

Semi-Quantitative Measurements of Normal Organs With Variable Metabolic Activity on FDG PET Imaging

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Abstract

Introduction: This study evaluates the variable physiological fluoro-deoxyglucose (FDG) uptake in normal organs and their normal standardised uptake values (SUVs) among the Chinese population. **Materials and Methods:** One hundred Chinese patients were enrolled into the study. There were 52 males and 48 females; their mean age was 53.5 years (range, 13 to 79 years). The SUVs of various organs were obtained from the transaxial views, but coronal and sagittal images were used whenever the exact location was in doubt. If there was further doubt, correlation with computed tomography images was made. **Results:** The highest FDG uptakes were found in the cerebellum, tonsils, myocardium, liver, spleen, stomach and rectum. **Conclusion:** Knowing the variability of normal FDG accumulation is valuable for proper interpretation of whole-body FDG positron emission tomography (PET) studies.

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Key words: Normal organ, Standardised uptake value (SUV), Variable metabolic activity

Introduction

Positron emission tomography (PET) has a proven clinical role in oncology, cardiology and neurology that primarily uses 2-deoxy-2-[18F]-fluoro-deoxyglucose (FDG). FDG is an analogue of glucose that mimics the cellular uptake and initial metabolism of glucose, which enables cells utilising excess glucose to be visualised. Increased glucose metabolism is commonly seen with malignant and inflammatory pathology, but there is also physiological accumulation in various organs in the body. It is important to appreciate that physiological FDG accumulation can be significant in some organs that occasionally may mimic pathology. Recognising this physiological activity is essential for accurate interpretation of whole-body FDG PET investigation. Semi-quantitative measurements of glucose metabolism can be obtained using standardised uptake value (SUV), which is defined as the regional tissue radioactivity concentration normalised for injected dose and body weight. This measurement is independent of the body constitution.¹⁻³ This study evaluates the variable

physiological FDG uptake in normal organs and their normal SUVs among the Chinese population.

Materials and Methods

One hundred Chinese patients were enrolled into this study. There were 52 males and 48 females; their mean age was 53.5 years (range, 13 years to 79 years). Both oral and written informed consents were obtained from the subjects.

All patients fasted for at least 4 hours before imaging and their fasting blood sugar level was within the normal range. Whole-body PET or computed tomography (CT) imaging was obtained with the Siemens Biograph (Siemens/CTI, Knoxville, TN, USA). A whole-body acquisition was performed immediately 1 hour after intravenous administration of FDG and images obtained from skull base to the upper thigh region. High-quality images were acquired and semi-quantitative measurements of glucose metabolism obtained. The SUVs of various organs were obtained from the transaxial views, but coronal and sagittal images were used whenever the exact location of the measurement was

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in doubt. If there was further doubt, correlation with CT images was made.

Results

There was a wide variation of FDG accumulation in normal organs. The highest FDG uptakes were found in the cerebellum, tonsils, myocardium, liver, spleen, stomach and rectum (Table 1).

Discussion

The bio-distribution of FDG after intravenous administration of FDG in the brain is 6.9% of the injected dose, 4.4% in the liver, 3.3% in the heart, 1.7% in red marrow, 1.3% in kidneys and 0.9% in lungs.⁴ This partly explains the variability in physiological FDG uptake in various organs in the human body.

Typical sites of accumulation in the gastrointestinal tract include the gastro-oesophageal junction, gastric fundus and colon (caecum, proximal ascending colon and the recto-sigmoid colon). The bowel, especially the colon, can be problematic when detecting small lesions. In pregnancy (gestation sac) and during menstruation (endometrium and corpus luteum cyst), there is an associated increase in physiological FDG accumulation. Age can affect the appearance of a normal scan, such as increased FDG uptake in denser glandular breast and thymus of younger patients. In situations where there is excessive usage of a particular group of muscle prior to scanning, that group of muscle can accumulate significant FDG. These include not only the skeletal muscles, but also muscles of the oro-pharynx. Occasionally, when insulin is used to normalise the blood

Table 1. Summary of Findings

Variable	Mean	(Range)	Male (n = 52)	Female (n = 48)
Age (y)	53.5	(13-79)	54.2	52.7
Weight (lbs)	131.1	(85-160)	134.6	126.4
Fluoro-deoxyglucose (FDG) (mCi)	13.4	(10.3-17.3)	13.6	12.7
Standardised uptake value (SUV)				
Nasopharynx (right/left)	1.8/1.8	(0.8/0.8-4.3/3.1)	1.7/1.8	1.8/1.8
Tonsil	2.9	(1.3-5.9)	2.7	3.0
Parotid gland	1.3	(0.4-3.7)	1.5	1.4
Submandibular gland	1.7	(0.7-3.5)	1.8	1.7
Tongue	2	(0.8-3.6)	1.9	2
Sternocleidomastoid muscle	1.0	(0.5-2.2)	1.1	1.0
Thyroid	1.7	(0.2-2.8)	1.5	1.9
Lung (right/left)	0.6/0.6	(0.2/0.2-1.2/1.8)	0.5/0.5	0.6/0.6
Hilum (right/left)	1.1/1.1	(0.4/0.3-1.8/2.1)	1.0/1.1	1.2/1.2
Aorta (ascending)	2.0	(1.1-3.2)	1.8	2.2
Inferior vena cava	1.9	(1.0-2.9)	1.8	2.0
Myocardium (left lateral ventricular wall)	3.0	(0.4-12.5)	2.4	3.7
Liver	2.8	(1.4-5.0)	2.7	2.9
Gall bladder	1.6	(0.7-2.5)	1.5	1.8
Spleen	2.3	(0.3-3.5)	1.8	2.0
Pancreas	1.7	(0.7-2.5)	1.5	1.9
Stomach	2.1	(0.8-4.4)	2.0	2.1
Caecum	1.9	(0.8-4.5)	1.6	2.3
Ascending colon	1.8	(0.6-1.8)	1.8	2.2
Transverse colon	1.8	(0.6-5.6)	1.5	2.1
Descending colon	1.6	(0.3-5.7)	1.5	1.8
Sigmoid colon	1.7	(0.8-4.9)	1.7	1.8
Rectum	2.0	(0.8-8.8)	1.8	2.3
Uterus		1.2-3.6		2.0
Ovary (right/left)		0.6/0.7-2.7/2.2		1.4/1.3
Prostate		1.1-3.4	2.2	
Testis		1.5-4.6	3.0	
Vertebral bodies (cervical/thoracic/lumbar)	2.1/2.0/2.0	(1.0/0.8/0.8-3.1/3.5/3.3)	2.0/1.9/1.9	2.0/2.0/2.1
Cerebellum hemispheres	6.0	(2.6-10.7)	5.6	6.3

glucose level prior to scanning, this invariably results in 'pushing' a fair amount of the FDG into the skeletal muscle. Post-treatment or recent instrumentation can similarly increase metabolic activity that includes healing surgical wounds, injection sites, colostomy site and ileal conduit.³⁻⁷

In most organs, FDG accumulation is often fairly homogeneous within the organ. However, in lungs, the lower lung field accumulates slightly more than the upper and middle lung fields.

The distribution of FDG may not always be homogeneous in an organ, such as in the case of the liver. The liver often has a diffuse accumulation, but can appear slightly heterogeneous in uptake. This may lead one to miss small genuine lesions. Despite the slight heterogeneous accumulation, there is 'homogeneity to the pattern of heterogeneity'.

The regions that are frequently associated with high FDG uptake may make the diagnosis of tumour or inflammation difficult. In these areas, careful evaluation is necessary to distinguish abnormal accumulation from normal variation.^{8,9} In physiological FDG uptake, the pattern tends to be diffuse rather than focal.

It can be difficult to window and level the body PET scan images in a consistent fashion. Fortunately, in PET, even without extensive experience, this can be achieved using the SUV, which is a semi-quantitative measurement of glucose metabolism in the body. SUV can also be used to measure all radiopharmaceuticals, such as the more specific tracers which include methionine, thymidine, labelled drugs and probes to monitor gene expression and angiogenesis. The literature is full of definitions of SUV thresholds,

above which a lesion becomes pathological. Unfortunately, the discriminatory value of these thresholds is limited.² In most cases, the evaluation should include the pattern and intensity of the uptake that is appropriate to the suspected lesion to reduce the false positive and negative results.

In conclusion, knowing the variability of normal FDG accumulation is essential for proper interpretation of whole body FDG PET studies.

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