PET/MR: Techniques, Indications and Applications

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Need of Image Fusion?

Hardware Fusion

- PET/CT
- SPECT/CT
- PET/MR

Medical Innovation of the Year (2000)

Software Fusion

- PET/MR
  for the rest of us?

Baum K.G. et al: Algorithm Generated Schemes for PET/MR Image Fusion
PET-MR in Children

- 1. Why PET/MR ?
- 2. How does PET/MR work?
- 3. Why children?
- 4. Application
- 5. Own examples
- 6. Trouble

Why PET/MR?

Single modalities can only see a part of the whole

- Morphology
- Physiology
- Biochemistry

PET/MR – complementary methods

Anatomy, flow, perfusion, diffusion, function

PET: perfusion, function

MR: Quelle: Siemens ©
PET/MR Concepts

Tandem vs. Integration

**Tandem PET / MR**
- Easier to avoid interferences
- No simultaneous registration
- Longer examination time

**Integrated PET / MR**
- Simultaneous MR and PET
- Best image coregistration
- Higher throughput

Source: Siemens ©
Attenuation correction for PET

DIXON-Sequence!

Small pulmonary nodules are not well recognized in Dixon sequence.
Problem with Attenuation Correction

Small pulmonary nodules are PET negative

7 years old girl with rhabdomyosarcoma

**Why Children?**

Significantly lower radiation exposure (compared with PET-CT)

**PET/CT**: 24.8 mSv

**PET**: 4.6 mSv (3 mSv)
Demands

1. No diagnostic loss compared to conventional MR studies
2. Acceptable time (45min)
3. Not only additive benefit but “symbiotic value" of the two modalities

Practical realization

Limitation of number and duration of the sequences
Field strength of 3.0 T is used for time reduction
<table>
<thead>
<tr>
<th>PET</th>
<th>TIRM cor</th>
<th>TIRM tra</th>
<th>DWI tra</th>
<th>FLAIR, T2 T1KM</th>
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<tr>
<td>PET</td>
<td>TIRM cor respiratory-triggered</td>
<td>TIRM tra respiratory-triggered</td>
<td>DWI tra</td>
<td>respiratory-triggered T2-TSE tra, cor T2 TSE FS tra</td>
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<td>DWI tra</td>
<td>T1 SE FS CE</td>
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**Note:** PET = Positron Emission Tomography, DWI = Diffusion Weighted Imaging, TIRM = T2-Relaxation Time Imaging Method, FLAIR = Fluid-Attenuated Inversion Recovery, T1KM = T1-Knee Magnetization, T2-TSE = T2-Short Echo Time, T1FLASH = T1 Fat-Suppressed FLASH, VIBE = Volume Imaging by using Balanced Eddy Currents, CE = Contrast Enhanced, T1 SE = T1 Spin Echo, 2D FS = Two-Dimensional Fat Suppression.
Radionuclides and Tracers
Radionuclides and Tracers

90% $^{18}$FDG PET
Visualization of glucose transport and glucose uptake

5% $^{11}$C Methionin PET
Visualization of protein synthesis / diagnostic of low grade glioma

2% $^{68}$Ga DOTATOC
Somatostatin receptor imaging: Neuroendocrine tumors, meningioma
**90% ¹⁸FDG PET**
Visualization of glucose transport and glucose uptake

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Somatostatin receptor imaging: Neuroendocrine tumors, meningioma
90% ¹⁸FDG PET
Visualization of glucose transport and glucose uptake

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Visualization of protein synthesis / diagnostic of low grade glioma

3% ¹⁸F-DOPA PET
higher sensitivity than 123I-MIBG Scintigraphy in neuroblastoma

2% ⁶⁸Ga DOTATOC
Somatostatin receptor imaging: Neuroendocrine tumors, meningioma
PET/MR Indications

1. Oncological diseases with disseminated tumor spread staging

2. Treatment response restaging

3. Therapy planning biopsy - surgery

Testicular tumor with retroperitoneal metastases Supraclavicular lymph nodes and a liver metastasis 14 years
Staging: Burkitt lymphoma cervical, 2.5 year old boy

The MR finding of the left-sided lymph nodes is not pathological (lymph node size left < 1.5 cm)

In PET +++

Lymph nodes involvement on both sides

In 10% of our patients with lymphomas it comes to an upstaging after PET-MR.
Restaging: Acute myeloid leucemia, extranodal involvement

Residual tumor or scar?

06th May

07th June

08th August

15 year old girl

No complete remission: surgery
Staging: Mixed neuroblastoma / ganglioblastoma

- 1 year old boy
- Originated from sympathetic trunk
- Inhomogeneous FDG uptake: highly differentiated tumor tissue
18F-FDOPA PET in neuroblastoma demonstrated a higher sensitivity than 123I-MIBG scintigraphy.
**18F-FDOPA PET in neuroblastoma**

Demonstrated a higher sensitivity than 123I-MIBG scintigraphy.

Examples Head and Brain
Refractory epilepsy without MR lesion

6 year old girl

Usfull only in patients with missing MR lesions

Interictal hypoperfusion / hypometabolism around of focus
$^{65}\text{Ga DOTATOC-PET}$ meningioma of the optic nerve

Retroorbital mass 7 year old boy
$^{11}$C-methionine-PET in multifocal brain tumor: Hot spot biopsy
C-methionine-PET

Anaplastic astrocytoma grade III

Hot spot biopsy
Summary PET/MR in Children

1 instead of 2 studies
Faster than sequential studies and more comfortable for patient

High soft tissue contrast by MR + functional information by PET
More detailed information on nature and distribution of lesions

Simultaneous data acquisition
Most accurate spatial allocation (hot spot biopsy / surgery)

Important for Children
Significantly lower radiation exposure than PET / CT
Thank you for your attention!

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