

Clinical ^{18}F -FDG Oncology Patient Preparation Techniques*

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Objectives: Clinical tumor imaging with ^{18}F -FDG in PET is growing in demand. This article will provide a review of current patient preparation and imaging techniques. The goal is to make the PET study as noninvasive as possible for the patient while obtaining quality images. Communication and coordination when scheduling these studies involves the patient and radiopharmacy, scanner, and support staff. A pertinent patient history (information about weight, pregnancy, breastfeeding, diabetes, etc.) is vital for appropriate patient instructions and patient sequencing. Patient preparation involves many variations on fluid intake, diet, medications, and other factors. Blood glucose levels must be ≤ 150 mg/dL. If the patient has diabetes mellitus or is glucose intolerant, diet-exercise regime and glucose levels should be monitored. Accurate ^{18}F -FDG dose calculation to be used for region-of-interest analysis or standard uptake value determination is imperative. After ^{18}F -FDG injection, the patient must remain quiet and still to minimize muscle use. Before the scan, the patient may need relaxation medications, urinary catheterization, or other interventions. At the conclusion of this article, the reader should be able to list pertinent patient history issues that are useful for scheduling an ^{18}F -FDG tumor scan, discuss methods to ensure accurate ^{18}F -FDG patient dose calculations, and describe possible methods to help minimize urinary ^{18}F -FDG excretion.

Key Words: PET; ^{18}F -FDG; oncology; patient preparation

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Reimbursed ^{18}F -FDG PET indications are expanding in oncology. The demand for PET as a clinical management tool is escalating. Techniques for performing PET scans are varied. Techniques will continue to change as the new imaging modality increases the scope of practice. The advent of PET and CT scanner integration will enhance the modality. The goal is to make ^{18}F -FDG PET oncologic tumor imaging as comfortable and noninvasive as possible

for the patient. This goal is to be accomplished while obtaining accurate, high-quality images.

PATIENT SCHEDULING

Communication and coordination when scheduling these studies is imperative. This involves the patient and staff from the referring physician's office, radiopharmacy, and scanner unit, as well as ancillary support staff. Obtaining a pertinent patient history allows the PET staff to issue appropriate patient instructions and plan patient sequencing to maintain a flexible facility schedule. Patient information, including a history of diabetes; possibility of pregnancy or breastfeeding; body weight; ability to tolerate the procedure; and need for relaxants, conscious sedation, or general anesthesia, is also critical. Patient information should include results of current anatomic imaging studies, and films should be available at the time of the ^{18}F -FDG study. Information about prior biopsies and surgical interventions is useful. Radiation therapy, chemotherapy, and other medical therapy information is vital and should include dates, doses, and site of therapy.

Diabetic or glucose-intolerant patients need monitoring before the day of the PET study. This monitoring will ensure that the glucose level is ≤ 150 mg/dL (1). This may require daily monitoring for a few days along with instructions to watch diet and follow exercise recommendations. Diabetic patients may continue to adhere to their oral agents or insulin routines. These medications should not be administered near the ^{18}F -FDG injection time. Insulin administration within 2 h of the ^{18}F -FDG injection time may cause increased glucose uptake in muscle or other soft tissue and compromise tumor uptake (1). If the blood glucose levels are high and cannot be lowered on the day of the study, a patient may have to be rescheduled. In some cases, a diabetic-control specialist may be consulted.

In women of childbearing age, an inquiry regarding the possibility of pregnancy is necessary. It is important for the PET facility and radiation safety personnel to convey the radiation risks to pregnant women and their physicians. The decision to obtain an ^{18}F -FDG tumor scan during pregnancy is a medical decision to be made by the woman and her physician. They must determine whether the benefits outweigh the risks. Management of breastfeeding women usu-

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ally involves the PET facility radiation safety officer. It is currently recommended that breastfeeding be discontinued for approximately 24 h after the ^{18}F -FDG injection because of ^{18}F -FDG accumulation in breast milk. The normal lactation schedule can be maintained with a breast pump during the 24-h period. A torso tumor scan demonstrates ^{18}F -FDG distribution during lactation in Figure 1. Another method to determine the ^{18}F -FDG accumulation during lactation is to express breast milk and count it in a γ -counter.

Each PET imaging table has a maximum weight-bearing load limit. Some patients may exceed these limits and should not be scheduled for imaging. In some cases, the patient may need to be measured before the scan day or at least before the ^{18}F -FDG injection to ensure their ability to enter the scanner bore comfortably. Idiosyncracies of body size and weight distribution may limit the area of possible imaging even when the table weight-bearing limit is not exceeded. It is vital to make the effort to check these parameters before the ^{18}F -FDG injection to ensure that the area of interest can be imaged optimally.

The ability to tolerate the imaging study is important. Claustrophobic, anxious, or pediatric patients may need special attention. They may require relaxants, conscious sedation, or general anesthesia. This should be scheduled before the day of the PET procedure to arrange family, nursing, and anesthesia support, as well as scanner time and availability. Not all of these situations can be anticipated. Patients in pain also may need to monitor and control their pain by medication or other means (positioning methods, meditation).

The patient history also will help determine whether the patient needs special consideration for the abdomen and pelvis regions. In some cases it may be necessary to enhance

the urinary excretion of ^{18}F -FDG during the uptake period and scan. These cases will demand additional effort and time from the patient, PET staff, and ancillary support staff.

Once detailed patient information and history are obtained, the patient may be scheduled. It is important to know at the time of scheduling whether the PET tumor scan will include the brain, torso (orbit through pelvis), or lower extremities. Knowing the indication for the PET scan and the patient's history of disease is essential in determining the length of the study, informing the patient of the scan's duration, and scheduling scanner time availability. Most patients with body tumors are imaged from the orbits through the pelvis (30–60 min). A total-body scan, including the brain, torso, and lower extremities (30–90 min), may be indicated on some occasions. PET tumor scans for brain malignancy include only the brain (15–30 min). The additional effort when scheduling a patient is useful in preparing the patient, family, and ancillary support staff and in maintaining the facility schedule and good customer relations.

PATIENT PREPARATION

Patient preparation for ^{18}F -FDG oncologic tumor imaging varies with the patient's history and abilities. Water intake recommendations vary. The recommendation of 1,418 mL (48 oz) the day before the scan, 709 mL (24 oz) or more the day of the scan, and continued intake after the scan is typical and appropriate. Hydration and frequent bladder voiding decrease the bladder (critical organ) radiation absorbed dose (2). Muscle uptake occurs in nondiabetic patients who are receiving dextrose or lactose in their running intravenous lines. Hyperinsulinemia occurring with carbohydrate administration is likely the cause. This problem can be avoided by the discontinuation of these fluids. The administration of other appropriate fluids should begin 2–4 h before the ^{18}F -FDG injection. These nonglucose fluids may be continued during the scan.

The avoidance of strenuous exercise on the day of the study to limit muscle uptake (muscles use glucose to replace glycogen stores) is recommended (3). In some cases, a patient who is constantly coughing (Fig. 2), chewing, or fidgeting will have increased muscle uptake. Muscle stress, tension, and movement during the uptake portion should be minimized to decrease muscle uptake (Fig. 3). Restful positioning and a calm environment will help reduce stress-related muscle tension. In some situations, the use of a muscle relaxant, such as diazepam, is necessary (1,3,4). This should be given at an appropriate time before the ^{18}F -FDG injection to alleviate muscle uptake. These medications also help anxious or claustrophobic patients tolerate the procedure. It is necessary to make arrangements for a nurse or physician to administer these medications and for a family member to transport the patient home.

Dietary recommendations vary widely from facility to facility. Many of the recommendations have not been well explained but are the result of practice experience. The

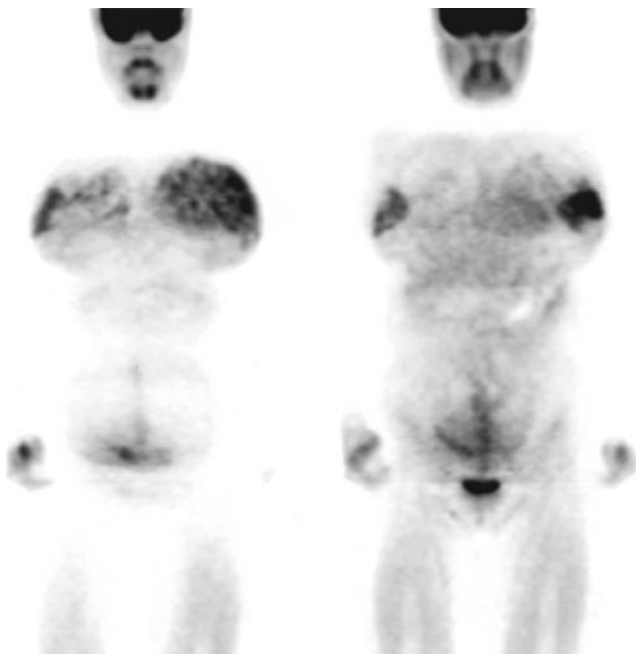


FIGURE 1. Patient was lactating at time of ^{18}F -FDG tumor study. Patient was asked to discontinue breastfeeding for 24 h.

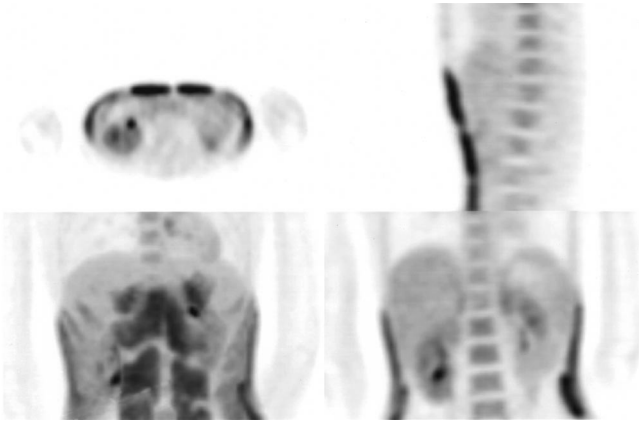


FIGURE 2. Patient coughed persistently during ^{18}F -FDG injection and uptake phase. Muscle uptake is demonstrated in 4 different views.

patient should abstain from caffeine and nicotine for several hours. The effects of caffeine and nicotine on tumor response to glucose have not been documented, but the absence of these drugs may reduce cardiac stimulation and myocardial glucose uptake. The patient may have nothing by mouth (NPO) for 12 h or may have a light breakfast with no sugar the morning of the study and be NPO for 4 h before the study (4). Most medications may be taken with water during the NPO period.

^{18}F -FDG is removed from the human body by excretion

in the urinary system. Diuretics and urinary catheterization are used for all patients at some facilities. Other facilities use these methods only when there is a suitable clinical indication. A patient with abdominal or pelvic areas of interest may need to have urinary catheterization and possibly a 3-way continuous flushing catheter to allow clear visualization of structures near or in the bladder or urinary drainage pathways. Diuretics to enhance the excretion of ^{18}F -FDG during the uptake and scan (3,4,6) may be used. When a urinary catheter is used, there should be continual assessment after insertion and throughout the scan. If the catheter is not draining, the bladder will continue to fill with radioactive urine and become uncomfortable for the patient. Special consideration to alleviate radioactive contamination from urine is a must. If urinary contamination occurs, it can cause artifacts and difficulty in scan interpretation. If patients use urinary underpads (Fig. 4), it is advisable to change these just before the ^{18}F -FDG imaging to avoid contamination caused by artifacts. Care must be taken to meet a facility's radiation safety measures for the radioactive urine and urine-contaminated articles in these cases.

Patients who need conscious sedation or general anesthesia require special consideration and scheduling. It is advisable in such cases to try to perform the ^{18}F -FDG injection before the medication, if possible, to avoid any drug-related changes in ^{18}F -FDG distribution from metabolic or blood flow alterations. Conscious sedation or general anesthesia medication parameters and times should be documented for the interpreting and referring physicians. These parameters should be considered when interpreting the scan.

PATIENT ^{18}F -FDG INJECTION

The patient should be positioned on a bed or in a reclining chair for the injection. The bed or chair can be adjusted so that the patient and technologist are comfortable during the injection and then readjusted to make the patient comfort-

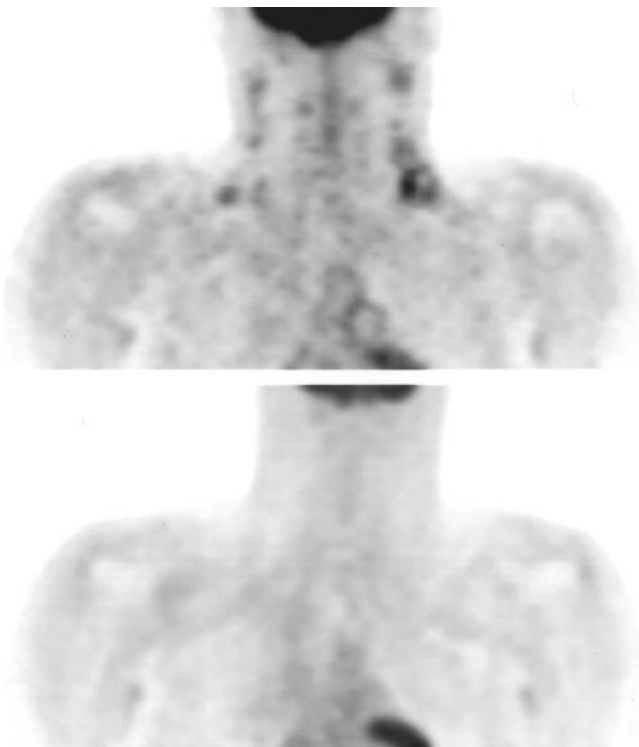


FIGURE 3. (A) Neck muscle uptake is evident. For this image set, patient had been injected with ^{18}F -FDG and instructed to relax during uptake phase. (B) Image obtained when patient returned at later date and diazepam was administered before ^{18}F -FDG injection in effort to minimize neck muscle uptake.

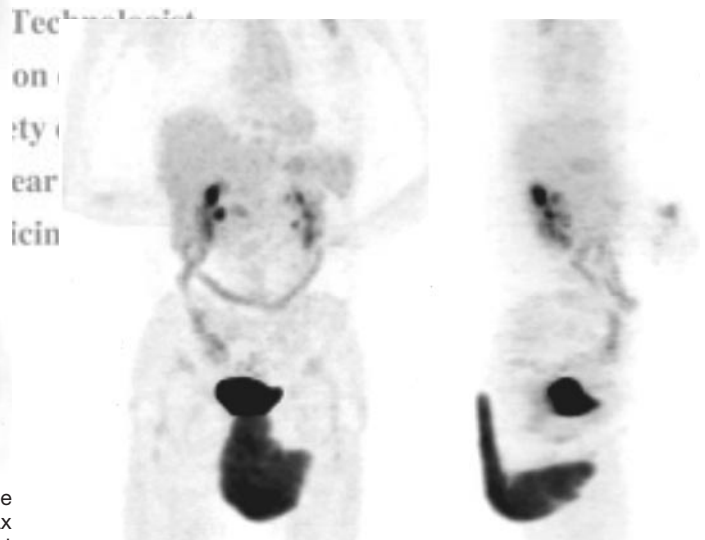


FIGURE 4. Coronal and lateral images of patient wearing ^{18}F -FDG-contaminated urinary underpad.

able during the uptake portion of the study. This will alleviate the need for the patient to walk (which causes muscle uptake) or be moved after the injection. It is imperative for the technologist to spend adequate time before the ^{18}F -FDG injection communicating with the patient about the procedure time sequencing and expectations. Currently, intravenous access is recommended. The intravenous access site should be determined from the patient history and chosen so as to avoid lymph node uptake or dose infiltration in areas of disease (1,3). Intravenous access also assures the technologist that the vein is and will remain viable and provides a method to flush the ^{18}F -FDG dose syringe and intravenous line with saline. Some facilities assume that if the patient is not diabetic that the glucose level at the time of the ^{18}F -FDG injection will be normal. Other facilities monitor the glucose level at the time of the ^{18}F -FDG injection with a glucometer or by serum glucose. The glucometer blood sample can be taken from the intravenous line to be used for the ^{18}F -FDG injection. This eliminates an additional needle stick for the patient. The glucose taken by this method ensures that the glucose level is ≤ 150 mg/dL. Stress, anxiety, or medications may cause the serum glucose level to be elevated.

The patient should be quiet and lie still in a dimly lit room before the glucose determination and ^{18}F -FDG injection. The technologist should be efficient and timely in the glucose determination, ^{18}F -FDG injection, 20- to 30-mL saline flush, and postinjection activities. A 20- to 30-mL saline flush is useful in reducing the venous retention of ^{18}F -FDG. This should be accomplished with minimal interruption. The patient should be monitored during the uptake period. During the ^{18}F -FDG tumor uptake time the patient should remain quiet and still. The technologist should leave the patient-uptake area at this time and should record dose injection information. The injection site location should be noted in writing to alleviate any concerns when physicians interpret the study. A note should be made of any suspicion of dose infiltration. Dose infiltration will negate the study quantification by region-of-interest (ROI) analysis or standard uptake value (SUV) (3). To ensure accurate ROI and SUV analysis, it is important to assay before and after the ^{18}F -FDG injection syringe with accurate times (5). At some sites, the clocks in the radiopharmacy, patient dosing area, and imaging areas are set to match the PET scanner computer clock or other clock system to maintain accuracy in all the areas. This ^{18}F -FDG dose information may also be entered on the scanner for the patient information and the ^{18}F -FDG tumor imaging study decay corrected for the patient dose data. ^{18}F -FDG injection in central lines or intravenous lines should be performed in cases in which the line and connectors are not in the field of interest. These lines must be flushed with saline to minimize ^{18}F -FDG adherence that may obscure visualization or create artifacts. Documenting the ^{18}F -FDG tumor uptake period is critical for the image decay correction and SUV uptake calculation (5). During the ^{18}F -FDG uptake period, a patient scheduled for

an ^{18}F -FDG brain scan should not be allowed any neurologic stimulation. He or she should remain quiet and still in a dimly lit room (1). Brain uptake of ^{18}F -FDG is more rapid than tumor uptake. The ^{18}F -FDG uptake for the brain is approximately 30–45 min. A patient who is to have brain imaging included may be imaged during this period. The ^{18}F -FDG tumor uptake time varies from 60 to 120 min. Patients for whole-body scan (without brain) may be started during this time period.

PATIENT POSITIONING

Patients are requested to empty their bladders or colostomy bags, change diapers or underpads, empty pockets (keys, wallets, etc.), and remove injection site gauze or bandages before positioning on the scanner for the ^{18}F -FDG tumor scan. Artifacts may be caused by an unemptied bladder or colostomy bag with ^{18}F -FDG excretion. Wallets and other items in pockets can create discomfort during the scan. If the clinical indication for the scan includes the neck or esophagus, the patient is asked to take a swallow of water or rinse his or her mouth before the scan to minimize the salivary excretions. The ^{18}F -FDG tumor scan involves patient positioning for patient comfort and anatomic correctness. Special care in positioning is crucial for symmetry of body areas on the transaxial and reformatted images. Extra effort in positioning is important.

It may be helpful to have the patient positioned with his or her head out of the scanner for most of the ^{18}F -FDG tumor scan, if possible. This may help with claustrophobic or anxious patients. Patient positioning must allow for body movement freely through the scanner bore. Extreme care must be taken to place intravenous lines, catheter lines, and all connecting bags, oxygen tubing, safety straps, sheets, and other equipment (e.g., blood pressure cuff, pulse oximeter) in alignment to allow safe movement through the scanner bore for the entire scan time. Patient motion during ^{18}F -FDG tumor imaging creates artifacts or questions about patient position. Technologists must meet this challenge with innovative methods and the use of pillows, cushions, and other props (sandbags, foam, etc.) to decrease motion as a result of discomfort.

The imaging protocol for a clinical indication that involves the head, neck, or upper chest regions should have the imaging begin at the head and continue to the pelvis. Along with the water the patient sipped before positioning, this technique should minimize any ^{18}F -FDG salivary excretions. For clinical indications that involve the pelvis and lower abdomen, the imaging should begin at the pelvis and continue to the head. This will help reduce the bladder artifact and enhance pelvis/abdomen imaging.

Urinary catheter clamping after saline infusion (200 mL) into the bladder before the pelvic images accentuates bladder definition without creating artifacts from intense activity and can be used for appropriate indications. This method can help to visualize abnormal ^{18}F -FDG uptake behind and around the urinary bladder (Fig. 5). After the pelvis imaging

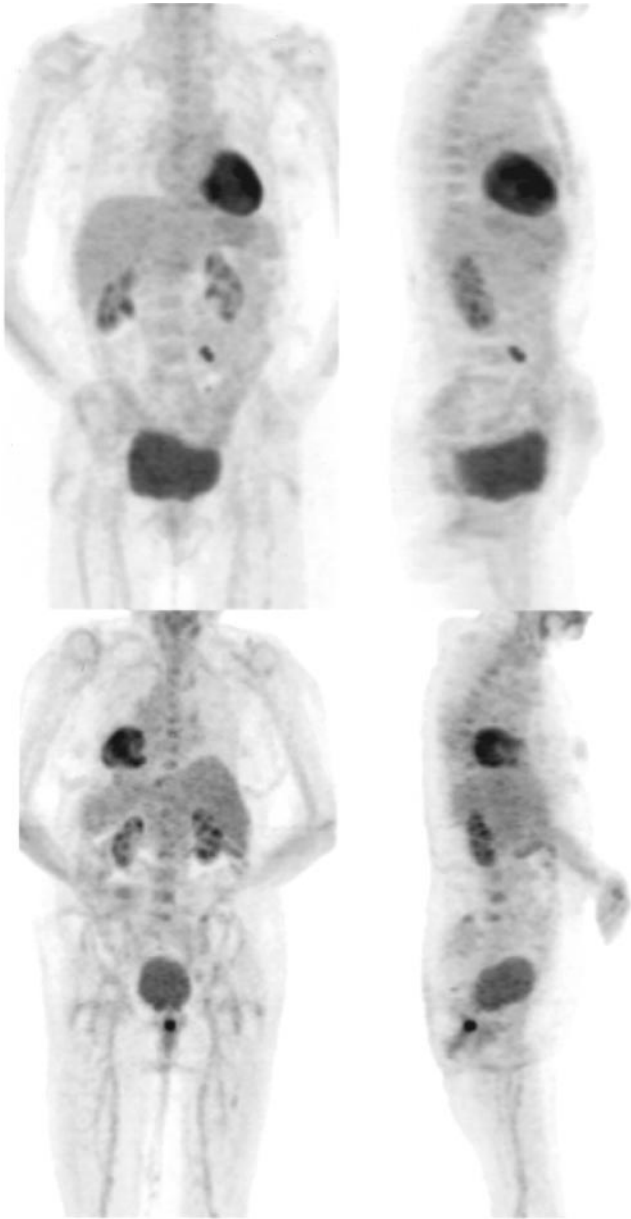


FIGURE 5. Projection images of patient with triple-lumen urinary catheter. Bladder was flushed with normal saline during ^{18}F -FDG uptake period. Bladder was continuously drained. At time of scanning, draining catheter tube was clamped and 200–300 mL normal saline were infused into bladder. Imaging was begun at femur region. When pelvis images were finished, draining catheter tube was unclamped and allowed to drain for patient comfort during rest of ^{18}F -FDG imaging. Top row shows patient with no pelvic lesion. Bottom row shows patient with anal lesion.

is complete (usually in the first 2–3 bed positions), fluid is discontinued and the urinary catheter is unclamped.

Music, books on tape, or CDs may be played or the patient may meditate after any ^{18}F -FDG brain imaging is complete, so that he or she is comfortable and relaxed during the ^{18}F -FDG tumor scan. Some sites use aromatherapy to help patients relax. It is important to note patients' metal bone pins, pacemakers, etc., so that the physicians will be aware of these items when reviewing transmission and nonattenuated ^{18}F -FDG tumor scans. After the study, the patient should be told to continue with fluid intake to minimize radiation exposure.

CONCLUSION

^{18}F -FDG oncologic tumor imaging is an evolving modality. The advent of CT and PET scanner integration is just one of the advances. Patient, family, referring physician, scheduling secretaries, and ancillary staff education and communication are vital. It is important for technologists and physicians to improve techniques, decrease imaging times, and increase patient comfort while providing quality noninvasive ^{18}F -FDG PET scans. This article is intended to help nuclear medicine technologists and physicians understand some of the challenges involved.

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CONTINUING EDUCATION TEST: Clinical ^{18}F -FDG Oncology Patient Study Techniques

For each of the following questions, select the best answer. Then circle the number on the CE Tests Answer Sheet that corresponds to the answer you have selected. Complete the answer sheet. Keep a record of your responses so that you can compare them with the correct answers, which will be published in the next issue of *JNMT* after the test return deadline. Answers to these test questions should be returned on the Answer Sheet no later than **March 31, 2004**. An 80% correct response rate is required to receive 1.0 CEH (Continuing Education Hour) credit for each article. SNM Technologist Section members can find their VOICE number on the upper left-hand corner of their *JNMT* mailing labels. If you've joined our Nonmember VOICE Tracking Program, please write *NMVT* on the Answer Sheet (no extra fee is required). Documentation will appear on your VOICE transcript. Nonmembers who have not joined our Nonmember VOICE Tracking Program must mail a \$10.00 check or money order, made payable to SNM, for each completed quiz. You will receive a certificate of completion indicating credit awarded for receiving a passing score of 80% or better. All articles are approved by the Florida Department of Health Bureau of Radiation Control.

A. *A pertinent patient history will allow the scheduling personnel to determine:*

101. If the patient will need urinary catheterization
102. If there is a need for diazepam
103. The possible length of ^{18}F -FDG tumor scan
104. If patient is breastfeeding
105. All of the above

B. *A diabetic control specialist may be consulted for:*

106. All diabetic patients
107. Diabetic patient whose glucose level remains elevated after his or her attempts to regulate it
108. Patient with a glucose level < 150 mg/dL
109. If insulin is administered within 2 h of ^{18}F -FDG injection

C. *Water intake recommendations for ^{18}F -FDG tumor scans are:*

110. No water within 24 h of ^{18}F -FDG injection
111. Increased water intake (48 oz/day before scan and 24 oz on day of scan)
112. Increased water intake before and after
113. Both 111 and 112

D. *Hydration and frequent bladder voiding:*

114. Decrease the bladder radiation absorbed dose
115. Decrease urge to void during scan
116. Increase radiation absorbed dose to the bladder
117. Are necessary to avoid urinary catheterization in all situations

E. *Increased muscle uptake of ^{18}F -FDG is observed when:*

118. The patient is quiet and still in a dimly lit room
119. The patient is chewing gum during uptake time
120. The patient's glucose level is ≤ 200 mg/dL at the time of ^{18}F -FDG injection
121. The patient is well hydrated

F. *Muscle tension and stress may be alleviated by:*

122. Patient instruction and positioning
123. Diazepam administration before the ^{18}F -FDG injection
124. Patient abstinence from nicotine and caffeine for several hours before the ^{18}F -FDG injection
125. Both 122 and 123

G. *Patient dietary recommendations include:*

126. NPO for 4 h before the ^{18}F -FDG injection
127. No medications for 12 h before the ^{18}F -FDG injection
128. Carbohydrate diet for 24 h before the ^{18}F -FDG injection
129. None of the above

H. *Patient glucose levels may be elevated as a result of:*

130. Strenuous exercise
131. Hydration and frequent bladder emptying
132. Anxiety and stress
133. ^{18}F -FDG injection

I. *^{18}F -FDG dose infiltration will cause:*

134. Muscle uptake
135. SUV calculation to be invalid
136. Image artifact
137. Both 135 and 136

J. *The documentation of ^{18}F -FDG uptake time is vital to:*

138. The SUV calculation
139. ^{18}F -FDG tumor scan decay correction
140. Patient dose calculation
141. Both 138 and 139

K. *To enhance urinary excretion some facilities use:*

- 142. Urinary catheterization
 - 143. Urinary catheterization and continuous saline bladder flush
 - 144. Diuretics
 - 145. All of the above
-

L. *A patient with a clinical indication for an ^{18}F -FDG tumor scan that includes the neck and/or esophagus should:*

- 146. Be catheterized after ^{18}F -FDG injection and before the ^{18}F -FDG tumor scan
- 147. Chew gum during the ^{18}F -FDG uptake phase
- 148. Have a few sips of water and/or rinse mouth before the ^{18}F -FDG tumor scan to alleviate ^{18}F -FDG salivary distribution
- 149. Have lemon juice to drink before the ^{18}F -FDG tumor scan

M. *Contraindications for an ^{18}F -FDG tumor scan include:*

- 150. Pregnancy
 - 151. Breastfeeding
 - 152. Glucose level of 400 mg/dL at time of the ^{18}F -FDG injection
 - 153. All of the above
-

N. *A patient who is to have an ^{18}F -FDG brain scan included in his or her ^{18}F -FDG tumor scan should:*

- 154. Listen to music during the ^{18}F -FDG uptake time for brain stimulation
- 155. Exercise strenuously immediately before the ^{18}F -FDG injection
- 156. Remain in a quiet and dimly lit room for the ^{18}F -FDG uptake
- 157. Both 158 and 159.

Answers to CE Article Test, Dec 2001

The CE article "Federal Regulations and Reimbursement for PET" by Keppler was accompanied by a CE test. The correct answers are:

- | | | | | |
|--------|--------|--------|--------|---------------|
| A. 102 | D. 120 | G. 132 | J. 147 | M. 162 or 165 |
| B. 106 | E. 122 | H. 138 | K. 152 | |
| C. 111 | F. 130 | I. 145 | L. 157 | |

Note: Answers to the CE tests in this issue will be given in the June 2004 issue.

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**CONTINUING EDUCATION TEST
Clinical ¹⁸F-FDG Oncology Patient Preparation Techniques**

Answer Sheet

101	106	110	114	118	122	126	130	134	138	142	146	150	154	158
102	107	111	115	119	123	127	131	135	139	143	147	151	155	159
103	108	112	116	120	124	128	132	136	140	144	148	152	156	160
104	109	113	117	121	125	129	133	137	141	145	149	153	157	161
105														



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