Prevention of Artifacts in PET and PET/CT

Susan E. Sharp MD
Objective

- Discuss *preventable* PET and PET/CT artifacts common in children
- Focus on
  - patient preparation
  - imaging protocol
Patient Preparation

- Standard FDG Injection Rules
  - NPO for at least 4 hours
  - No IV glucose or hyperalimentation for 4 hours

↓ FDG uptake in background tissues
Patient Preparation

- Standard FDG Injection Rules
  - NPO for at least 4 hours
  - No IV glucose or hyperalimentation for 4 hours
  - Stay warm for several hours
Cold Temperatures

↓ Sympathetic Activation

↑ Brown Fat Metabolism

↑ FDG and MIBG Uptake
Dawkins MJH, Holt D.  
FDG Uptake in Brown Adipose Tissue

- Adult experience
  - Occurs into sixth decade of life
  - More common in winter (13.7%) than summer (4.1%)
  - More common in young women

FDG Uptake in Brown Adipose Tissue

- Pediatric experience
  - Occurs even in summer due to
    - air conditioning (cars and hospital)
    - dressing lightly on cool mornings
  - Common in adolescents of both sexes

Interferes with interpretation in up to 25-30% of pediatric patients

FDG Uptake in Brown Adipose Tissue

- Two main approaches to prevention
  - Pre-warming
  - Pharmacologic pre-medication
Pre-Warming: Prevention of FDG Uptake in BAT

- Warming after FDG injection does NOT work
- Warming should start
  - at least 30 minutes prior to FDG injection
  - preferably 60 minutes prior to FDG injection

Garcia CA, et al. Mol Imaging Biol 2006; 8:24-9

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Pharmacologic Approach: Prevention of FDG Uptake in BAT

- FDG uptake interfering with image interpretation (PET only)

<table>
<thead>
<tr>
<th>Medication</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Pre-Medication</td>
<td>6/23</td>
<td>26.1%</td>
</tr>
<tr>
<td>Low Dose Diazepam po</td>
<td>10/34</td>
<td>29.4%</td>
</tr>
<tr>
<td>Moderate Dose Diazepam po</td>
<td>0/9</td>
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<td>Opiates (for pain)</td>
<td>0/7</td>
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</tr>
<tr>
<td>Fentanyl IV</td>
<td>3/45</td>
<td>6.7%</td>
</tr>
</tbody>
</table>

Pharmacologic Approach: Prevention of FDG Uptake in BAT

FDG uptake interfering with image interpretation (PET only)

- No Pre-Medication: 6/23 (26.1%)
- Low Dose Diazepam po: 10/34 (29.4%)
- Moderate Dose Diazepam po: 0/9 (0%)
- Opiates (for pain): 0/7 (0%)
- Fentanyl IV: 3/45 (6.7%)

Pharmacologic Approach: Prevention of FDG Uptake in BAT

- Other drugs used in adults
  - Diazepam
  - Propranolol

No pre-medication

December
Outside temp 2 C

Fentanyl 1 mcg/kg

March
Outside temp 4 C

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FDG Uptake in Brown Adipose Tissue

- Difficult or impossible to suppress
  - immediately after chemotherapy
  - in patients shaking from fright
Why not use the CT component of PET/CT to decide what is brown fat?

- Patient movement
- PET generally more sensitive than CT
  - especially for lymph nodes < 1 cm
- Risk of false positives or false negatives

Easier to read scans without brown fat uptake

Metastatic Paraganglioma

No uptake in BAT

Uptake in BAT
Patient Preparation

- Standard FDG Injection Rules
  - NPO for at least 4 hours
  - No IV glucose or hyperalimentation for 4 hr
  - Stay warm for several hours +/- pre-medication
  - No intense exercise for 1-2 days
  - Quiet rest during uptake period
Lifted weights the day before the scan
Text messaging during the uptake period
Sucking during the uptake period

Coronal

Sagittal

MIP

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Patient Preparation

- Optimize timing of imaging relative to therapy

**Lymphoma and Hodgkin's Disease**

One dose (or one cycle) of chemoRx wipes out FDG uptake

Wait 2 weeks after chemoRx before FDG PET imaging
Granulocyte Colony-Stimulating Factor

- Increased FDG uptake in bone marrow
- May persist up to 4 weeks
- Dependent on dose and duration

Wait at least a few days before imaging

Ideally image just before next course of therapy

Ewing Sarcoma

Prior to Therapy

After GCSF

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Neuroblastoma

Prior to Therapy

After GCSF
Patient Motion

- **PET only**
  - May require repeat images

- **PET / CT**
  - May cause loss of co-registration
  - May require repeat images

repeating the CT significantly increases effective radiation dose
Minimizing Patient Motion

- Image in position of maximum comfort
- Use positioning aids and immobilization devices

Arm Movement During Scan

Courtesy of Barry Shulkin MD
St. Jude Children’s Research Hospital
CT Scan with Arms Down
Minimizing Patient Motion

- Image in position of maximum comfort
- Use positioning aids and immobilization devices
- Sedation if needed
Respiratory Motion - Position of the Diaphragm

- PET acquired during free breathing
- CT acquired at full inspiration
  - Up to 3 cm mismatch in diaphragmatic position when compared to PET

CT acquired at end expiration gives best match in diaphragm position

CT acquired during shallow free breathing gives next best match
Respiratory Motion

CT

Non-AC PET

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CT Attenuation Correction Artifact
Misleading AC PET Image
CT Attenuation Correction Artifacts

- Incorrect attenuation correction maps occur if CT and PET acquired under different conditions
  - Altered position of organ or structure (patient movement)
  - Altered radiodensity of organ or structure (bolus contrast)
Oral Contrast

- Barium causes hot artifacts at locations of high contrast concentration

An issue after fluoroscopic procedures
Barium Artifact

CT

AC PET

Non-AC PET

Oral Contrast

- Barium causes hot artifacts at locations of high contrast concentration
- GI water soluble contrast
  - Usually does not cause artifacts
  - May slightly raise SUV

Use sugar free oral contrast mixes
Oral Contrast

- Barium causes hot artifacts at locations of high contrast concentration
- GI water soluble contrast
  - Usually does not cause artifacts
  - May slightly raise SUV
- Negative oral contrast avoids artifacts
Intravenous Contrast

- Bolus IV contrast causes hot artifacts at locations of high contrast concentration
CT Contrast Bolus Artifact

Intravenous Contrast

- Bolus IV contrast causes hot artifacts at locations of high contrast concentration

IV contrast bolus artifact reduced with “saline chaser” or adaptive pressure pump

Intravenous Contrast

- Bolus IV contrast causes hot artifacts at locations of high contrast concentration
- IV contrast after bolus dispersal
  - Usually does not cause artifacts
  - May slightly raise SUV