PET/MR: An Update

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Disclosures

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- Consultant – Wyeth Nutrition

MR vs. PET

- Detailed anatomical information
- Better soft tissue contrast
- No radiation
- Availability of many sequences
- Limited sensitivity to molecular events
- Limited anatomical definition
- Poor soft tissue contrast
- Radiation
- High sensitivity to molecular events
Outlines

- Technical specs of Siemens and GE hybrid PET/MR scanner
- Attenuation correction approaches
- Motion correction of PET images
- Radiation dose reduction
- Clinical applications

### Technical Specs: PET

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Siemens</th>
<th>GE</th>
</tr>
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<tbody>
<tr>
<td>Detector</td>
<td>3D rings</td>
<td>4D rings</td>
</tr>
<tr>
<td>Acquiring</td>
<td>64 slices</td>
<td>64 slices</td>
</tr>
<tr>
<td>Iterative</td>
<td>1 arch</td>
<td>1 arch</td>
</tr>
<tr>
<td>Reconstructed</td>
<td>2D arch</td>
<td>2D arch</td>
</tr>
<tr>
<td>Tracer</td>
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<tr>
<td>Energy</td>
<td>680 keV</td>
<td>680 keV</td>
</tr>
<tr>
<td>Resolution</td>
<td>15.5%</td>
<td>13.5%</td>
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<tr>
<td>Field of View</td>
<td>23 cm</td>
<td>23 cm</td>
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<tr>
<td>Acquisition</td>
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<td>[data]</td>
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<tr>
<td>SDM</td>
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<tr>
<td>Naline</td>
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<tr>
<td>EM</td>
<td>[data]</td>
<td>[data]</td>
</tr>
<tr>
<td>PET/CT</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>PET/MR</td>
<td>Yes</td>
<td>No</td>
</tr>
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</table>
Technical Specs: MR

<table>
<thead>
<tr>
<th>Siemens</th>
<th>GE</th>
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<tbody>
<tr>
<td>Field Strength</td>
<td>3T</td>
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<tr>
<td>Bore-size</td>
<td>60cm</td>
</tr>
<tr>
<td>Gradient</td>
<td>65mT/m</td>
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<tr>
<td>Rise-time</td>
<td>200T/m/s</td>
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</table>

Attenuation Correction

- Standalone PET
  - Using an external radionuclide source ($^{68}$Ge/$^{68}$Ga) emitting gamma photons at ~511 KeV
- PET/CT
  - 80-140 KeV
  - CT-based attenuation maps
- PET/MR
  - MR works under different physical principles from CT-based and external radionuclide based attenuation correction

MR-Based Attenuation Correction Methods

- Atlas-based approaches
- Direct imaging methods
  - Two-point Dixon methods
  - Double-echo Ultra-short TE methods
Two-Point Dixon Method

- Separate tissues into four tissue classes, including soft tissues, fat, lung, and background.

Double-echo Ultra-short TE (DUTE)

- Since bone is MR "invisible", bone is assigned as soft tissue, using two-point Dixon
- Double-echo Ultra-short TE approaches were proposed to provide accurate delineation of bone from air
  - Echo 1 (TE < 0.1ms)
    - bone tissues → somewhat MR visible
    - air → not MR visible
  - Echo 2 (TE ~ 2ms)
    - bone tissues → not MR visible
    - air → not MR visible
Radiation Dose Reduction

Comparison of PET images with doubled acquisition time and half of activity.

A Machine Learning Approach

L-PET
S-PET
Ground truth S-PET
Predicted S-PET
Difference

CLINICAL APPLICATIONS
Cervical Cancer

- 26 yo, female
- Staging/path/size:
  - IIB (clinically) vs. metastatic IIIB (by imaging) with positive pelvic nodes by PET.
  - Adenosquamous carcinoma with both clear cell and glassy cell areas;
  - Initially 10 cm decreased to 5 cm at time of removal.
- PET/MR added value:
  - Provided baseline anatomic and functional data including L external iliac lymph node
  - Mid-treatment scan showed significant decrease in size by MR and residual active disease adjacent to the cervix by PET
**Pediatric Applications**

- Reduce radiation doses
- Allow repeated imaging sessions

**Methionine C11**
- Anaplastic astrocytoma
- Homogeneous FLAIR but a hot spot on PET


- Rhabdomyosarcoma was suspected
- 68Ga-DOTATATE
- Meningioma


**Radiation Planning**

47 yo F with T1 N3 squamous cell carcinoma

Chemoradiation and Chemotherapy

Visit 1
Visit 2

**Hybrid PET/CT Imaging**

Integration of PET/CT imaging into treatment

BRIC