Multimodality Imaging in Inflammation: from Morphology to Function and Beyond

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Agenda

• Oncology
  - CT Perfusion / Dual Energy CT
  - MR Perfusion (DCE-MRI / ASL)
  - MR-DWI (Diffusion-weighted Imaging)

• Atherosclerosis and Vasculitis
  - High-Resolution Coronary CTA
  - CT Perfusion in Vasculitis
  - MRI Carotid: High Resolution and DCE-MRI

• Myocardium
  - LGE, Function, Perfusion, Mapping

• Tissue Characterization: Advanced MR Techniques

• Hybrid Imaging
Inflammation in Tumors

Advanced CT: Functional Imaging of Tumor Response
RCC, pulmonary met

Volume perfusion CT shows marked increase in BF and BV

Advanced CT: Quantitative Perfusion CT Imaging
1 week during anti-CD52 Ab (CLL)
Inflammation in Tumors

Advanced CT: Dual-Energy CT / Spectral CT for Tissue Composition

Iodine Content?

Diffusion MRI

- No contrast media / Brownian motion
- High cell density restricts diffusion
- Detection/Characterization/Monitoring

Apparent Diffusion Coefficient:
ADC: $-\ln \frac{x}{b_{\text{max}}} - b_0$

http://www.microscopy-uk.org.uk/dww/home/hombrown.htm

http://www.microscopy-uk.org.uk/dww/home/9897608.htm

Subcutanes Colon-CA Xenograft, Regorafenib-Therapie
73-year old patient, NET, hepatic metastases, tumor heterogeneity visible in ADC-map

• Signal-time-curves after Gd i.v.
• Kinetic modelling
• of perfusion parameter maps
• Assessment of vascularization and vessel permeability
  → lesion characterization and treatment monitoring
Inflammation in Tumors

MR: Perfusion Imaging by ASL

- No contrast media application
- Labeling of blood water protons
- Creation of perfusion maps

Healthy volunteer, perfusion of medulla and cortex

Regional thyroid perfusion assessment in a patient with Graves' disease (M. Basedow)

NHL - two weeks after onset of anti-CD20 therapy

ASL: Increased perfusion in responding bone lymphoma

Atherosclerosis and Vasculitis

Advanced CT Imaging

- Non-invasive, low radiation dose (<1 mSv)
- Low iodine contrast material (<50 ml)
- <2 sec acquisition

Stenosis

Stenosis

normal

Plaque
CT Perfusion Imaging
• Morphologic and functional information

Advanced MR: Carotid Plaque Characterization
Collaboration with Neuroradiology Prof. U. Ernemann

56 y/o asymptomatic, vulnerable plaque features Acute plaque rupture
MR Perfusion for Carotid Plaque Characterization

AHA Typ VI Plaque left CCA

- T1 post Contrast
- Extractions fraction

Advanced MR Cardiac Imaging

- Functional Information
- Enhancement Patterns

Myocardium

- LGE - AMI
- T2w-Imaging
- Myocarditis
- HOCM
MR-Mapping: T2 / T1 quantitative relaxation times
- Absolute and relative relaxation times of myocardium
- Detection / Quantification of diffuse inflammatory disease

Inflammation in the Lung

MR: Proton Density using very Short TE
- Potential for Allergic / Inflammatory Lung Disease
- Anterior-posterior PD gradient position dependent
- Differences between maximum in- and expiration

Healthy volunteers (n=10)

**MR: Bronchial inflammation obstruction: Quantification of Air Trapping**

- Segmentation of lung volume
- Stepwise calculation of the relative signal (ex) and cumulative lung volume

\[ R^2 = 0.87 \]

**Histogram of Signal Intensity**

- Inspiration
- Expiration

**MR: Chemical-Shift-selective Imaging: Synovitis, Effusion, Osteonecrosis**

- Water-selective
- Fat-selective
Fat-selective Imaging of Muscle Tissue

Male, 34 y/o
Lipody strophic Patient

Male, exercises 34 y/o
Kennedy

Rho-weighted
Fat-selective

Quantitative fat-selective imaging of muscle in different degenerative and inflammatory muscular disease entities / rheumatic diseases

Diabetes and Prediabetes: Volumetry of Visceral and Subcutaneous Fat

Total Cross-Section

visceral adipose tissue

subcutaneous adipose tissue

lower extremity

body trunk

upper extremity

- Compensating Coil characteristics
- Definition of thresholds
- Differentiation of SAT and VAT using “active contours”

Machann J et al., J Magn Reson Imaging 2005
Composition of Visceral Fat: MR Spectroscopy

small VAT volume | high VAT volume

MUFA+PUFA | CH₃ | Reference

Liver inflammation in Non-alcoholic steatosis hepatitis: T2- and T2*-Mapping

A | B

C | D

Machann J et al., NMR Biomed. 2013

Bongers, Schick, Machann et al, submitted for publication
PET/CT: Oncology

Potential: Evaluation of tumor metabolism (PET) and vascularity (CT-Perfusion) enables imaging of vascular-metabolic relationships in tumors.

PET/CT: Bone Inflammation

- Evaluation of disease activity and accurate assessment of the extent of infection for surgical planning
- Double tracer PET examination: 18F-FDG: Inflammation, 18F-Fluorid: bone metabolism
- Complementary information regarding bone infections
- High resolution CT provides exact anatomical and structural information of the bone
- Osteomyelitis versus Osteonecrosis after radiotherapy
**Hybrid Imaging**

**PET/CT: Vascular Inflammation**

**Large vessel vasculitis:** 18F-FDG-PET/CT

![Pre Therapy](image1.png)  ![Post Therapy](image2.png)

**PET/CT: Plaque Imaging**

**Novel Tracer:** 64Cu-GP VI-Fc (= Glycoprotein VI)

- GPVI-Fc binds with high affinity to collagen and atherosclerotic plaque tissue.
- Non-invasive imaging studies (preclinical) with radiolabeled sGPVI-Fc show specific binding activity to vascular lesions in vivo.

79 y male patient with a significant CAD, 1 week after cardiac catheterization, PET/CT with 64Cu-GPVI-Fc PET/CT, (uptake time 24h), focal tracer uptake at the access site of the right AFC.
**Hybrid Imaging**

**PET/CT: Plaque Characterization**

*ACS*

- ACS: LM Activity
- ACS: New Stent

*Stable*

- Stable Syndrome; New Stent
- Stable Syndrome; Old Stent

**Hybrid Imaging**

**MR/PET**

Simultaneous acquisition of metabolic (PET) and functional/anatomical (MRI) Parameters:

- Anatomie, Atrophie, Biomechanik
- Diffusion, Magnetisation, Transfer, Permeabilität
- Blutfloss/Perfusion
- Blut- / Gewebeoxyژgenierung
- Glukoseverbrauch*
- Aminosäurenmetabolismus*
- Neurotransmittermetabolismus*
- Rezeptordichte
- cell labeling
- GewebepH
- Metabolitenkonzentration

* MRS = Konzentration, PET = Umsatz
MR/PET: Vessel Wall

Takayasu Vasculitis

PET MIP

FDG-PET 307 MBq, 122 min p.i.

Initial Stage

No Stenosis

Wall enhancement

76 y/o female, fatigue and muscle score, weakness upper extremity, BSG: 69 mm; CRP: 9.23 mg/dl

MR/PET: Oncology

Multiparametric Tissue Characterization

Prostate Cancer

Glioma Oligoastrozytom WHO II

Histology

Multiparametric Tissue Characterization

1H-Spektroskopie

Collaboration with Neuroradiology Prof. U. Ernemann
MR/PET

16 y/o male w/ lymphoma: Reduction in size, increase in ADC, reduction in SUV → response

Reduction in size, only slight reduction in ADC, persistent SUV → suspicion of residual vital tumor
Thank you!

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