PET/CT and Lung Cancer

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Overview
- What is PET/CT
- What to expect if you were a patient coming to our clinic
- Notes on Radiation exposure
- PET/CT for Lung Cancer
  - Staging
  - Surveillance
  - Treatment Monitoring

What is PET/CT?

The tracer: FDG
- FDG is an accurate tracer for evaluating metabolism of most cancers.
- FDG uptake can occur in non-cancerous conditions such as infection or inflammation.
- FDG does not have any side effects nor does it cause allergic reactions.
2-[F-18]fluoro-2-deoxy-D-glucose (FDG)

SUV: Standardized Uptake Value

\[ \text{SUV} = \frac{c(t)}{D / \text{body weight}} \]

- \( c(t) \): activity concentration in the tissue
- \( D \): injected dose

Common Errors affecting Measurement of SUVs

<table>
<thead>
<tr>
<th>Error</th>
<th>Effect on tumor SUV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood glucose levels</td>
<td>Lower values with increasing blood glucose levels</td>
</tr>
<tr>
<td>Region-of-interest definition</td>
<td>Lower mean uptake for larger regions of interest; larger random errors for small regions of interest</td>
</tr>
<tr>
<td>Paravenous 18F-FDG injection, residual activity in syringe</td>
<td>Incorrectly low SUV</td>
</tr>
<tr>
<td>No decay correction of injected activity</td>
<td>Incorrectly low SUV</td>
</tr>
<tr>
<td>Incorrect cross-calibration of scanner and dose calibrator</td>
<td>Incorrectly low or high SUV, depending on error of calibration factor</td>
</tr>
<tr>
<td>Variable uptake period (time between injection and imaging)</td>
<td>Higher SUV with longer uptake period</td>
</tr>
</tbody>
</table>

(IV and PO contrast do not affect SUV significantly)


Standardized Uptake Value (SUV)

- Brain ~ 8-10
- Mediastinal Blood Pool ~ 2-3
- Malignancy ~ 2-3
- Myocardium ~ 2-7
- Liver ~ 2-3
- Urine ~ 15-50
- Soft Tissue ~ 1

In the Clinic…

Welcome to the UCLA Ahmanson Biological Imaging Center
Nuclear Medicine Division
How to prepare for a PET/CT

- On the day of the scan take your regularly prescribed medications with water only.
- Do not eat or drink anything except water for 4 to 6 hours before the scan.
- Refrain from heavy exercise for 12 hours prior to the scan.
- Drink at least two glasses of water one hour before the scan.

What to expect when you come to the Nuclear Medicine Clinic

- Your blood sugar will be checked
- An IV catheter will be placed
- FDG will be injected
- You might be asked to drink oral contrast
- You will rest comfortably for ~45 minutes
- You will receive IV contrast
- CT images will be obtained first (less than 1 minute)
- PET images will be obtained (about 25 minutes)

You should be in and out of the clinic in less than 2 hours.

Does the PET/CT Scan have Side Effects?

The PET component
- IV placement
- Claustrophobia
- FDG has no side effects

The CT Component
- IV contrast can cause an allergic response; cautious use in patients with kidney problems
- Oral contrast can cause abdominal discomfort

Frequent Patient Concerns after PET/CT

- Am I radioactive? No, not dangerous
- Can I be around children or pregnant women? Yes
- Can I eat anything I want? Yes (and you are encouraged to drink more than usual)

Radiation Exposure

Relative Risk of developing a fatal cancer from Radiation (1 PET/CT ~3 rem)

<table>
<thead>
<tr>
<th>DOSE</th>
<th>RISK</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 rem</td>
<td>1 in 100</td>
</tr>
<tr>
<td>10 rem</td>
<td>1 in 250</td>
</tr>
<tr>
<td>1 rem</td>
<td>1 in 2500</td>
</tr>
<tr>
<td>0.1 rem</td>
<td>1 in 25000</td>
</tr>
</tbody>
</table>

Annual dose limit for radiation workers: 5 rem
Annual background radiation: 0.72 rem
Lifetime risk of dying in a car accident: 1 in 84
Lifetime risk of developing a fatal cancer: 1 in 5

PET/CT: the Scanning Procedure

Oral contrast
Intravenous contrast
FDG PETCT

Breath-Hold vs. Shallow Breathing CT

In 13% of patients nodules were only detected on breath-hold images.

Allen-Auerbach et al, J Nucl Med. 2006 47:298-301
Where’s Waldo?

Early “Imaging” Application of PET

PET/CT for Staging of Lung Cancer
PET/CT for Detection of Recurrence
**PET/CT for Treatment Monitoring**

**Why is Treatment Monitoring important?**

- Some patients benefit from a particular therapy whereas others (despite what seems to look like the same type of cancer) do not.
- Current therapies can have a lot of side effects. Doctors want to know as early as possible whether a treatment is working.
- The definitive proof of whether a therapy is working is if a patient feels better and lives longer.
- Looking at the cancer with scans is generally used to measure the effects of a treatment earlier.
- Current response assessment is based primarily on changes in tumor size as measured by CT (RECIST).

**History of Response Criteria**

16 oncologists determined the diameter of 12 differently sized wooden spheres hidden under a rubber foam.

**RECIST**

Response Evaluation Criteria in Solid Tumors

**Treatment affects Metabolism of the Cancer before Changes in Size are seen**

<table>
<thead>
<tr>
<th>Patient 1</th>
<th>Patient 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>Baseline</td>
<td>Baseline</td>
</tr>
<tr>
<td>24 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td>7 days</td>
<td>7 days</td>
</tr>
<tr>
<td>2 months</td>
<td>2 months</td>
</tr>
<tr>
<td>5.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>
What is missing?

- A decrease in FDG uptake on a PET scan likely means that the cancer is responding to the treatment.
- There have been many PET studies, but the definition of a response and how the scans were done have been quite variable.
- As of now there is no agreement of when treatment monitoring should be performed or how much FDG uptake has to go down to call it a good response to treatment.
- Ongoing trials are trying to answer these questions.
Summary

• FDG PET/CT is a safe test
• PET/CT is useful for Staging of Lung Cancer
• PET/CT is useful for Detection of Recurrence
• PET/CT is useful for Treatment Monitoring