PET-MRI: A new frontier in hybrid imaging

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Disclosure

Washington University has a Biograph mMR System and a research agreement with Siemens
Objectives

- Types of PET-MRI
- Technical challenges with simultaneous PET-MR scanners
- Imaging protocols
- Applications
Evolution of Hybrid Imaging

- Software co-registration
  - 1990s
- PET-CT, SPECT-CT
  - Early 2000s
- PET-MRI
  - 2010
Types of PET-MR scanners

- Sequential imaging systems
- Simultaneous imaging system
Types of PET-MR scanners

- Sequential imaging system
- GE Healthcare
Types of PET-MR scanners

- Sequential imaging system
  - Phillips Healthcare
  - Ingenuity TF PET-MR
Types of PET-MR scanners

- Simultaneous imaging system
Simultaneous PET-MR - Technical Challenges

- MR interferes with PET photomultipliers
  - Avalanche photodiodes
- PET electronics interfere with MR
- MR coils
  - Attenuation of PET data
- MR based attenuation correction
MR-based Attenuation Correction

- 2-point gradient echo Dixon sequence

In phase  Out of phase  Water-weighted  Fat-weighted
MR-based Attenuation Correction

- Attenuation map: $\mu$-map

![Diagram showing different tissue types: air, fat, lung, soft tissue]
MR-based Attenuation Correction

- SUV correlation between PET-MR and PET-CT

Drzezga, et al. JNM 2012

**A. Suspected lesions**

\[ Y = 0.57 + 0.79X \]

\[ \rho = 0.93 \]

**B. Background**

\[ Y = 0.06 + 0.67X \]

\[ \rho = 0.92 \]
MR-based Attenuation Correction

- Challenges
  - Bone
  - Metal implants

CT  MR-sag T1  Ultra-short TE  UTE μmap
MR-based Attenuation Correction

- Challenges
  - Cortical Bone
  - Metal implants

Regarding MR based attenuation correction of PET data, which of the following is TRUE?

- MR based attenuation correction is required for both sequential and simultaneous PET-MR scanners
- MR provides improved attenuation correction of bone compared to PET-CT
- MR provides improved attenuation correction of metal compared to PET-CT
- Current evidence suggests good correlation between PET- MR and PET-CT estimated SUVs
### Whole-body PET-MR Protocol

#### Basic Whole Body Protocol

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<th>PET</th>
<th>AC HASTE DWI</th>
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Whole-body Protocol

- NAC PET
- μ-map
- AC PET
- HASTE
- DWI
- ADC
### Whole-body Protocol

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Basic Whole Body Protocol + Regional Imaging
Advantages of combining MR with PET
Eliminate CT ionizing radiation

- PET-CT protocols adjusted for children

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<th>Effective Dose</th>
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<tr>
<td>PET</td>
<td>5-7 mSv</td>
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<tr>
<td>CT</td>
<td>3-6 mSv</td>
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<tr>
<td>PET-CT</td>
<td>8-13 mSv</td>
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- Approximately 50% dose reduction
- Up to 80% reduction reported in pediatric and adult literature

Alessio, et al. JNM 2009
Advantages of combining MR with PET

- Improved soft tissue contrast compared to CT
- Organs with high background PET activity
Advantages of combining MR with PET

- Improved spatial resolution compared to PET alone
- Areas of complex anatomy

Images courtesy of T. Benzinger/ J. McConathy
Advantages of combining MR with PET

- Combine functional MR information
- Diffusion weighted imaging

16-year-old with large B-cell lymphoma
Which of the following statements regarding hybrid PET-MR imaging is TRUE?

- MR acquisition can be truly simultaneous with PET acquisition.
- PET-MR is as sensitive as CT in detecting <1cm pulmonary metastasis.
- Radiation exposure from PET-MR is not significantly different as compared to PET-CT.
- Hybrid systems use low strength magnets which can only be used for anatomic localization.
Summary of PET/MR

➢ Pros
   ➢ Truly simultaneous acquisition
   ➢ Improved soft tissue contrast
   ➢ Incorporation of functional MR
   ➢ Decreased ionizing radiation

➢ Cons
   ➢ Expense
   ➢ AC not entirely resolved
   ➢ Need free breathing, high resolution/contrast, motion insensitive sequences, without time penalty
   ➢ Lung metastasis evaluation
Unanswered Questions

- Is the cost/complexity of PET-MR justified by the incremental improvements?
- What indications are likely to benefit the most from PET-MR?
- Will PET-MR lead to better tumor characterization and ultimately improved patient outcomes?
Acknowledgements

- PET-MR team at MIR

- Siemens
Thank you!
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