MRI-PET: Oncologic Applications

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Boston, MA
October, 2012

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Acknowledgement

Osman Ratib, MD,
James K. ODonnell, MD
Peter Faulhaber, MD
Raj Paspulati, MD
Karin Herrmann, MD
Ray Muzik, PhD
Zhenghong Lee, PhD
Smitha Thomas, MD
Bryan Traubergh, MD
Oliver Steinbach, PhD
Deborah Kaminsky, Pharm D
Philips – Cleveland
Learning Objectives

• Define MR-PET technology
• Compare PET-CT with MR-PET
• Discuss MR-PET opportunities and challenges
• Review applications focusing in abdominal oncology
### MR-PET

<table>
<thead>
<tr>
<th></th>
<th>Anatomy</th>
<th>Physiology</th>
<th>Metabolism</th>
<th>Molecular</th>
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<tbody>
<tr>
<td>CT</td>
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<td>MRI</td>
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<td>Nuclear</td>
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- **PET**: whole body imaging
- **MRI**: whole body AND organ based imaging
- **MR-PET**: anatomic, metabolic and functional tissue characteristics
  - Comprehensive information
Current Architectures

Sequential

Simultaneous

MR/PET

mMR
Simultaneous: mMR
Sequential: MR-PET

Philips Ingenuity TF PET/MR
MR-PET

- Combines in an integrated hybrid unit:
  - A state of the art 3.0T MRI
  - A state of the art Time-of-Flight PET
- Sequential design
- Maintains integrity of both units

- Whole body imaging
- Simplified workflow
- Superior soft tissue contrast
- Reduced radiation

The Pathway to Molecular Imaging
PET-CT vs. MR-PET

CT in PET-CT

• Strengths:
  • Great attenuation correction
  • Anatomic morphologic information

• CT weaknesses:
  • Limited soft tissue contrast resolution
    (brain, bone marrow, prostate, uterus, liver, soft tissue tumors,...)
  • Considerable radiation exposure
    (2/3 PET-CT scan)
  • Typically not used as diagnostic CT
PET-CT v MR-PET

MR in MR-PET

• Strengths:
  • Superb soft tissue contrast
    • Superior to CT in local cancer staging: prostate, rectum, ...
  • Beyond anatomic morphological imaging
    • Functional imaging (DWI, DCE, MRS)
    • Parametric data

• Weaknesses:
  • Integration with PET technically challenging
    • Detectors, Shielding, Surface coils with cables+connectors
  • Attenuation correction based on hydrogen nuclei and tissue relaxation not tissue density
  • MRAC still work in progress (artifacts, sequences)
MR-PET Opportunities

- Ultimate molecular imaging machine
  - Spectroscopy
  - New NM agents
- Applications where CT lacks
- Less ionizing radiation
- Novel contrast approaches
- Beyond oncology
  - Neurodegenerative diseases
  - Cardiac
  - Other metabolic disorders
MR-PET Challenges

- Attenuation correction validation
- Current socio-economic environment
  - Question high technology without proven outcomes
  - Unclear “killer” application
- Price
- Study Length (efficient MR protocols)
- Practical operational aspects
  - Intrinsic MRI complexity
  - Ownership (NM-Radiology)
  - Collaboration
Technical Challenges

• Hardware implications
  • Possible interference of the two systems
  • APD (Avalanche Photodiodes) instead of Photomultipliers
  • Shielding of both

• Attenuation correction:
  • Compensation for MRI hardware (coils, cables, etc)
  • Compensation for system inherent artifacts (truncation, metal, respiratory, etc)
MR-PET: Attenuation Correction (MRAC)

MR image for basic anatomical “pilot” and attenuation correction support for PET
MR-PET: MRAC Hardware

Patient Table  Head 8ch  NV 16ch  Cardiac 6ch

Spine 15ch  Cardiac 32ch posterior  Breast 7ch
MR-PET Applications

- Oncologic
  - Pediatrics (lower radiation exposure)
  - Breast Imaging (lower dose staging)
  - Rectum (staging), Liver
  - Prostate, GYN and pelvis
  - Head and Neck
  - Soft tissue tumors
  - Neuro-oncology (Tumor vs Treatment response)
- Neurologic (other than oncology):
  - Degenerative diseases (Dementia, Epilepsy)
- Cardiac
- Contrast agents
  - Beyond Gadolinium-DTPA, FDG
# MRI-PET vs PET-CT in Oncology (PET-MRI)

<table>
<thead>
<tr>
<th></th>
<th>PET/CT</th>
<th>PET/MR</th>
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<tbody>
<tr>
<td>Oncology Colorectal</td>
<td>★★★★★</td>
<td>★★★★★</td>
</tr>
<tr>
<td>Oncology Prostate</td>
<td>★</td>
<td>★★★★</td>
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<tr>
<td>Oncology Breast</td>
<td>★★★</td>
<td>★★★★★★</td>
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<tr>
<td>Oncology Gyn &amp; Cervical</td>
<td>★★</td>
<td>★★★★★★</td>
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<tr>
<td>Oncology Soft Tissue Tumours</td>
<td>★★★</td>
<td>★★★★★★</td>
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<tr>
<td>Oncology Head &amp; Neck</td>
<td>★★★</td>
<td>★★★★★★</td>
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<tr>
<td>Oncology Pediatric</td>
<td>★★★</td>
<td>★★★★★★</td>
</tr>
<tr>
<td>Lymph Node Involvement</td>
<td>★★</td>
<td>★★★★★★</td>
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MR-PET: Next Steps

• Optimize image quality, artifact correction
• Accuracy of PET quantification (SUVs)
• Evaluate the effect of Gadolinium on MRAC
• Compare to standard-of-care PET/CT or SPECT/CT (NM)
• Determine the incremental value PET/MRI over standard-of-care imaging with CT and MRI
• Assess its time efficacy as compared to separate imaging studies
• Assess radiation dose reduction if PET-CT may be substituted with PET-MRI
MR-PET: Pearls to take Home

- MRI as dominant modality
- Will affect your life (Radiologist or NM MD)
- If MRI preferred to CT
- If MRI and PET-CT clinically appropriate
- Pediatrics and repeated imaging
- Not a replacement for PET-CT
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