Methodological aspects in FDG PET/CT imaging

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EANM procedure guidelines

PATIENT INFORMATION
PATIENT PREPARATION
FDG PET/CT STUDY PROTOCOL
IMAGE RECONSTRUCTION
REPORTING PET/CT FINDINGS
QUANTIFICATION: SUV CALCULATIONS
Patient information

- Indication, reason for request of PET or PET/CT study
- Height and body weight (BMI)
- Oncology prior history, relevant co-morbidity (especially inflammation)
- In case of therapy evaluation, type and date of last therapeutic intervention
- Diabetes mellitus (including medication)
- Allergy for contrast agents
- Renal function
Prior Surgery
Prior Radiation Therapy

Pneumonitis
Prior Chemotherapy
Patient preparation

- Explain the thomographic technique and the preparation to the patient.
- Fasting: 6 hours prior to the start of the PET study.
- Medication can be taken as prescribed (DM).
- Adequate pre-hydration
- Parental nutrition and intravenous fluids containing glucose should be discontinued at least 4 h before the PET/CT examination.
- Blood glucose level < 120 mg/dl
Importance of fasting

Glycemia > 120 mg/dl.

Glycemia < 120 mg/dl.
Importance of blood glucose level

Nuclear Medicine and Biology

Impact of blood glucose, diabetes, insulin, and obesity on standardized uptake values in tumors and healthy organs on $^{18}$F-FDG PET/CT

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Importance of blood glucose level and medication

High and typical $^{18}$F-FDG bowel uptake in patients treated with metformin

Eric Gontier • Emmanuelle Fourme • Myriam Wartski • Cyrille Blondet • Gerald Bonardel • Elise Le Stanc • Marina Mantzarides • Herve Foehrenbach • Alain-Paul Pecking • Jean-Louis Alberini


METFORMIN

- BOWEL NON-SPECIFIC $^{18}$F-FDG UPTAKE IS QUITE FREQUENT ON $^{18}$F-FDG IMAGING

PATTERN

- HIGH AND DIFFUSE UPTAKE

STOP

- 48 H: IF SUSPECTED ABDOMINAL DISEASE
Metformin causes an increase in (18)F-FDG uptake in the bowel and stopping metformin before PET/CT study significantly decreases this unwanted uptake, especially in the colon, facilitating the interpretation of images obtained from the abdomen and preventing the obliteration of lesions.
Importance of blood glucose level and medication
Importance of blood glucose level and medication

Importance of blood glucose level and Insulin

Optimization of Whole-Body Positron Emission Tomography Imaging by Using Delayed 2-Deoxy-2-[F-18]fluoro-d-glucose Injection Following I.V. Insulin in Diabetic Patients

Eric Turcotte, MD, Michel Leblanc, MD, André Carpentier, MD, François Bénard, MD

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SATURATED CARRIERS

FDG – GLU

HYPERINSULINISM

LESS SENSITIVITY WITH PET

HEART

MUSCLES
Importance of blood glucose level and Insulin
**Insulin injection**

Fig. 1. PET coronal slices demonstrating the FDG biodistribution in two patients who received rapid onset i.v. insulin with different waiting time before FDG injection: 60 minutes (left) and 30 minutes (right: muscle scan).

<table>
<thead>
<tr>
<th>Glycemia (mg/dl)</th>
<th>Insulin units (i.v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150-189</td>
<td>2</td>
</tr>
<tr>
<td>190 - 219</td>
<td>3</td>
</tr>
<tr>
<td>220-249</td>
<td>4</td>
</tr>
<tr>
<td>250-300</td>
<td>5</td>
</tr>
</tbody>
</table>

**Procedure Table:**
- Up to 2 bolus
  - 30 minutes waiting period
  - Verify capillary BGL

- < 190 mg/dl
  - 30 minutes waiting period
  - Verify capillary BGL
  - If < 190 mg/dl, yes; if ≥ 190 mg/dl, no

- 18FDG injection
  - 60 minutes waiting period
  - Verify BGL
  - Acquisition
  - End of acquisition
  - Verify BGL, patient can eat

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**Patient preparation**

- Stop breast feeding 24 h. after FDG injection

- Avoid exercise for at least 6 hours before the PET study

- During the uptake phase the patient should remain seated or recumbent and silent to minimise FDG uptake in muscles.

- The patient should be kept warm before the injection of FDG and throughout the following uptake period to minimise FDG accumulation in the brown fat.
Breastfeeding
Muscle Uptake
Vocal Cords Uptake

BILATERAL AND SYMMETRIC UPTAKE ➔ TALK, CRY
Vocal Cords Uptake

BILATERAL AND SYMMETRIC UPTAKE → NORMAL

ASYMMETRIC AND FOCAL UPTAKE

• Muscular compensation
• Recurrent laryngeal nerve palsy
Recurrent laryngeal nerve palsy
Importance of Thermogenesis and Brown Fat

Uptake in Supraclavicular Area Fat ("USA-Fat"): Description on $^{18}$F-FDG PET/CT

Christian Cohade, Medhat Osman, Harpreet K. Pannu and Richard L. Wahl


Focal FDG Uptake in Mediastinal Brown Fat Mimicking Malignancy: A Potential Pitfall Resolved on PET/CT
Importance of Thermogenesis
Information and patient preparation

Reason for consultation
Medical Record
Habitual drugs
Medical and surgical history
Treatments Received
Renal and Cardiac function
Glycemia
Weight, Height (BMI)
Date of last menstruation
Menstruation
Scan Schedule $^{18}$F-FDG

- **INFORMATION PREPARATION**
- $^{18}$F-FDG injection
- Min 0
- Min 30
- Min 60
- Min 180
- Hydration & diuretic
- Acquisition
- Delayed Images
- $^{18}$F-FDG Incorporation (50-60 min)
CT Acquisition Protocol

Attenuation: air < water < soft tissue < bone

CT: Attenuation values more accurate than $^{68}$ Ge

Conversion of CT values in PET values

TC: 10 → 140 mA

$\Delta$ mA: Obese; Diagnostic CT; RT Planning

CT Parameters

- 50 mAs (10-140 mA)
- 130 kV (70 - 140 kV)
- 5 mm slice thickness
- Pitch: 1.6 (8mm/5mm)
CT Attenuation Correction

Conversion of CT images to 511 keV attenuation maps
CT Attenuation Correction

PACEMAKER ARTIFACT

PORT-A-CATH ARTIFACT

CORRECTED IMAGE

UNCORRECTED IMAGE

CT IMAGE

FUSION IMAGE
Artifact: Truncation
### FDG PET/CT Protocol

<table>
<thead>
<tr>
<th>Section</th>
<th>Details</th>
</tr>
</thead>
</table>
| **DOSE**                 | - Adults: 5-7 MBq/Kg  
                         - Children: 4.5 MBq/Kg                                               |
| **MIN/BED**              | - WHOLE BODY: 6-7 BEDS  
                         - TIME: 1-3 MIN/Bed                                                   |
| **STANDARD PROTOCOL**    | - Base of the skull to midthigh                                         |
| **RECONSTRUCTION**       | - TOF + OSEM + PSF  
                         (3 iterations / 21 subsets)                                          |
| **FILTER**               | - Gaussian                                                              |
| **MATRIX**               | - 200 X 200                                                             |
FDG PET/CT Protocol – BMI

2-5 MIN/BED, 3D ACQUISITION, OSEM RECONSTRUCTION

<table>
<thead>
<tr>
<th>WEIGHT</th>
<th>&lt;60</th>
<th>60-80</th>
<th>80-90</th>
<th>&gt;90</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN/BED</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
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BMI: 22  BMI: 29  BMI: 41  BMI: 59
FDG PET/CT Protocol - H&N

HEAD&NECK: ARMS DOWN
BODY: ARMS UP
FDG PET/CT Protocol – Total Body
Artifact: Respiratory Motion
Artifact: Respiratory Motion
Artifact: Respiratory Motion
Reporting Guidance for Oncologic $^{18}$F-FDG PET/CT Imaging

Ryan D. Niederkohr$^1$, Bennett S. Greenspan$^2$, John O. Prior$^3$, Heiko Schöder$^4$, Marc A. Seltzer$^5$, Katherine A. Zukotynski$^6$,$^7$, and Eric M. Rohren$^8$

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**Learning Objectives:** On successful completion of this activity, participants should be able to discuss (1) the elements of a concise and complete oncologic $^{18}$F-FDG PET/CT report; (2) the importance of obtaining and including in the report a focused history of the patient malignancy and treatments; and (3) the importance of interpreting both the $^{18}$F-FDG PET and the CT findings of PET/CT and of integrating both the metabolic and the anatomic components in the report.
Quantification: SUV

**IMPORTANT FACTORS**

- Time to acquisition
- Glucose levels
- Body Weight
- Injection Technique
- Camera Calibration
- Partial Volume
- ROI-VOI
- Reconstruction method
- Matrix Size

Mathematical Formula:

\[
SUV(t) = \frac{\frac{c(t)}{\text{injected activity}(t)}}{\text{body weight}}
\]
The age of reason for FDG PET image-derived indices

Dimitris Visvikis • Mathieu Hatt • Florent Tixier • Catherine Cheze Le Rest

SUV: Standard Uptake or Silly Useless Value?

John W. Keyes, Jr.

PET Center, Bowman Gray School of Medicine, Winston-Salem, North Carolina

SUV: From Silly Useless Value to Smart Uptake Value
When should we recommend use of dual time-point and delayed time-point imaging techniques in FDG PET?

Gang Cheng · Drew A. Torigian · Hongming Zhuang · Abass Alavi

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RECOMMENDATIONS

- INJURY ASSESSMENT WITH HIGH ACTIVITY (liver, spleen, mediastinum).
- EVALUATE TUMOR EXTENSION: staging and response to treatment. CHARACTERIZATION OF INJURY.
- ASSESS THE AGGRESSIVE TUMOR.
- IMAGE QUALITY IMPROVEMENT IN PATIENTS WITH HIGH ACTIVITY.

IT INCREASES DIAGNOSTIC ACCURACY AND RELIABILITY
**Dual Time-Point Imaging**

Inflammatory lesion partially solved

\[ \text{SUV}_{\text{max}} = 2.1 \]

\[ \Delta \text{SUV} = -24\% \]

\[ \text{SUV}_{\text{max}} = 1.6 \]
**Dual Time-Point Imaging**

**Non-small cell lung poorly differentiated**

\[ \text{SUV}_{\text{max}} 2.73 \]

\[ \text{IC} = 63.8 \% \]

\[ \text{SUV}_{\text{max}} 4.5 \]

\[ \text{SUV}_{\text{max}} 4.75 \]
Reporting FDG PET findings

Physiology and Pathophysiology of Incidental Findings Detected on FDG-PET Scintigraphy

Yiyan Liu, MD, PhD, Nasrin V. Ghesani, MD, and Lionel S. Zuckier, MD