PET/CT Imaging: Patient Instructions and Preparation

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Shaunak Navalkissoor, Thomas Wagner, Gopinath Gnanasegaran, Teresa A. Szyszko, and Jamshed B. Bomanji

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7.1 Introduction

^{18}F-FDG PET is a frequently used imaging modality in the evaluation of cancer patients. A high-quality study performed ^{18}F-FDG PET study should be repeatable (same result produced if imaged on the same system) and reproducible (similar result if imaged at different sites). An essential component of this is adequate patient preparation to ensure study reproducibility and technical quality. Rigorous instructions should be followed regarding patient procedure. In addition, adequate referral information is important so that the correct timing of study and imaging protocol can be followed, e.g. lung gating for a base of lung lesion. This section addresses

S. Navalkissoor (✉) • T. Wagner • G. Gnanasegaran
Department of Nuclear Medicine, Royal Free London NHS Foundation Trust, London, UK
e-mail: s.navalkissoor@nhs.net

T.A. Szyszko
King's College and Guy's and St Thomas' PET Centre, Division of Imaging Sciences and Biomedical Engineering, Kings College London, St Thomas' Hospital, London, UK

J.B. Bomanji
Department of Nuclear Medicine, University College London Hospitals NHS Foundation Trust, London, UK

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Table 7.1 Contents of PET/CT request [1–5]

1. Patient name, date of birth, address and hospital identifier number
2. Clinical indication
3. Clinical question to be answered
4. Oncological history: site of tumour (if known), recent biopsy (site, date of biopsy and results if known) and comorbidity
5. Drug allergies and allergy to contrast agents
6. Diabetes status, if relevant (IDDM, NIDDM), and treatment
7. Renal function
8. Therapeutic interventions: type and date of last treatment (chemotherapy, surgery, radiotherapy, bone marrow stimulants and steroids administration)
9. Result and availability of previous imaging
10. Height and body weight
11. Referring clinician's contact details: (a) to discuss about the referral, (b) to contact during emergency and (c) to send the reports
12. Date at which results of the PET or PET/CT study must be available

some of these issues, and summaries of required clinical information, patient preparation, procedure and imaging parameters are shown in Tables 7.1, 7.2 and 7.3.

FDG is a glucose analogue and is transferred intracellularly by glucose transporters. Many tumour cells overexpress glucose transporter proteins and hexokinase intracellularly, which allows FDG to be used to image these tumours.

7.2 Patient Preparation

One of the main aims in patient preparation is to reduce the hyperinsulinemic state, which occurs with recent glucose ingestion. Increased glucose levels cause competitive inhibition of ^{18}F-FDG uptake by the cells leading to decreased tumour (or other active process) to background ratio. Also increased insulin secondary to elevated blood glucose increases translocation of GLUT4, thereby shunting ^{18}F-FDG to organs with high density of insulin receptors (e.g. skeletal muscles). Patients should thus fast for at least 6 h prior to the study to ensure low insulin levels. Recent EANM guidelines suggest that patients with blood glucose <11 mmol/l can have FDG administered, whilst patients with glucose >11 mmol/l need to be rescheduled. Patients with diabetes (particularly with insulin-based treatments) need to be carefully scheduled to avoid a hyperinsulinemic state. (An example of scheduling includes a late morning appointment with an early breakfast and insulin injection.)

If glucose control is not achieved, then the PET scan can be rescheduled.

Other patient preparations also aim to reduce tracer uptake in normal tissues, thus increasing target and nontarget uptake. Patients should be hydrated adequately to decrease the concentration of FDG in the urine, decreasing artefacts and potentially reducing radiation dose. Drinking water is permitted; however, flavoured water contains sugar and cannot be consumed prior to the PET scan. Patients should be advised to dress warmly on the way to the PET suite and should be kept in a warm room prior to the administration of FDG. This is to avoid accumulation of

Table 7.2 General instructions for an ^{18}F-FDG PET scan [1–5]

Appointment:
1. Send leaflets related to the scan and instructions
2. Confirm appointment
3. Medications list if any
4. History of diabetes, fasting state and recent infection/intervention
Before arrival:
1. Fast, except for water (for at least 6 h before the injection of ^{18}F-FDG for most studies, at least 4 h before dedicated neuroimaging). Avoid chewing gum
(a) Morning appointment: patient should not eat after midnight [preferably have a light meal (no alcohol) during the evening prior to the PET study]
(b) Afternoon appointment PET study: patient may have a light breakfast before 8.00 a.m. (no sugars or sugar-containing fillings/products)
2. Advise adequate pre-hydration
3. Intravenous fluids containing dextrose or parenteral feedings should be withheld for 4–6 h before radiotracer injection
4. Consider if intravenous contrast material is to be used for CT
Before injecting:
1. The blood glucose level should be checked and documented
FDG PET study can be performed: *if plasma glucose level is* $<$ *11 mmol/l* (*or* $<$ *200 mg/dl*)
FDG PET study should be rescheduled: *if plasma glucose level is* $\geq$ *11 mmol/l* (*or* $>$ *200 mg/dl*) *depending on patients circumstances*
2. Keep the patient in a warm room for 30–60 min before the injection and during the uptake period and maintain warmth with blankets during scan to reduce uptake in the brown fat. (*Lorazepam*, *diazepam and beta-blockers may help to reduce uptake by brown fat uptake if problematic*)
3. Check patient's ability to lie still for the duration of the scan and ability to put his or her arms overhead
4. Ask for history of claustrophobia
5. If intravenous contrast material is to be used, patients should be screened for iodinated contrast material allergy, renal disease and use of metformin for diabetes mellitus treatment
6. Take a brief history and document site of malignancy, including recent investigations and treatment history: surgery, radiation, chemotherapy

Table 7.3 ^{18}F-FDG PET/CT imaging parameters [1–5]

Routine imaging: skull base to upper thigh
Additional views: lower limb views, dedicated head and neck or occasionally scan to vertex are acquired as necessary
Brain imaging is frequently omitted in many institutions routinely (poor sensitivity of FDG PET for brain metastases)
Typical adult administered activities: 185–370 MBq (5–10 mCi), up to 400 MBq
Largest effective dose administered: urinary bladder
Whole-body effective dose of PET study is approximately 0.02 mSv/MBq or 7–8 mSv for an adult administered activity of 370 MBq. CT dose depends on local protocol

FDG in activated brown fat. In some cases with no contraindications to oral beta-blockers, propranolol (1 mg/kg, maximum 40 mg) should be given at least 90 min before FDG injection to reduce FDG uptake in brown adipose tissue. This is especially important in young patients. Strenuous physical activity should be avoided for

Table 7.4 Example of low-carbohydrate high-fat diet provided to patients prior to FDG PET cardiac imaging

Do not eat the following:
Sugar in any form (including natural's sugars in fruits)
No starches, e.g. pasta, breads, cereals, rice and potatoes
No vegetables with high carbohydrate content, no carrots or beetroot
No chocolates, sweets, chewing gums, mints and cough syrups
No processed products, e.g. processed deli meats
No sweetener substitutes like Canderel or Splenda
No milk or milk products
No cheese or cheese products
No nuts
No fruits
No alcohol
You can eat the following:
Poultry: fatty unsweetened chicken and turkey (fried or boiled, *NOT* grilled)
Meats: fatty unsweetened, red meat, bacon, ham (fried or boiled, *NOT* T grilled)
Fish: any fish (fatty unsweetened, fried or boiled, *NOT* grilled)
Shellfish: any non-processed shellfish
Eggs: fried, scrambled preparation without milk, omelette prepared without milk or vegetables
Butter and margarine
Vegetables: cucumber, broccoli, lettuce, celery, mushroom, green pepper, cabbage, spinach, asparagus, radish
Drinks: mineral water (still or sparkling), coffee, tea, herbal tea (without milk or sugar)

at least 6 h prior to the scan to avoid excessive skeletal uptake. During the uptake period, the patient should not talk and avoid reading or chewing, to minimise uptake in these respective muscles.

If a lesion near the myocardium or the myocardium itself is being evaluated for suspected disease, careful patient preparation is required to limit cardiac uptake. A low-carbohydrate, high-fat, high-protein diet for at least 24 h before the scan (Table 7.4) and extended fasting for 18 h before the scan are recommended to switch the myocardial energy substrate from glucose to fatty acids. This is coupled with one or two intravenous bolus of heparin (50 IU/kg) given 90 min prior to ^{18}F-FDG injection for suppression of myocardial FDG uptake.

Review of patients' medication should be performed, e.g. steroids in high doses may cause hyperglycaemic states and, in patients with suspected vasculitis, may reduce the sensitivity of the test; metformin may cause diffuse large bowel uptake due to increased glucose utilisation of the intestinal mucosa. If intravenous contrast is going to be administered, metformin needs to be withheld on the day of the test and for a further 48 h.

7.3 Timing of FDG PET Scan After Treatment

When the PET scan is being protocolled, adequate information about previous treatments should be available to the authoriser to ensure accurate timing, e.g. in chemotherapy response assessments in lymphoma, the FDG PET scan should not be performed too early to avoid false negatives due to tumour stunning or false

positives due to inflammatory uptake. An interval of at least 10 days should be allowed post chemotherapy (interim PET) or at least 3 weeks at the end of chemotherapy to allow evaluation of response to chemotherapy. If patients are undergoing radiotherapy, the recommended post-therapy interval is 2–3 months.

Key Points

- Rigorous instructions should be followed regarding patient procedure.
- Adequate referral information is important so that the correct timing of study and imaging protocol can be followed.
- Increased glucose levels cause competitive inhibition of ^{18}F-FDG uptake.
- Increased insulin secondary to elevated blood glucose increases translocation of GLUT4.
- Patients should thus fast for at least 6 h prior to the study to ensure low insulin levels.
- Patients with blood glucose <11 mmol/l can have FDG administered, whilst patients with glucose >11 mmol/l need to be rescheduled (EANM guidelines).
- Patients with diabetes (particularly with insulin-based treatments) need to be carefully scheduled to avoid a hyperinsulinemic state.
- Patients should be hydrated adequately to decrease the concentration of FDG in the urine, decreasing artefacts and potentially reducing radiation dose.
- Keep the patient in a warm room for 30–60 min before the FDG injection.
- Strenuous physical activity should be avoided for at least 6 h prior to the scan.
- An interval of at least 10 days should be allowed post chemotherapy (interim PET) or at least 3 weeks at the end of chemotherapy to allow evaluation of response to chemotherapy.
- In patients undergoing radiotherapy, the recommended post-therapy interval is 3 months.

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