Fusion of FDG-PET and Proton-MRI of the Lung in Patients with Lung cancer: Initial Results in Differentiating Tumor from Atelectasis

C. Hintze[1], A. Dimitrakopoulou-Strauss[2], L. G. Strauss[2], F. Risse[3], C. Thieke[4], J. Dinkel[1], N. Qureshi[1], R. Eberhardt[5], M. Klopp[6], C. P. Heußel[7], and J. Biederer[1]

[1]Radiology, German Cancer Research Center, Heidelberg, Germany, [2]Clinical Cooperation Unit Nuclear Medicine, German Cancer Research Center, Germany, [3]Department of Medical Physics in Radiology, German Cancer Research Center, Germany, [4]Clinical Cooperation Unit Radiation Oncology, German Cancer Research Center, Germany, [5]Pneumology, Thoraxklinik, Heidelberg, Germany, [6]Surgery, Thoraxklinik, Heidelberg, Germany, [7]Radiology, Thoraxklinik, Heidelberg, Germany

Introduction:

The differentiation between a central mass and poststenotic atelectasis is of significant clinical value. In particular for biopsy in staging of lung cancer and other malignant diseases like malignant lymphoma a precise depiction of the target helps to increase the likelihood of acquiring a representative sample. Another potential application is the definition of appropriate target volumes for radiotherapy planning. To be able to describe the changes of the atelectasis separately from the tumor itself might also contribute to follow up of changes during therapy.

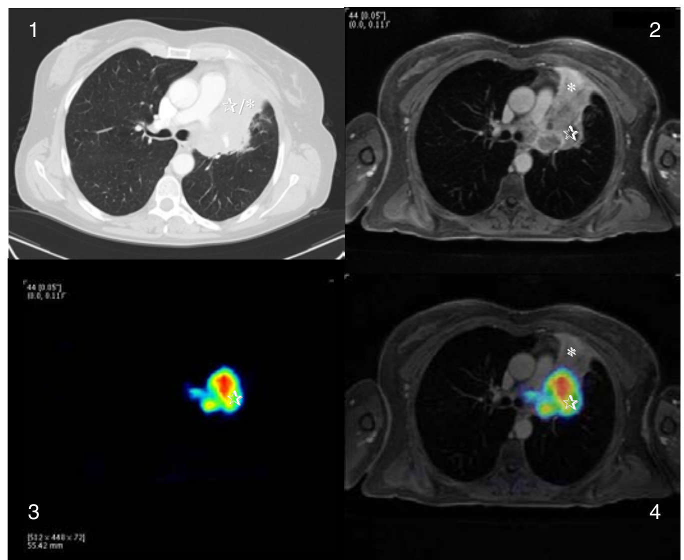
For this purpose, the combination of Computed Tomography (CT) with ^{18}F-FDG-Positron Emission Tomography (PET) - so-called PET/CT - has been introduced recently. While general form and overall size of a primary pulmonary tumor and secondary changes can be identified on CT, delineation of the border between vital tumor, necrosis and adjacent atelectasis is usually difficult. The high specificity of functional information like glucose uptake and metabolism as obtained from ^{18}F-FDG-PET and the excellent spatial resolution from the CT are combined in this examination. However, MRI of the lung including dynamic series could not only contribute additional soft tissue contrast, but also an analysis of tumor displacement during respiration. The aim of this work was to evaluate the possible benefits of combining metabolic and respiratory function fusing ^{18}F-FDG-PET with high resolution Magnetic Resonance Imaging (MR).

Methods:

3 patients with suspected lung cancer underwent routine staging with contrast enhanced CT of the thorax. After determining the clinical indication of performing ^{18}F-FDG-PET to differentiate the tumor and associated atelectasis, the patients were asked to enroll for an additional MR study. The MRI protocol included a range of morphological sequences like steady-state GRE (coronal and transversal, TR 437.2ms, TE 1.16ms, FA 80°, TA 56s, tidal breathing), half-Fourier single shot TSE (coronal and transversal, TR 600ms, TE 31ms, FA 180°, TA 18s, insp. breath hold), high-resolution (1.3 x 1.0mm), navigator triggered T2-TSE (coronal, TR 1700ms, TE 100ms, FA 150°, TA >5min, free breathing), multi breath hold STIR (coronal and transversal, TR 3360ms, TE 100ms, FA 150°, TA 54s, multi breath hold) and 3D-GRE (coronal and transversal, TR 3.15ms, TE 1.38ms, FA 8°, TA 20s, insp. breath hold; native and contrast-enhanced: Gd-DTPA, 0.07 mmol/kg i.v.) of the lung.

Additional MR based functional imaging of the lung was performed. Tumor perfusion was measured using a hybrid breath hold and free breathing, navigator triggered fast low angle shot GRE (transversal, TR 2.32ms, TE 0.76ms, FA 15°, TA ~4min, Gd-DTPA, 0.07 mmol/kg i.v. 5ml/s) and tumor motion was measured with steady-state GRE in tidal breathing.

From the dynamic PET 4-dimensional images, parametric images (regression-based) were computed and a software fusion with the corresponding MR images was performed based on the use of the mutual information (MI) algorithm.



Squamous cell carcinoma: Contrast enhanced CT (1) and 3D-GRE (2). Parametric PET image (3) and fused PET–MR (4). Solid tumor (☆), Atelectasis (*)

Results:

In all three patients, routine CT did not allow to differentiate between the central mass and the atelectasis. Instead, MRI with native T2 weighted sequences allowed to delineate tumor margins inside the atelectasis and tumor. A very good differentiation was possible with the contrast enhanced VIBE. The demarcated tumor in the MR showed a corresponding uptake in the ^{18}F-FDG-PET.

Furthermore thoracic motion during breathing was reliably tracked in the MR with steady-state GRE. The tumor, delineated in the fused PET and MR images, showed a marked difference in displacement and local deformation from the adjacent atelectasis.

Discussion and Conclusion:

Like PET/CT the fused PET and MR images generate a benefit in combining functional parameters with high resolution imaging for better tumor delineation. The benefit of the fused PET and MR images over the PET/CT is the additional functional information from the MR. MRI findings give a second view on defining the border between tumor and secondary changes by the use of perfusion parameters, proton density and motion. Follow up examinations as well as target volume definition in radiotherapy treatment are very likely to benefit from the increased information in a single, fused PET and MR image. The added functional information, for example the tumor and atelectasis motion should allow for a better alignment of target volume in Radiotherapy.

References:

1. Biederer J, Hintze C, Thieke C, et al. Diagnostic Imaging for Advanced Radiation Therapy of Lung Cancer. Siemens Medical Solutions; October 2006; 71 - 77.
2. Biederer J, Puderbach M, Hintze C. A Practical Approach to Lung MRI at 1.5T; Siemens Magnetom Flash; 2/2006; 38 - 43.
3. Burger C, Buck A. Requirements and implementations of a flexible kinetic modeling tool. J Nucl Med. 1997; 38:1818-1823.
4. Dimitrakopoulou-Strauss A, Georgoulias V, Eisenhut M, et al. Quantitative assessment of SSTR2 expression in patients with non-small cell lung cancer using 68Ga-DOTATOC PET and comparison to 18F-FDG PET. Eur J Nucl Med Mol Imaging. 2006; 33:823-830.
5. Grosu AL, Piert M, Weber WA, et al. Positron emission tomography for radiation treatment planning. Strahlenther Onkol 2005; 181:483-499.
6. Skalski J, Wahl RL, Meyer CR. Comparison of Mutual Information-Based Warping Accuracy for Fusing Body CT and PET by 2 Methods: CT Mapped onto PET Emission Scan Versus CT Mapped onto PET Transmission Scan. J Nucl Med 2002; 43:1184-1187.