way analysis of variance (ANOVA) test to determine the significance of differences for dynamic SUV values, using the GraphPad Prism 4 (GraphPad Software, Inc, San Diego, CA). Probability values less than .05 were considered significant. The retention index (RI)[5,8] is defined as the difference in SUV between early and delayed FDG-PET imaging as a percentage of the initial uptake ($RI = (SUV_{delayed} - SUV_{early})/SUV_{early} \times 100\%$).[9]

RESULTS

Tissues with Decreased FDG Uptake on Delayed Images

The delayed FDG-PET imaging showed significantly decreased FDG activity in the blood pool of the aorta, the liver, spleen, lung, pancreas, adrenal gland, skeletal muscle, and lymph nodes. This decrease was observed in 48 of 49 patients for the liver and 46 of 50 patients for the aortic blood pool activity both from 1 to 2 hours and from 2 to 3 hours. However, the degree of the decrease in FDG activity was variable depending on tissue types. The continued decrease of SUV_{max} was more remarkable in the aortic blood pool and liver