Practical Aspects of ACR PET Accreditation

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Objectives

- ACR PET Phantom
- Activation of ACR Phantom
- Image acquisition and processing

Accreditation Program Objective

To provide a solid foundation for continuous quality improvement through a peer review and education process for clinical facilities committed to image quality

Quality Patient Care

Accreditation Attests to a Site’s High Standard of Clinical Practice

- Personnel: physicians, technologists, physicists
- Policies and procedures
- Scanning equipment
ACR Accreditation

PET Physicist Qualifications

- Board Certification (recommended):
  Nuclear Medicine Physics or Radiologic Physics
- Training (required):
  40 hrs of on-site practical experience providing PET physics support
- Continuing Education (recommended):
  150 hours every 3 years with 15 hours in PET

ACR Accreditation

Two Part Submission

- Initial site application (online)
- Clinical review
  - Phantom images that reflect the performance of the equipment during routine clinical studies
- Clinical images

Quality Patient Care

Scanner Performance

- ACR Phantom testing for clinical image quality is required for ACR accreditation and renewal
- Phantom testing recommended quarterly
- Clinical performance, not NEMA acceptance testing

Quality Patient Care

Image Submission

- Clinical images and techniques
- PET phantom images
  - Equipment quality assurance
  - FDG worksheet
  - SUV analysis worksheet

Quality Patient Care
Quality Patient Care

ACR Phantom

PET Phantom

Hot-Cylinder Cover Plate

Fillable thin-walled cylinders (8, 12, 16, and 25 mm in diameter), a Teflon cylinder and two 25 mm cylinders, one for air and one for “cold” water.
ACR PET Phantom
Hot Cylinders & Cold Rods

Typical Images
2.5:1 Ratio (10 mCi)
Clinical Protocol

HR+
High Count, 12E/7T

PET Phantom Review
1 cm slices
1 - 5 Grading Scale

Uniformity

Contrast – Hot Cylinders
8, 12, 16, 25 mm

Resolution – Cold Rods
4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm
**PET Phantom Review**

1 - 5 Grading Scale

- **5** – **Excellent**, best image quality.
- **4** – **Good**, minor variations in quality.
- **3** – **Satisfactory**, some variations in image quality, but not likely to affect interpretations of clinical studies.
- **2** – **Marginal**, may affect interpretation of clinical studies.
- **1** – **Failure**, probably will affect interpretation of clinical studies. Scanner should not be used for clinical studies.

**Contrast** - marginal passing:
16 mm vial is resolved with acceptable contrast; larger vial resolved with high contrast.

**Resolution** - marginal passing:
11.1 mm rods are resolved with low contrast; larger rods are resolved with high contrast.

**Uniformity** - marginal passing:
Strong artifacts are seen in a small number of slices.

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**Siemens ACCEL**

1 cm slice Rods: 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm

**GE Discovery: LightSpeed 4**

16 mCi, 6 min per bed, 1 cm slices

Rods: 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm
**PET Contrast:**

**11C Spheres/ 18F Background**

HR+ (resolution ~ 6 mm at 10 cm), 3D (FBP)

5 min  15 min  25 min

Typical brain scan (10 mCi): ~ 0.5 μCi/ml, 35 min acquisition

18F (1.2 μCi/ml) and 11C spheres (ratio to background = 2.6)
Sphere diameters (volumes): 31.3 (16.0), 24.8 (8.0), 15.6 (2.0),
19.7 (4.0), 12.4 (1.0), **9.85** (0.5 ml) mm.

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**PET Statistics: Resolution**

Activity: 1.6 μCi/ml FDG
Scanner: HR+, 3D Single slice

<table>
<thead>
<tr>
<th>Rods (mm)</th>
<th>5 min</th>
<th>10 min</th>
<th>15 min</th>
<th>30 min</th>
<th>60 min</th>
<th>90 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.8, 6.4, 7.9, 9.5, 11.1, 12.7</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

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**Required Supplies**

- **1,000 ml bag of saline solution**
- **Two tuberculin syringes and FDG doses**
  1) **Activation Dose A** - added to 1,000 ml bag,
  2) **Activation Dose B** - added to phantom, background activity
- **Three 60 ml syringes**
  1) **Test Dose #1** (60 ml) - vial activity from saline bag
  2) **Test Dose #2** (60 ml) - background from phantom
  3) Vial doses from saline bag (40 ml)
Required Supplies

Dose Dilution

<table>
<thead>
<tr>
<th>Patient Dose</th>
<th>Dose A</th>
<th>Dose B</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 mCi</td>
<td>0.140</td>
<td>0.330</td>
</tr>
<tr>
<td>6 mCi</td>
<td>0.210</td>
<td>0.495</td>
</tr>
<tr>
<td>8 mCi</td>
<td>0.280</td>
<td>0.660</td>
</tr>
<tr>
<td>10 mCi</td>
<td>0.350</td>
<td>0.825</td>
</tr>
<tr>
<td>12 mCi</td>
<td>0.420</td>
<td>0.990</td>
</tr>
<tr>
<td>14 mCi</td>
<td>0.490</td>
<td>1.154</td>
</tr>
<tr>
<td>16 mCi</td>
<td>0.560</td>
<td>1.319</td>
</tr>
<tr>
<td>18 mCi</td>
<td>0.630</td>
<td>1.484</td>
</tr>
<tr>
<td>20 mCi</td>
<td>0.700</td>
<td>1.649</td>
</tr>
</tbody>
</table>

Phantom Doses

Two required doses (from Dilution Chart)

- **Activation Dose A** will be added to 1000 ml bag (or bottle) to diluted activity for the 4 test vials
- **Activation Dose B** will be added to the phantom as background activity.

Radiation Safety
Scanning Time Line for PET Phantom

Measurement of Doses

- Measure and record the activity of Activation Dose A and Activation Dose B (tuberculin syringes) with time on the work sheet.

- Scanning begins 1 hr after the Activation Dose A measurement time.

Background Correction

Measurement of Dose
Activation of Vials

Add **Activation Dose A** to the 1000 ml bag or bottle and mix well. Then with the first 60 ml syringe withdraw 60 ml — this is **Test Dose #1** (set aside).

Next, using the second 60 ml syringe withdraw 40 ml from the bag and fill the 4 appropriate chambers in the phantom top.
Vial Activation

Withdraw 40 ml from the saline bag using the second 60 ml syringe and fill the 4 appropriate chambers in the phantom top.

Phantom Background Activation

Thoroughly mix Activation Dose B into the main chamber of the PET phantom (a bubble of air will help ensure a well-mixed solution).
Test Dose #2
After mixing, using the third 60 ml syringe, withdraw 60 ml from the phantom — this is Test Dose #2 (set aside).

Measurement of Test Doses with Time

- Measure and record the activity of Test Dose #1 and Test Dose #2.
- Inject Test Dose #2 back into the phantom. Fill any remaining air-space in the phantom with water and mix again.
- Scan at the specified time. Dispose of syringes appropriately.

Phantom Dilution Worksheet
Enter dose and time below

<table>
<thead>
<tr>
<th></th>
<th>Dose</th>
<th>Time</th>
<th>Dose Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Dose:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDG dose (A), mCi:</td>
<td></td>
<td></td>
<td>FDG Doses: 8/6</td>
</tr>
<tr>
<td>FDG dose (B), mCi:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test dose #1, µCi:</td>
<td></td>
<td></td>
<td>Test Dose: 1/2 (enter ratio value below)</td>
</tr>
<tr>
<td>Test dose #2, µCi:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actual start time of phantom scan:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When entering SUV parameters for the PET scanning protocol assume a 70 kg patient and use the Patient Dose (e.g. 18 mCi) as shown with the measurement time entered for dose A.
### Phantom Dilution Worksheet

Enter dose and time below

<table>
<thead>
<tr>
<th>Patient Dose</th>
<th>Dose</th>
<th>Time</th>
<th>Dose Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mCi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDG dose (A), mCi</td>
<td>0.38</td>
<td>2:21:10</td>
<td>2.36</td>
</tr>
<tr>
<td>FDG dose (B), mCi</td>
<td>0.83</td>
<td>2:21:49</td>
<td>2.18</td>
</tr>
<tr>
<td>#1 0.25 µCi x 60 = 15</td>
<td>17.10</td>
<td>2:34:54</td>
<td>1.2</td>
</tr>
<tr>
<td>#2 0.14 µCi x 60 = 8.4</td>
<td>7.25</td>
<td>2:35:32</td>
<td>2.50</td>
</tr>
</tbody>
</table>

Actual start time of phantom scan: 3:21

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When entering SUV parameters for the PET scanning protocol assume a 70 kg patient and use the Patient Dose (e.g. 10 mCi) from above with the measurement time entered for dose A.
PET Phantom Image Processing

- Clinical whole-body reconstruction protocol
- 1 cm transaxial slices of phantom

Pitfall: Merged PET/CT

Warning: merged images do not provide adequate information on PET component.
Clinical Importance

Based on the evaluation of Phantom Images, patient dose increased to 12 mCi.

1 cm slice rods: 4.8, 6.4, 7.9, 9.5, 11.1, and 12.7 mm

10 mCi
6 min

Phantom Activation Objectives

- Background: SUV = 1.0
  0.14 µCi/cc for 10 mCi patient dose
- Cylinders: SUV = 2.5
  0.35 µCi/cc for 10 mCi patient dose

(for scanner SUV setup use patient dose and 70 kg patient weight)

\[ \text{SUV} = \frac{\text{activity in tissue/ml}}{\text{Inj. dose/body wt (gm)}} \]

**SUVR Analysis Worksheet**

<table>
<thead>
<tr>
<th>Patient Name:</th>
<th>Date:<strong>/</strong>/__</th>
</tr>
</thead>
</table>
| From ROI data of maximum (min), maximum (max), and mean SUV (SUV parameter), patient dose and 70 kg patient weight data in Tables 1 and 2 below. If the smallest value is below 1, please enter the value below.
<table>
<thead>
<tr>
<th>A) Contrast/Background</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rod width (mm)</td>
</tr>
<tr>
<td>SUV</td>
</tr>
<tr>
<td>B) Scatter/Attenuation</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Rod width (mm)</td>
</tr>
<tr>
<td>SUV</td>
</tr>
<tr>
<td>C) Ratio Calculations (using data from Tables 1 &amp; 2 above)</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Rod width (mm)</td>
</tr>
<tr>
<td>Background SUV</td>
</tr>
<tr>
<td>Rod Width SUV</td>
</tr>
<tr>
<td>Rod Width SUV</td>
</tr>
<tr>
<td>Rod Width SUV</td>
</tr>
</tbody>
</table>

**SUVR Activation Worksheet**

<table>
<thead>
<tr>
<th>Patient Name:</th>
<th>Date:<strong>/</strong>/__</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background: 22 µCi/cc, SUV = 1.0</td>
<td></td>
</tr>
<tr>
<td>Cylinders: 56 µCi/cc, SUV = 2.5</td>
<td></td>
</tr>
<tr>
<td>A) Contrast/Background</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>Rod width (mm)</td>
<td>8 mm</td>
</tr>
<tr>
<td>SUV</td>
<td>5.12</td>
</tr>
<tr>
<td>B) Scatter/Attenuation</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
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<td>Rod width (mm)</td>
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<tr>
<td>Rod width (mm)</td>
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</tr>
<tr>
<td>Background SUV</td>
<td>5.12</td>
</tr>
<tr>
<td>Rod Width SUV</td>
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<td>Rod Width SUV</td>
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</table>
New Reviewer Guidelines
SUV Analysis Worksheet

- **Pass or Fail Criteria**
  - Maximum SUV for 25 mm high Contrast Vial must be > 2 and < 3
  - 16mm/25mm = 0.7 or greater, other ratios should decrease in a reasonably manner
  - In the future, the scoring criteria will be adjusted

Current Program Status

- **Accredited Sites**
  - PET: 870+
  - Nuclear Medicine: 1600+

- WEB based review process
- WEB based image submission under development

Special thanks to

- Chitra Saxena, Manager, Kreitchman PET Center
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