Brain

Normal Variations and Benign Findings in Fluorodeoxyglucose-PET/Computed Tomography Imaging

Valentina Berti, MD, PhD[a,*], Lisa Mosconi, PhD[b], Alberto Pupi, MD[a]

KEYWORDS

• 18F-FDG-PET • Normal brain • Normal variants • Aging brain • Medications effect • Artifacts

KEY POINTS

- Brain 18F-fluorodeoxyglucose (18F-FDG) PET allows the in vivo study of cerebral glucose metabolism, reflecting neuronal and synaptic activity.
- 18F-FDG-PET has been extensively used to detect metabolic alterations in several neurologic diseases compared with normal aging; however, healthy subjects have variants of 18F-FDG distribution, especially as associated with aging.
- Healthy aging is associated with mild cortical hypometabolism involving preferentially the frontal lobes; in particular anterior cingulate cortex, dorsolateral and medial prefrontal cortices, and orbitofrontal cortex.
- 18F-FDG uptake in the normal brain could be affected by several substances and medications, including caffeine, alcohol, abused drugs such as amphetamines and cocaine, sedatives, neuroleptics, corticosteroids, and chemotherapy agents.
- Several artifacts may influence 18F-FDG brain distribution and cause interpretation errors.

INTRODUCTION

Glucose is the main metabolic substrate of the brain and its oxidation produces the amount of energy that is necessary for adequate cerebral activity.

The PET tracer 18F-fluorodeoxyglucose (18F-FDG) allows the in vivo study of glucose metabolism, and since its introduction in 1976 it has been the most widely used PET tracer in both clinical and research settings.[1]

The local glucose consumption, and thus 18F-FDG cerebral uptake, correlates strictly with local neuronal activity, and proportionally increases with stimulus intensity or frequency[2] or decreases in conditions of sensory deprivation.[3] Such metabolic variations take place at the level of synaptic connections.[4] As such, neurotransmission and signal transduction are the processes with the highest energy requirements. It has been estimated that the energy demand of neurotransmission and related events exceeds 80% of total cerebral energy consumption.[5]

Connections between neurons are performed mainly by excitatory glutamatergic synapses, which

This work was supported in part by National Institute of Health/National Institute on Aging 5R01AG035137 and Alzheimer's Association IIRG-09-132030 (L. Mosconi).

[a] Nuclear Medicine Unit, Department of Biomedical, Experimental and Clinical Sciences, University of Florence, Largo Brambilla, 3, Florence 50134, Italy; [b] Center for Brain Health, New York University School of Medicine, 145 East 32nd Street, 5th Floor, Room 5122, New York, NY 10016, USA

* Corresponding author.

E-mail address: valentina.berti@unifi.it

PET Clin 9 (2014) 129–140

http://dx.doi.org/10.1016/j.cpet.2013.10.006

1556-8598/14/$ – see front matter

account for most all the cortical synapses, yielding an energy consumption of around 80% of total cortical consumption.[5]

A large body of literature shows that 18F-FDG-PET adds value to diagnostic evaluation of several neurologic diseases. In particular, 18F-FDG-PET substantially improves diagnostic accuracy and differential diagnosis, and enables earlier and better treatment planning of neurodegenerative disorders.[6,7]

Although most studies have focused on detection of abnormal, disease-specific 18F-FDG distribution patterns, little is known about brain glucose metabolism in clinically and cognitively normal, healthy individuals, and about normal variants of 18F-FDG uptake in this population.

Thorough knowledge of the normal variants of brain function, occurring in healthy aging or related to gender, is critical for detection of abnormal findings and for investigating neurologic diseases.

This article focuses on 18F-FDG-PET findings in so-called normal brain aging, and in particular on metabolic differences occurring with aging and as a function of gender. The effects of different substances, medications, and therapy procedures are discussed, as well as common artifacts.

IMAGING TECHNIQUE

Updated procedure guidelines for 18F-FDG-PET brain imaging were published by the Society of Nuclear Medicine in 2009[8] and include all relevant information to be collected during the procedure, instructions for patient's management and preparation for PET scanning, and a summary of the standardized acquisition protocol. These topics are summarized in **Boxes 1–3**, respectively.

18F-FDG-PET images should be reconstructed in transaxial, coronal, and sagittal planes.

Box 1
Relevant patient history and data

Focused history: head trauma, known neurologic or psychiatric disorders, brain tumors, prior brain operations

Clinical history: patient complaints, neurologic/psychiatric examination, mental status examination (Mini-Mental State Examination, neuropsychological tests), cognitive impairment

Recent morphologic imaging studies (eg, computed tomography, magnetic resonance imaging, or prior PET or single-photon computed tomography brain studies)

Current medications

Box 2
Patient preparation before PET scanning

Fasting for at least 4 to 6 hours

Oral hydration with water should be encouraged

Avoid caffeine, alcohol, or drugs that may affect cerebral glucose metabolism

Check blood glucose level (ideally not greater than 150–200 mg/dL)

Environmental conditions: resting state, patient with eyes open and ears unoccluded in a quiet, dimly lit room, with minimal background noise

Start intravenous line for 18F-FDG administration (at least 10 minutes before tracer injection)

For a comprehensive evaluation of brain 18F-FDG-PET images, all 3 projection planes should be used. The transaxial plane is recommended for evaluation of all cortical and subcortical structures. Transaxial images should be reoriented both along the anterior commissure–posterior commissure (AC-PC) line and temporal long axis (for better assessment of the temporal lobe) (**Fig. 1**). The coronal plane is recommended for inspection of posterior cingulate, angular gyri, and medial temporal lobes (including hippocampal areas). The sagittal plane is valuable in evaluations of the frontal and temporal poles.

NORMAL ANATOMY

Glucose is the only source of energy of the brain, which is known to account for as much as 20% of total-body glucose metabolism in the fasting

Box 3
Acquisition protocol

Administered dose	185–370 MBq
Acquisition starting time	30 minutes after injection 60 minutes after injection (oncology)
During acquisition	Well-tolerated head immobilization procedures should be implemented, to minimize head movements
Acquisition duration	20 minutes (depending on PET equipment and patient compliance)
Reconstruction	Transaxial matrix size: 128 × 128 or 256 × 256 Typical pixel size: 2–4 mm