# ACR–ACNM–SNMMI–SPR PRACTICE PARAMETER FOR PERFORMING FDG-PET/CT IN ONCOLOGY

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## PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question. The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner considering all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The purpose of this document is to assist practitioners in achieving this objective.

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[1] *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the "ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008)" sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.*

## I. INTRODUCTION

This practice parameter was revised collaboratively by the American College of Radiology (ACR), the American College of Nuclear Medicine (ACNM), the Society of Nuclear Medicine and Molecular Imaging (SNMMI), and the Society for Pediatric Radiology (SPR) to guide physicians interpreting oncologic positron emission tomography/computed tomography (PET/CT) with fluorodeoxyglucose (fluorine-18-2-fluoro-2-deoxy-D-glucose (FDG)) for adult and pediatric patients.

FDG is radiolabeled with 18-F, which is cyclotron-produced, emits positrons, has a half-life of approximately 110 minutes, and is the most commonly used PET oncology imaging radiopharmaceutical. FDG-PET provides

information about glucose metabolism in the body and is a sensitive method for detecting, localizing, staging, and monitoring the effects of therapy for many malignancies. Computed tomography (CT) uses an external source of radiation to produce 3-D images that demonstrate the size, shape, and composition of organs and abnormalities within the body. FDG-PET and CT are proven diagnostic procedures.

Techniques for registration and fusion of images obtained from separate PET and CT scanners have been available for years [1,2]. Combined PET/CT provides both the metabolic information from FDG-PET and the anatomic information from CT in a single examination. The information obtained by PET/CT has been shown to be more accurate in evaluating patients with known or suspected malignancy than either PET or CT alone or PET and CT obtained separately but interpreted together [1,3-17]. The advantages of having both PET and CT in a single device have resulted in rapid dissemination of this technology in the United States. This practice parameter pertains only to integrated PET/CT devices.

Issues related to PET/CT practice include equipment specifications, image acquisition protocols, supervision, interpretation, professional qualifications, and safety. A prior discussion of these issues by representatives of the ACR, the SNMMI, and the Society of Advanced Body Imaging (SABI), (formerly Society of Computed Body Tomography and Magnetic Resonance (SCBT-MR)) is available [18,19].

For the purposes of this practice parameter, the following definitions apply:

PET/CT scanner: A hybrid device that includes a single patient table for acquiring a PET scan and CT scan in sequential fashion.

PET/CT registration: The reconstructed PET and CT images are spatially co-registered. This is the process of aligning PET and CT image sets that represent the same body volume, such that there is a voxel-by-voxel match for the purpose of attenuation correction as well as combined image display (fusion).

PET/CT fusion: PET/CT fusion refers to the simultaneous display of these co-registered PET and CT images.

PET/CT acquisitions: The extent of tumor imaging can be tailored to suit the specific indications with the following fields of view considered standard [18]:

1. Whole body (skull vertex to feet)
2. Skull base to mid thighs
3. Vertex to mid thighs
4. Limited region (eg, brain only, chest only)

## II. INDICATIONS

Examples of indications for FDG-PET/CT include, but are not limited to, the following:

1. Staging on presentation for guiding initial treatment strategy in patients with a known malignancy
2. Monitoring response to therapy to include determining whether residual abnormalities identified with another imaging modality represent persistent viable tumor or posttreatment changes (inflammation, fibrosis, or necrosis)
3. Restaging in the setting of relapse
4. Attempting to localize the site of primary tumor when metastatic disease is the initial manifestation of malignancy
5. Verifying and localizing "occult” disease, especially in the presence of clinical indicators such as elevated tumor markers
6. Evaluating an abnormality considered "indeterminate” by another imaging modality to determine whether glucose metabolism in that abnormality favors a benign or malignant process
7. Guiding treatment goals, such as curative versus palliative therapy
8. Guiding biopsy and radiation therapy planning.

FDG uptake is variable for different tumor types and can range from high to low uptake. A continuing review of

the literature is recommended to determine the most effective applications.

For information on radiation risks to the fetus, see the ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation [20].

## III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

### A. Physician

All PET/CT examinations must be performed under the supervision of and interpreted by a physician who has the following qualifications:

Certification in radiology or diagnostic radiology, nuclear radiology, or nuclear medicine by the American Board of Radiology, American Board of Nuclear Medicine, American Osteopathic Board of Radiology, American Osteopathic Board of Nuclear Medicine, the Royal College of Physicians and Surgeons of Canada, or the Collège des Médecins du Québec.

or

At a minimum, completion of a formal Accreditation Council for Graduate Medical Education (ACGME)-approved general nuclear medicine program that must include radiation physics and instrumentation, radiochemistry, radiopharmacology, radiation dosimetry, radiation biology, radiation safety and protection, and quality control (QC). In addition, clinical training in general nuclear medicine is required and must cover technical performance, calculation of dosages, evaluation of images, correlation with other diagnostic modalities, and interpretation.

and

1. Evidence of CME in PET/CT
2. Evidence of ongoing interpretation of oncologic PET/CT

In addition, all physicians supervising and/or interpreting nuclear medicine examinations must satisfy all applicable state and federal regulations as well as any institutional policies that pertain to the in vivo use of radiopharmaceuticals, performance of imaging procedures, and the safe handling of radioactive materials.

## III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

### B. Qualified Medical Physicist

For qualified medical physicist qualifications, see the ACR–AAPM Technical Standard for Medical Physics Performance Monitoring of PET/CT Imaging Equipment [21].

## III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

### C. Radiologic and Nuclear Medicine Technologist

The nuclear medicine technologist performing the PET/CT should be appropriately registered/certified. Additional qualifications for performance of diagnostic CT may also be required, depending upon the technologist's location [22]. The Nuclear Medicine Technology Certification Board (NMTCB) has developed PET and CT specialty examinations (www.nmtcb.org) and the American Registry of Radiologic Technologists (ARRT) offers a CT certification examination (https://www.arrt.org/earn-arrt-credentials/credential-options/computed-tomography).

For more information regarding training and certification, see the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) and the ACR-ACNM-SNMMI-SPR Practice Parameter for the Use of Radiopharmaceuticals in Diagnostic Procedures [23,24].

## III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

### D. Radiation Safety Officer

The radiation safety officer (RSO) must meet applicable requirements of the Nuclear Regulatory Commission (NRC) for training as specified in 10 CFR 35.50, or equivalent state regulations [25].

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

See the ACR–ASNR–SPR Practice Parameter for the Performance of Computed Tomography (CT) of the

Extracranial Head and Neck, the ACR–SABI–SPR–STR Practice Parameter for the Performance of Thoracic Computed Tomography (CT), and the ACR–SABI–SAR–SPR Practice Parameter for the Performance of Computed Tomography (CT) of the Abdomen and Computed Tomography (CT) of the Pelvis [26-28].

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### A. Written Request for the Examination

The written or electronic request for an FDG-PET/CT examination should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state scope of practice requirements. (ACR Resolution 35 adopted in 2006 – revised in 2016, Resolution 12-b)

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### B. Patient Preparation [29-31]

#### 1. Prior to appointment:

a. Instruct patients to avoid strenuous activity 24 hours prior to FDG injection.
b. Recommend low-carbohydrate meals for 24 hours prior to FDG injection.
c. No caffeine, alcohol, or nicotine 12 hours prior to FDG injection.
d. Provide fasting instructions (a minimum of 4 hours) with no parenteral nutrition or oral/intravenous fluids containing sugar or dextrose for the same period. No candy, mints, gum, or over-the-counter medicines containing sugar. Even "sugar-free" items may contain traces of sugar.
e. Encourage oral hydration with a goal of 1 L (34 oz) in 2 hours prior to appointment.
f. Prescription medications should be taken as directed.
g. Discontinue metformin 48 hours before the study.
h. Determine whether there is a history of iodinated contrast allergy and determine renal function if a contrast-enhanced CT portion of the examination has been requested.
i. If a patient requires sedation or general anesthesia, individual institutional policies should be followed.

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### B. Patient Preparation [29-31]

#### 2. Prior to FDG injection

Perform pregnancy testing when appropriate and in accordance with institutional policies (see the ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation) [20,31,32].

a. Review the patient's history with attention to:
    i. Reason for examination (symptoms, diagnoses, and recent imaging examinations)
    ii. Treatment (surgical, radiation, and/or chemotherapy)
    iii. Medications
    iv. Recent trauma/exercise
    v. Presence of concurrent infection
    vi. Presence of diabetes
    vii. Specific details and dates should be obtained whenever possible.
b. Consider premedications:
    i. Anxiolytics can be administered in patients with claustrophobia or anxiety. Oral alprazolam (0.5 mg given 10–60 minutes prior to FDG injection) is an option. Patients must be counseled against driving

given the medication's sedative and motor-impairing effects, and it is recommended that the patient should sign a form agreeing to this.

c. Oral beta-blockers (such as propranolol 20 mg) can be administered 60 minutes prior to injection or benzodiazepines (such as diazepam 5 mg) 10–30 minutes prior to injection to help minimize physiologic brown fat uptake. For pediatric patients, 0.10 mg/kg of oral diazepam or 1 mg/kg oral propranolol can be given, but the combination of warming blankets and propranolol in this patient population best reduces brown fat uptake [33]. Keep the patient warm:
   The patient should be advised to remain warm 24 hours prior to FDG injection. In addition, the patient can be kept warm with warming blankets prior to and after FDG injection. This helps minimize physiologic brown fat and may be preferable to giving the patient medications for this purpose.
d. Serum glucose analysis performed immediately prior to FDG administration (<200 mg/dL acceptable)
   i. If the serum glucose is >200 mg/dL, but <300 mg/dL, contact the interpreting physician for further instructions. If the serum glucose is >300 mg/dL, then the patient should be rescheduled. Of note, if the patient did in fact properly follow fasting instructions, the referring physician may need to be informed about testing the patient for diabetes and/or consider referring the patient to urgent care or the emergency department in cases of extremely high blood glucose levels.
e. Diabetic patient guidelines:
   i. PET scan should be scheduled early in the morning (if possible) as this is the time that most diabetic patients have the lowest glucose level. However, some diabetic patients may have lower glucose levels in the afternoon, and for these patients an afternoon appointment is preferable.
   ii. Diabetic patients should take their usual insulin the day before. After midnight, patients should fast (except for water).
   iii. A low- or no-carbohydrate diet the evening prior to the PET/CT may improve glycemic control.
   iv. On the morning of the PET scan, hold all insulin if FDG injection is scheduled in the early morning.
   v. Oral diabetic medications can be taken as prescribed (see prior comments on metformin).
   vi. If PET scan is scheduled after 10 AM, patient should eat a low-carbohydrate breakfast at least 4 hours before the injection and should receive half of the usual regular (short-acting) insulin. Do not use long-acting or mixed (70/30) insulin after midnight.
   vii. If the patient is on an insulin pump, it is preferred that it is turned off 4 hours prior to the study, but if unable to, the setting should be on the night/basal setting during the PET scan. After the PET scan, settings can be adjusted as prescribed.
   viii. After completion of the PET scan, patients should be encouraged to eat a meal immediately. It may be advisable for patients to take half of the usual morning dosage of insulin with the post-PET meal.

Technologist should inform the interpreting physician if the patient has hyperglycemia >200 mg/dL or hypoglycemia with symptoms. In these situations, waiting approximately 20 to 30 minutes and repeating a finger-stick glucose measurement should be considered prior to rescheduling the patient.

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### B. Patient Preparation [29-31]

#### 3. Following injection (uptake period)

a. Have the patient remain seated or recumbent in a quiet room during uptake period (decreases muscle uptake). Additionally, in adult patients with head and neck cancer, oral alprazolam 0.5 mg given immediately after FDG injection reportedly can reduce skeletal muscle uptake that can impede lesion detection and confound scan interpretation [35].
b. The uptake room should be dimly lit if the patient is to undergo brain imaging.
c. Patients should void immediately prior to being positioned on the PET/CT table for imaging. In special circumstances, intravenous hydration, diuretic administration, and/or bladder catheterization can be used to reduce radiation burden and artifacts related to accumulated physiologic radiopharmaceutical activity in the ureters and urinary bladder.
d. Consider use of sedation as necessary in younger children or developmentally delayed patients (see the

ACR–SIR Practice Parameter for Minimal and/or Moderate Sedation/Analgesia [34]).

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### B. Patient Preparation [29-31]

#### 4. Lactating Patients

a. Nursing mothers should express/pump milk prior to the study.
b. Per recent Advisory Committee for Medical use of Isotopes (ACMUI) guidelines, nursing should be interrupted for 4 hours following 18-F FDG injection [36].

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### C. Radiopharmaceutical

For adults, the generally accepted range for administered activity of FDG is 185 to 740 MBq (5-20 mCi) [37]. However, the administered activity could be below 5 mCi with a weight-based approached or depending upon the type of PET detector being used.

For children, the administered activity of FDG should be determined based on body weight and should be as low as reasonably achievable (ALARA) for diagnostic image quality[1]. Per the 2016 Update of the North American Consensus Guidelines, pediatric FDG administered activity should be 3.7–5.2 MBq/kg (0.10-0.14 mCi/kg), a minimum of 26 MBq (0.7 mCi) for body and 3.7 MBq/kg (0.10 mCi/kg, a minimum of 14 MBq (0.37 mCi) for head [38].

The specific administered activity typically depends upon the local imaging protocol. The local protocol may require a standard activity, or the activity may vary as a function of various parameters, such as patient size, scanning mode (2-D versus 3-D), percentage of scan bed (slice) overlap, or clinical indication. For variable dosages, other means of determining the administered activity can be based upon a combination of factors, for example, as outlined in European Association of Nuclear Medicine guidelines [29], which use the patient's weight, duration of bed positions in minutes, and percent bed position overlap in certain PET/CT systems (some systems do not use bed positions). The variable dose calculation's goal is to optimize a personalized dosage with the ALARA principle. Without a dedicated dosage injector with the ability to precisely elute a calculated dosage, a fixed dose with a range may be more practical for adults.

With PET/CT, the radiation dose to the patient is the combination of the dose from the PET radiopharmaceutical and the dose from the CT portion of the examination. Lower administered activities or changes in CT parameters resulting in decreased radiation dose may be appropriate with advances in PET/CT technology.
When feasible, the radiopharmaceutical should be injected intravenously at a site away from sites of known or suspected disease. If peripheral IV access is not achievable, a central line can be used but must be sufficiently flushed with normal saline.

[1]For more specific guidance on pediatric dosing, please refer to the *Pediatric Radiopharmaceutical Administered Doses: 2010 North American Consensus Guidelines.*

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### D. Protocol for CT Imaging

The CT performed as part of a PET/CT examination provides attenuation-correction information and diagnostic information that may be relevant to both PET interpretation and overall patient care. A variety of protocols exist for performing the CT scan in the context of PET/CT scanning. In some cases, low-dose CT scans are designed primarily to provide attenuation correction and anatomic localization. In other cases, the CT portion of the examination is performed with intravenous and/or oral contrast media and optimized CT parameters designed to lower image noise. If a diagnostic CT scan is requested as part of PET/CT, the CT protocol appropriate for the body region(s) requested should be used. Regardless of the CT technique used, a careful review of CT images is

necessary for comprehensive interpretation of the PET/CT examination.

For a diagnostic CT scan of the abdomen and/or pelvis, intraluminal gastrointestinal contrast media may be administered to improve visualization of the gastrointestinal tract unless medically contraindicated or unnecessary for the clinical indication. This may be positive-contrast media such as a dilute (2%) solution of a water-soluble iodinated contrast agent–diluted barium sulfate or diatrizoic acid or negative-contrast media such as water [39]. Highly concentrated barium collections may result in an attenuation-correction artifact that may lead to overestimation of the regional FDG concentration and should be avoided. Dilute barium sulfate and oral iodinated contrast media cause less overestimation and are less likely to have an adverse impact on PET image quality [40-42].

When indicated, the CT scan can be performed with intravenous contrast media using appropriate injection techniques. It has been shown that there is no statistically significant or clinically significant interference with standardized uptake values (SUVs) on PET/CT due to intravenous contrast administration [43].

Breathing patterns during CT acquisition should be optimized so that the positions of the diaphragm on the PET emission and the CT transmission images match as closely as possible.

If a single breath-hold technique is used for CT imaging, optimal alignment of the PET and CT images is obtained with respiration suspended in the quiet end-expiratory (end–tidal volume) phase. If respiration is not suspended during CT imaging, the patient should be coached on shallow/quiet breathing. To optimize breathing pattern, gating of the PET and/or CT can be performed in more modern PET/CT scanners.

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### E. Protocol for PET Imaging

Emission images are acquired immediately after CT and are generally obtained 60 minutes following radiopharmaceutical administration. However, this time period may be shorter (no less than 45 minutes) or longer for certain trials or unique clinical situations. Note that consistency of SUV measurements depends on strict observance of the uptake time [44].

Emission image acquisition time typically varies from 1–5 minutes or longer per bed position for body imaging and is based on the administered activity, patient body weight, and the sensitivity of the PET device (as determined largely by the detector composition and acquisition method). Acquisition time can be adjusted in certain clinical situations to provide higher count images in a given anatomic area.

Iterative reconstruction techniques have largely replaced filtered back projection, and when used with time of flight, image quality can be maintained while reducing administered FDG activity. Of note, new scanners may utilize artificial intelligence/machine learning–based reconstructions or Bayesian penalized-likelihood reconstruction algorithms as methods.

Semiquantitative estimation of FDG accumulation using the SUV is based on local radioactivity concentration measured on images corrected for attenuation and normalized for the injected activity and body weight, lean body mass, or body surface area. The accuracy of SUV measurements depends on the accuracy of the calibration of the PET device, among other factors. SUV is utilized in determining tumor response over time. Measures should be taken to minimize the factors that may affect it and should include using the same scanner configuration on subsequent examinations (including reconstruction algorithms, attenuation maps, etc), maintaining the same interval between injection and scanning, avoiding infiltration of injected activity, and using the same measurement techniques (volume-of-interest volumes, max/peak/mean measurements). Some factors that affect SUV currently remain beyond control, such as variations in serum glucose and patient motion/breathing-related attenuation-correction artifacts [45].

Recording changes in the intensity of FDG uptake with semiquantitative measurements, expressed in absolute values and percent changes, may be appropriate in some clinical scenarios. However, the technical protocol and analysis of images need to be consistent in the 2 data sets.

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### F. Interpretation

With integrated PET/CT systems, the software packages typically provide a comprehensive platform for image review, including registered and aligned CT images, FDG-PET images with and without attenuation correction, and PET/CT fusion images in the axial, coronal, and sagittal planes. In addition, maximum-intensity projection (MIP) images of the PET examination should be generated for review. FDG-PET images with and without attenuation correction should be available for review.

On whole-body scans, studies have shown that FDG-PET imaging of the brain is relatively insensitive for detecting cerebral and cerebellar metastases. This is due in part to the high physiologic FDG uptake in the normal gray matter, and thus images of the brain should be reviewed with attention to both FDG-avid and photopenia (non–FDG-avid) areas.

Although the pattern of FDG uptake and associated CT findings as well as correlation with history, physical examination, and other imaging modalities are usually the most helpful in differentiating benign from malignant lesions, semiquantitative estimates (eg, SUVs) may also be of value, especially for evaluating changes with time or therapy.

Tissues other than neoplastic disease may show substantial FDG uptake. Other conditions may lead to poor FDG uptake in neoplastic tissue. The following list, although not all-inclusive, includes the most commonly encountered situations in which FDG uptake is caused by processes other than malignant disease and in which FDG uptake does not occur despite the presence of malignant disease:

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### F. Interpretation

#### 1. Situations that can lead to benign FDG-PET/CT uptake

##### a. Physiologic uptake

- Salivary glands and lymphoid tissue in the head and neck
- Thyroid
- Orbital, speech, and tongue muscle (especially in children)
- Brown adipose tissue
- Thymus, especially in children and young adults
- Lactating breast
- Areola
- Skeletal and smooth muscle (more marked with recent exercise or hyperinsulinemia). Laryngeal muscle uptake with phonation. Masticator muscle uptake with chewing. Diaphragm/intercostal muscle uptake with crying (pediatric) or labored breathing.
- Gastrointestinal tract (eg, esophagus, stomach, bowel, and anal sphincter, with large-bowel uptake, which is often very intense in patients using metformin, uptake in the cecal region)
- Urinary tract structures (containing excreted FDG)
- Female genital tract (eg, uterus during menses, corpus luteum cyst)
- Skeletal: physes in children, ischiopubic synchondrosis
- Axillary node uptake (from infiltration at site of injection or recent tattoo in same extremity or secondary to recent vaccination for COVID 19)

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### F. Interpretation

#### 1. Situations that can lead to benign FDG-PET/CT uptake

##### b. Infectious and inflammatory processes

- Postprocedural inflammation/infection/hematoma, biopsy site, thoracentesis, paracentesis, amputation site
- Postradiation inflammation (eg, radiation pneumonitis)
- Postchemotherapy changes, including inflammation and necrosis
- Local inflammatory disease, especially granulomatous processes (eg, sarcoidosis, fungal, and mycobacterial disease)
- Ostomy site (eg, trachea, colon), feeding and drainage tubes
- Injection site
- Thyroiditis
- Esophagitis, gastritis, inflammatory bowel disease, appendicitis
- Acute and occasionally chronic pancreatitis
- Acute cholangitis and cholecystitis
- Osteomyelitis, recent fractures, joint prostheses
- Lymphadenitis and reactive lymph nodes (especially in children)
- Vascular inflammation, including vasculitis and atherosclerotic disease

**IV. FDG-PET/CT EXAMINATION SPECIFICATIONS**

**F. Interpretation**

**1. Situations that can lead to benign FDG-PET/CT uptake**

**c. Benign tumor or tumor-like conditions**

- Pituitary adenoma
- Adrenal adenoma
- Thyroid gland follicular adenoma
- Salivary gland tumors (eg, Warthin, pleomorphic adenoma)
- Colonic adenomatous polyps
- Ovarian thecoma and cystadenoma
- Skeletal: aneurysmal bone cyst, fibrous cortical defect, enchondroma, giant-cell tumor, benign fibro-osseous lesions (in pediatric patients)
- Plexiform neurofibroma
- Leiomyoma

**IV. FDG-PET/CT EXAMINATION SPECIFICATIONS**

**F. Interpretation**

**1. Situations that can lead to benign FDG-PET/CT uptake**

**d. Hyperplastic and dysplastic conditions**

- Graves disease
- Cushing disease
- Bone marrow hyperplasia (eg, anemia, colony-stimulating factor)
- Thymic rebound hyperplasia (after chemotherapy)
- Fibrous dysplasia
- Paget disease

**IV. FDG-PET/CT EXAMINATION SPECIFICATIONS**

**F. Interpretation**

**1. Situations that can lead to benign FDG-PET/CT uptake**

**e. Artifacts**

- Misalignment between PET and CT data can cause attenuation-correction artifacts. Fusion images and PET images without attenuation correction can be used to help identify these artifacts.
- Inaccuracies in converting from polychromatic CT energies to the 511-keV energy of annihilation radiation can cause artifacts around implanted devices, metal, highly concentrated iodinated contrast, or dense barium, although these artifacts are less common with newer conversion algorithms.
- Motion artifact
- Edge artifact
- Metallic artifact
- Truncation artifact

## IV. FDG-PET/CT EXAMINATION SPECIFICATIONS

### F. Interpretation

#### 2. Situations that can lead to false-negative FDG-PET/CT interpretation:

- Small lesion size (<2 × resolution of the system)
- Hyperglycemia and hyperinsulinemia
- Recent therapy
- Chemotherapy
- Radiation therapy
- Steroid therapy
- Tumors with low metabolic activity
- Certain low-grade or well-differentiated tumors, such as mucinous neoplasms to include lung adenocarcinoma in situ
- Prostate carcinoma
- Carcinoid tumor and islet cell tumors
- Medullary thyroid cancer
- Lobular carcinoma of the breast
- Hepatocellular tumors, including well-differentiated hepatocellular carcinoma
- Indolent lymphoma, including marginal zone lymphoma and small-cell lymphocytic lymphoma

## V. EQUIPMENT SPECIFICATIONS

See the ACR–AAPM Technical Standard for Medical Physics Performance Monitoring of PET/CT Imaging Equipment, the ACR–ASNR–SPR Practice Parameter for the Performance of Computed Tomography (CT) of the Extracranial Head and Neck, the ACR–SABI–SPR–STR Practice Parameter for the Performance of Thoracic Computed Tomography (CT), and the ACR–SPR Practice Parameter for the Performance of Computed Tomography (CT) of the Abdomen and Computed Tomography (CT) of the Pelvis [21,26-28].

Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications, to include iodinated contrast media. The equipment and medications should be monitored for inventory and drug expiration dates on a regular basis. The equipment, medications, and other emergency support must also be appropriate for the range of ages and sizes in the patient population.

A fusion workstation with the capability to display PET, CT, and fused images with different percentages of PET and CT blending should also be available. The workstation should also have the capability to measure SUV with volumetric ROI.

PET/CT scanning done specifically for radiation therapy planning should be performed with a flat table top, immobilization devices as needed, and the use of appropriate positioning systems in order to best match patient positioning during radiation therapy.

## VI. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging

Findings [46].
The technique section of the report should include the radiopharmaceutical (eg, FDG), the administered activity, route and site of administration, as well as any pharmaceuticals administered (eg, diuretics, benzodiazepines). The serum glucose level at the time of radiopharmaceutical administration should be reported as well as patient weight, time from injection to scanning, and technique for calculating SUVs (ie, body weight, lean body weight, or body surface area) [47].

Details of oral or intravenous contrast agents, if used for the CT attenuation-correction portion of the examination, should also be reported, to include the volume and route of administration. Other information relevant to contrast administration, such as steroid preparation, prehydration, or dialysis history, should be included. The report should also include documentation of contrast reactions and subsequent treatment, if observed during the examination.

The findings section should include description of the location, extent, and intensity of abnormal FDG uptake in relation to normal comparable tissues and should describe the relevant morphologic findings on the CT images. Ideally, image and series numbers should also be included. Additionally, background activity (eg, mediastinal blood pool and/or volumetric normal liver) should be measured and reported to help ensure comparable SUVs [48]. Often, injection-site infiltrates, such as in arms, or attenuation-correction errors can significantly alter SUVs in lesions, leading to false conclusions. An estimate of the intensity of FDG uptake can be provided with the SUV, and/or the intensity of uptake may be described as mild, moderate, or intense in relation to the background uptake in normal hepatic parenchyma or the mediastinal blood pool.

If the CT scan was requested and performed as a diagnostic examination, the CT component of the examination should be reported separately to satisfy regulatory, administrative, or reimbursement requirements. In that case, the PET/CT report should refer to the diagnostic CT scan report for findings not related to the PET/CT combined findings [49-51]. Even if the CT scan was not requested as a diagnostic examination, clinically important findings (eg, pneumothorax, aortic aneurysm, bowel obstruction, pneumoperitoneum, fracture, non–FDG-avid malignancy) on the CT scan should be reported.

When PET/CT is performed for monitoring therapy, a comparison of extent and intensity of uptake may be summarized as metabolic progressive disease, metabolic stable disease, metabolic partial response, or metabolic complete response using published criteria for these categories [52,53]

## VII. EQUIPMENT QC

PET performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Nuclear Medical Physics Performance Monitoring of Gamma Cameras and the ACR–AAPM Technical Standard for Medical Physics Performance Monitoring of PET/CT Imaging Equipment [21,54].

CT monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment [55].

The QC procedures for PET/CT should include both the PET procedures and the CT procedures according to the ACR Technical Standards. The QC procedures for PET should include a calibration measurement of activity in a phantom containing a known radiopharmaceutical concentration, generally as a function of axial position within the scanner field of view. The QC procedures for the CT should include air and water calibrations in Hounsfield units for a range of kV. A daily check on the stability of the individual detectors should also be performed to identify detector failures and drifts.

In addition, for PET/CT, the alignment between the PET and CT scanners should be checked periodically. Such a check should determine an offset between the PET and CT scanners that is incorporated into the fused image display to ensure accurate image alignment.

## VIII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, non-physician radiology providers, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, "as low as

reasonably achievable" (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel who work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection, application of dose constraints and limits) and the principles of proper management of radiation dose to patients (justification, optimization including the use of dose reference levels). https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1775_web.pdf

Nationally developed guidelines, such as the ACR's Appropriateness Criteria®, should be used to help choose the most appropriate imaging procedures to prevent unnecessary radiation exposure.

Facilities should have and adhere to policies and procedures that require ionizing radiation examination protocols (radiography, fluoroscopy, interventional radiology, CT) to vary according to diagnostic requirements and patient body habitus to optimize the relationship between appropriate radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used, except when inappropriate for a specific exam. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available from the following websites – Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org). These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be periodically measured by a Qualified Medical Physicist in accordance with the applicable ACR Technical Standards. Monitoring or regular review of dose indices from patient imaging should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry and relevant publications relying on its data, applicable ACR Practice Parameters, NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends; 2006, 2009, amended 2013, revised 2023 (Res. 2d).

## IX. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *ACR Position Statement on Quality Control & Improvement, Safety, Infection Control*, *and Patient Education* on the ACR website (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement). In all pediatric patients, the lowest exposure factors should be chosen that would produce images of diagnostic quality.

For specific issues regarding CT quality control, see the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [23].

For specific issues regarding PET and PET/CT quality control, see Section VIII on Equipment Quality Control.

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment [55].

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