Novel Molecular Breast Imaging

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Novel Molecular Breast Imaging

- Positron emission mammography (PEM)
- PET/MR
- Molecular Breast Imaging
Positron Emission Mammography
Positron Emission Mammography

Seven Imaging Planes (focused in plane)

Image planes

1  2  3  4  5  6  7
Positron Emission Mammography

• High (1.5 – 2.0 mm) spatial resolution
• Short 4-10 minute scan time
• Compact, portable, easy to use
• High Value 3-D tomographic PET images
• Gentle Immobilization vs. Compression
Positron Emission Mammography

CC

Right

MLO

Left

Normal Study
Positron Emission Mammography
Positron Emission Mammography
Positron Emission Mammography

12-mm grade II infiltrating ductal carcinoma

Narayanan D et al. AJR Am J Roentgenol. 2011; 196:971
Positron Emission Mammography

• Prospective study 94 consecutive women with known breast cancer or suspicious breast lesions
• PEM readings were correlated with histopathology
• 77 index lesions--48 malignant
• PEM depicted 10 of 11 (91%) DCIS and 33 of 37 (89%) invasive cancers.
• PEM sensitivity was 91%, specificity 93%, PPV 95%, NPV 88%, and accuracy 92% when interpreted with mammographic and clinical findings

Positron Emission Mammography

5-mm infiltrating ductal carcinoma

Narayanan D et al. AJR Am J Roentgenol. 2011; 196:971
## Positron Emission Mammography

<table>
<thead>
<tr>
<th>Index lesion</th>
<th>Total number</th>
<th>PEM Sensitivity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive Cancers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IDC</td>
<td>56</td>
<td>93.4%</td>
</tr>
<tr>
<td>IDC-DCIS</td>
<td>53</td>
<td>94.3%</td>
</tr>
<tr>
<td>ILC</td>
<td>20</td>
<td>80%</td>
</tr>
<tr>
<td>DCIS</td>
<td>28</td>
<td>92.9%</td>
</tr>
</tbody>
</table>
Positron Emission Mammography

Results for 388 Breasts with 404 Sites of Known Malignancy
Sensitivity data are based on 386 index lesion sites with residual malignancy confirmed at surgery

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PEM</th>
<th>MR Imaging</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tumor seen</td>
<td>357/386 (92.5)</td>
<td>344/386 (89.1)</td>
<td>.079</td>
</tr>
<tr>
<td>Tumor or biopsy site seen</td>
<td>365/386 (94.5)</td>
<td>379/386 (98.2)</td>
<td>.004</td>
</tr>
<tr>
<td>Specificity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tumor seen</td>
<td>2/18 (11)</td>
<td>13/18 (72)</td>
<td>.001</td>
</tr>
<tr>
<td>Tumor or biopsy site seen</td>
<td>0/18 (0)</td>
<td>0/18 (0)</td>
<td>NA*</td>
</tr>
<tr>
<td>Accuracy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tumor seen</td>
<td>360/404 (89.1)</td>
<td>357/404 (88.4)</td>
<td>.71</td>
</tr>
<tr>
<td>Tumor or biopsy site seen</td>
<td>366/404 (90.6)</td>
<td>379/404 (93.8)</td>
<td>.006</td>
</tr>
</tbody>
</table>

Fibroadenoma

Narayanan D et al. AJR Am J Roentgenol. 2011; 196:971
Positron Emission Mammography
Positron Emission Mammography

Narayanan D et al. AJR Am J Roentgenol. 2011; 196:971
Positron Emission Mammography

- Clinical use: diagnostic adjunct to mammography and breast US.
- PEM has higher resolution and a more localized field of view than PET/CT
- Performed on with dense breast tissue on mammogram
- Review of mammograms together with magnetic resonance or PEM images improves detection of primary breast cancer
Novel Molecular Breast Imaging

- Positron emission mammography (PEM)
- PET/MR
Eye-Ball Fusion

Breast Cancer Invading Chest Wall Muscle

MRI

PET
Integrated PET/MR Scanners
PET-MR Scanner
Challenges of Body PET/MR

- Physical integration of MRI and PET scanners
- New PET Technology (APD, SiPM)
- Attenuation Correction of PET by MRI data
- Detection/Evaluation of small lung and bone lesions
- Complexity of whole-body MR protocols especially in oncology
- Patient Comfort
- Cost- and time-efficient use of both MRI and PET
PET/MR
MR Breast Coil
PET/MR in Breast Cancer
PET/MR in Breast Cancer

- Overall 74 FDG positive lesions were visualized by both PET/CT and PET/MR
- No significant differences in anatomic allocation scores were found between PET/CT and PET/MR
- SUVmax and SUVmean of lesions were significantly higher on PET/MR than on PET/CT
- PET/MRI showed equivalent performance in terms of qualitative lesion detection to PET/CT.

PET/MR in Breast Cancer
PET/MR in Breast Cancer

A 63-year-old female patient with a probably benign mass on conventional breast examinations. MRI showed a lobulated mass in the right breast (A). DCE-MRI showed an indeterminate plateau-type kinetic curve (B). The lesion showed high signal on DWI (C) and a small decrease in signal intensity on ADC map (D), $\text{ADC} = 1.50 \times 10^{-3}$ mm$^2$/s, suggestive of benign lesion. PET-MRI fusion showed increased 18F-FDG uptake (E), suggestive of malignant lesion. Percutaneous biopsy was compatible with mucinous carcinoma.

PET/MR in Breast Cancer

- 38 lesions with histologic correlation
- 32 mass lesions (84.2%); 6 non-mass lesions (15.8%)
- Lesion mean diameter was 31.1mm
- Multiparametric evaluation provided 100% sensitivity, 55.5% specificity, 87.9% PPV, 100% NPV, and 89.5% accuracy
- No false-negative results
- Multiparametric evaluation with PET-MRI showed good diagnostic accuracy to differentiate benign from malignant breast lesions

PET/MR: Brachial Plexus Involvement

PET/MR in Breast Cancer

• Whole body hybrid PET/MR holds great promise once technical issues have been adequately solved
• PET/MR will not replace PET/CT
• Good image fusion is not enough!
• Clinical routine applications “one-stop-shop” when MRI and PET would be used anyway
• Leverage technology for translational research
Novel Molecular Breast Imaging

- Positron emission mammography
- PET/MR
- Molecular Breast Imaging
Prototype MBI Scanner

4 cm x 4 cm CZT module
MBI Scanner

• Cadmium Zinc Telluride (CZT) technology
  – Excellent Intrinsic Resolution = 1.6 - 2.5 mm
  – Excellent Energy Resolution ~4 %
  – Can be operated at room temperature
  – Minimal dead space at the detector edge
  – Expensive – currently limited to small FOV detectors

• Dual-detector design optimized for breast imaging
Clinical MBI Scanners
Molecular Breast Imaging

Normal
Molecular Breast Imaging

- 8.1, 10 mm IDC
- 17, 5.7, 3.3 mm ILC
- 4.7 mm IDC
- 12.7, 5.0 mm IDC
- 5.5 mm ILC
- 8.0 mm IDC with Extensive DCIS
- 3-4 cm IDC + DCIS
- 38 mm IDC + DCIS
- ~ 9 mm DCIS
- 7.0, 6.0 IDC
## Molecular Breast Imaging

<table>
<thead>
<tr>
<th>Tumor diameter (mm)</th>
<th>Tumors (n)</th>
<th>Average sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–5</td>
<td>16</td>
<td>0.67</td>
</tr>
<tr>
<td>6–10</td>
<td>45</td>
<td>0.87</td>
</tr>
<tr>
<td>11–15</td>
<td>30</td>
<td>0.97</td>
</tr>
<tr>
<td>16–20</td>
<td>19</td>
<td>0.95</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>18</td>
<td>1.00</td>
</tr>
<tr>
<td>≤ 10</td>
<td>61</td>
<td>0.82</td>
</tr>
<tr>
<td>All tumors</td>
<td>128</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Molecular Breast Imaging

Digital Screening Mammography (Negative)

Molecular Breast Imaging (Positive)
26x10x16 mm IDC with DCIS
Molecular Breast Imaging

• 1651 asymptomatic women with mammographically dense
• 300-MBq 99mTc-sestamibi
• 21 cancers: two by mammography only, 14 by MBI only, 3 by both modalities, and 2 by neither
• MBI added to mammography--overall cancer detection rate increased from 3.2 to 12.0 (p < 0.001)
• Mammography alone—sensitivity 24%; specificity, 89%; and PPV, 25%.
• Combined—sensitivity 91% (p < 0.001); specificity, 83% (p < 0.001); and PPV, 28%

Molecular Breast Imaging

Evaluation of disease extent, MBI and MRI detect 1 mass (8 mm Invasive Cancer)
Molecular Breast Imaging

Infiltrating Lobular Carcinoma – index lesion detected on mammography

Multifocal cancer detected by MBI and MRI

Mammogram  MBI  Breast MRI
Molecular Breast Imaging

- MBI substantially increases detection rates of invasive cancers in dense breasts
- Useful adjunct to mammography
- Compares favorably to MR for cancer detection—useful as an alternative
- Can now be performed with 300 MBq of TcSestamibi (effective dose 2.4 mSv)
Thank You

Eka Medical Center
Jakarta

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