PET-CT in Lung Cancer: Merging Anatomic and Metabolic Diagnosis

Paul Shreve, M.D.
Advanced Radiology Services, P.C.

Society of Nuclear Medicine Annual Meeting 2004
Philadelphia
PET-CT Scanners

Why PET-CT?

• Reduces total time for AC PET scan
• Accurate anatomic localization
• Merged anatomic and metabolic diagnosis

The CT diagnosis is forced into the PET diagnosis and the PET diagnosis is forced into the CT diagnosis

ONE SCAN, ONE INTEGRATED DIAGNOSIS
PET scanner in 1996

- Transmission: 3 minutes x 5
- Emission: 5 minutes x 5
- Source movement: .5 minute x 5

Total scan time - 43 min for 75 cm axial coverage
PET/CT scanner 2002

Transmission  Emission

.2 minute x 1  5 minutes x 5

Total scan time - 26 minutes for 75 cm axial FOV
PET-CT Scanners

Why PET-CT?

• Reduces total time for AC PET scan
• Accurate anatomic localization
• Merged anatomic and metabolic diagnosis
Focal FDG uptake in retroperitoneum in patient with lung...
Focal FDG uptake in retroperitoneum in patient with lung cancer

Focal FDG uptake corresponds to left adrenal mass on CT, findings are consistent with adrenal metastasis.
PET-CT circa 1995

Attenuation Corrected FDG PET

Rod Source Transmission Scan CT
PET-CT circa 2001

A. FDG PET
B. CT
C. Fused: 58% PET/42% CT

Courtesy of Memorial Sloan-Kettering Cancer Center, N.Y., N.Y.
PET → PET/ct → PET-CT

Emerging understanding circa 2004

Diagnostic AC PET → AC PET with CT anatomic localization → PET + diagnostic CT for merged diagnosis exam

Images Courtesy of MSKCC, N.Y.
Benefits of PET/CT

FOR PET:
дей Improved tumor detection and localization
 продуктов Improved identification of normal physiologic uptake
 лечников Convenience of a single scan
 лечников Reduced scanning time
 лечников Easier for physician to read

FOR CT:
дей Improved tumor detection
 продуктов Enhanced staging and restaging
 продуктов Superior assessment of response to therapy
 лечников Convenience of a single scan

CHANGE IN PATIENT MANAGEMENT IN 20 – 30% OF CASES
PET-CT: The Next 5 Years

Market Development of PET-CT

• Nearly all clinical PET scanners will be PET-CT
• PET-CT will largely replace stand alone CT for body oncology medical imaging
• FDG PET will be widely accepted* and widely available, and PET-CT will be the standard for body oncology imaging

* Adding Structure to Function  JNM 2000; 41: 1380-1383
PET-CT of Lung Cancer

Merging structure and function

- The solitary pulmonary nodule
- Staging non-small cell lung cancer
- Re-staging non-small cell lung cancer
- Assessment of response to therapy
PET-CT of Lung Cancer

The indeterminate solitary pulmonary nodule

- Incidentally found on chest radiographs and CT
- Indeterminate means non-calcified on CT
- Up to 40% are malignant
PET-CT of Lung Cancer

The indeterminate solitary pulmonary nodule

• FDG PET alone can characterize a solitary indeterminate pulmonary nodule with relatively high accuracy

Sensitivity 92%\(^1\) 97%\(^2\)
Specificity 90% 78%

2 Gould, et. al. JAMA 2001; 285:914-924
PET-CT of Lung Cancer

The indeterminate solitary pulmonary nodule

- Probability of malignancy depends on pretest factors as well as FDG PET scan findings
  - Smoking history
  - Age
  - Presence of hemoptysis

- Probability of malignancy also depends on anatomic findings
  - Spiculation
  - Size
## Solitary Pulmonary Nodule

### Likelihood ratios

<table>
<thead>
<tr>
<th>Feature</th>
<th>Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>0.05</td>
</tr>
<tr>
<td>60-69</td>
<td>2.64</td>
</tr>
<tr>
<td>Nonsmoker</td>
<td>0.15</td>
</tr>
<tr>
<td>&lt; 30 pk-yrs</td>
<td>0.74</td>
</tr>
<tr>
<td>30-39 pk-yrs</td>
<td>2</td>
</tr>
<tr>
<td>&gt;40 pk-yrs</td>
<td>3.7</td>
</tr>
<tr>
<td>Hemoptysis</td>
<td>5.08</td>
</tr>
<tr>
<td>Prev Malig</td>
<td>4.95</td>
</tr>
<tr>
<td>0-1 cm</td>
<td>0.52</td>
</tr>
<tr>
<td>1.1 - 2.0</td>
<td>0.74</td>
</tr>
<tr>
<td>2.1 - 3.0</td>
<td>3.67</td>
</tr>
<tr>
<td>&gt; 3.0 cm</td>
<td>5.23</td>
</tr>
<tr>
<td>Lobulated</td>
<td>0.74</td>
</tr>
<tr>
<td>Spiculated</td>
<td>5.54</td>
</tr>
<tr>
<td>Malignant growth rate</td>
<td>3.4</td>
</tr>
<tr>
<td>Not calcified</td>
<td>2.2</td>
</tr>
<tr>
<td>Benign calcification</td>
<td>0.01</td>
</tr>
<tr>
<td>Enhancement &lt; 15 HU</td>
<td>0.04</td>
</tr>
<tr>
<td>Enhancement &gt; 15 HU</td>
<td>2.32</td>
</tr>
<tr>
<td>SUR &lt; 2.5</td>
<td>0.06</td>
</tr>
<tr>
<td>SUR &gt; 2.5</td>
<td>7.1</td>
</tr>
<tr>
<td>PET (Gould et al)</td>
<td>4.3</td>
</tr>
<tr>
<td>PET - (Gould et al)</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Lung nodule spiculation clearly seen on “localizer” CT scan lung window images
PET-CT of Lung Cancer

Staging and management

- Staging provides prognostic information and determines management
- TNM staging most commonly used
- T stage - extent of primary tumor
- N stage - extent of lymph node involvement
- M stage - distant lung, bone or soft tissue
PET-CT of Lung Cancer

T stage

- T1 tumor < 3 cm, surrounded by lung
- T2 tumor > 3 cm, does not in invade
- T3 tumor which invades chest wall, diaphragm, mediastinum pleura, pericardium, in mainstem bronchus < 2 cm from carina
- T4 tumor which invades mediastinum, heart, great vessels, presence of malignant pleural or pericardial effusion, satellite nodule in same lobe
PET-CT of Lung Cancer

N stage

• N0 no regional lymph node involvement
• N1 ipsilateral hilar or peribronchial nodes
• N2 ipsilatereal mediastinal or subcarinal nodes
• N3 contralateral mediastinal or contralateral hilar or supraclavicular or scalene nodes
PET-CT of Lung Cancer

M stage

• M0 no distant metastases
• M1 distant metastases to bone, soft tissue organs (adrenals, liver), brain, satellite nodules in different lobe
<table>
<thead>
<tr>
<th>Nodes</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>N0</td>
<td>IA</td>
<td>IB</td>
<td>IIB</td>
<td>IIIB</td>
</tr>
<tr>
<td>N1</td>
<td>IIA</td>
<td>IIB</td>
<td>IIIA</td>
<td>IIIB</td>
</tr>
<tr>
<td>N2</td>
<td>IIIA</td>
<td>IIIA</td>
<td>IIIA</td>
<td>IIIB</td>
</tr>
<tr>
<td>N3</td>
<td>IIIB</td>
<td>IIIB</td>
<td>IIIB</td>
<td>IIIB</td>
</tr>
</tbody>
</table>

Definition:

- Stage I
- Stage II
- Stage IIIA
- Stage IIIB

IV = M1
PET-CT of Lung Cancer

Stage and prognosis

- Stage I (T1-2 N0 M0) 60-80%
- Stage II (T1-2 N1M0, T3N0M0) 25-50%
- Stage IIIa (T1-3 N2, T3N1) 10-40%
- Stage IIIb (N3, T4) < 5%
- Stage IV < 5%
PET-CT of Lung Cancer

Staging and management

• Stage I and II are surgically resectable
• Locally (T3-T4) or regionally advanced (N2-N3) radiation or chemoradiation therapy and possible subsequent resection
• Distant metastases (M1) palliative chemotherapy
PET-CT of Lung Cancer

FDG PET vs CT in staging

- T staging is CT driven
- N staging is driven by PET sensitivity, CT localization, and CT additive specificity
- M staging is driven by PET sensitivity, CT localization and CT additive specificity
PET-CT of Lung Cancer

T stage

• T1 tumor < 3 cm, surrounded by lung
• T2 tumor > 3 cm, does not invade
• T3 tumor which invades chest wall, diaphragm, mediastinum pleura, pericardium, in mainstem bronchus < 2 cm from carina
• T4 tumor which invades mediastinum, heart, great vessels, presence of malignant pleural or pericardial effusion, satellite nodule in same lobe
PET-CT of Lung Cancer

Lymph node staging with FDG PET vs CT

- FDG PET is more accurate than CT due to limitations of anatomic criteria (node size)

<table>
<thead>
<tr>
<th></th>
<th>PET</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>88%</td>
<td>63%</td>
</tr>
<tr>
<td>Specificity</td>
<td>91%</td>
<td>76%</td>
</tr>
</tbody>
</table>

Weighted average 9 studies 518 patients
PET-CT of Lung Cancer

N stage

- N0 no regional lymph node involvement
- N1 ipsilateral hilar or peribronchial nodes
- N2 ipsilateral medistinal or subcarinal nodes
- N3 contralateral mediastinal or contralateral hilar or supraclavicular or scalene nodes