Is there a diagnostic potential of Magnetization Transfer MRI in patients with Lung Cancer?

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Purpose/Objective: Currently, lung tumor treatment planning is mainly guided by CT. However, difficulties remain in distinguishing tumor from atelectasis or heart structures. Therefore, additional functional information is often desirable, e.g. in target volume definition for radiation therapy planning or staging for non-small cell lung cancer (NSCLC) patients. As an improvement to CT alone, FDG-PET has already proven its potential to be a useful adjunct. In this preliminary study, we propose the use of magnetization transfer (MT) prepared MRI [1] as an auxiliary alternative to gain functional information in NSCLC patients. The MT effect is known to strongly depend on the macromolecular content, which could be different in metabolically active lung tumor, necrosis, and atelectasis. Exploring and exploiting the MT characteristics of NSCLC may therefore allow for the discrimination of the tumor mass and its surrounding tissue. This, in turn, could be of practical importance in radiotherapy treatment planning.

Materials/Methods: Ten patients (5 male and 5 female) with NSCLC were examined on a 1.5 T whole-body scanner (Vision, Siemens, Erlangen, Germany). For high resolution morphological imaging, 3D-VIBE was performed [2]. Magnetization transfer ratio (MTR) maps were acquired as follows: During a single breath-hold, two single shot HASTE [3] images were acquired with a matrix size of 128 x 256 zero filled to 256 x 256, FOV = $(400\ mm)^2$ and a slice thickness of 10 mm. Imaging parameters were TE_{eff} = 43 ms, TE_{inter} = 4.2 ms and a refocusing flip angle of 120-140° to reduce SAR. The first image was acquired with MT preparation consisting of a series of 59 consecutive gaussian shaped pulses irradiated with 1560 Hz off-resonance and the second image without. Between both images a time delay of 6 s allowed for relaxation back to equilibrium, resulting in a breath-hold time of approximately 8 s. Pixel-by-pixel MTR maps were calculated as the percentage of signal change: $(1-SI_{image2}/SI_{image1}) * 100$ with SI as signal intensity of the corresponding image.

Results: An example of one measurement is shown in Figure 1. The lung tumor mass experiences much higher signal reduction due to magnetization transfer effects than its surroundings. The difference map allows for clear target discrimination. Another example is shown in Figure 2. No inhomogeneities are apparent in the mass either in CT or in VIBE MRI. FDG-PET shows high standard uptake value (SUV) in same areas as MTR shows a high percentage signal change. Suspected necrotic tissue appears to have low MTR values. In all ten patients, highly intratumoral variability could be seen in MTR maps, whereas the masses mostly appeared homogenous in 3D-VIBE images. In four cases, the patients also underwent FDG-PET shortly before or after the MRI examination. Metabolically active tumor tissue (high SUV) showed higher MTR values compared to the surrounding tissue in all cases. Average tumor MTR of all ten patients was 49 ± 7 %, and tissue suspected as atelectasis had an average MTR of 40 ± 7 %.

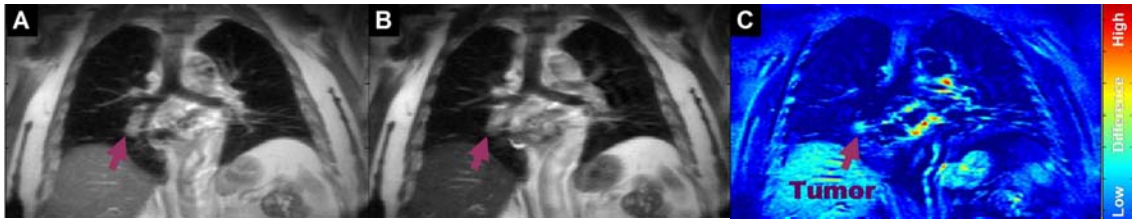

Figure 1: A) *HASTE image.* B) *Magnetization transfer prepared HASTE.* C) *Color-coded difference image. The arrows denote the tumor. Clear tumor discrimination is seen in the subtraction map.*

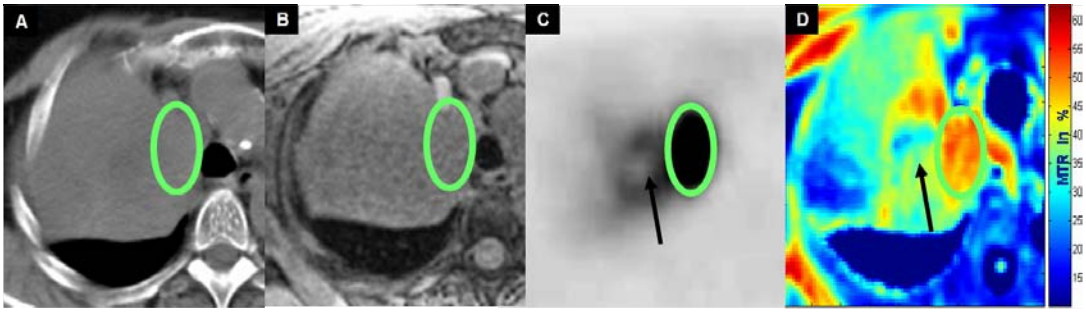

Figure 2: A) *Diagnostic contrast enhanced CT.* B) *Corresponding VIBE image.* C) *FDG-PET image of same slice.* D) *Color-coded MTR map. The ovals depict the area of FDG-PET indicated metabolically active tumor which corresponds to the area of high MTR values. The arrows point to metabolically low active tumor tissue corresponding to low MTR.*

Conclusions: Quantification of the MT effect of lung cancer is easily achievable using MTR maps acquired in a single breath-hold. MT preparation is able to generate various contrasts in lung tumor masses appearing homogenous on images acquired with standard MRI sequences. Whether there is a correlation between MTR and FDG-PET cannot yet be answered with certainty. However, similarities between information assessed by FDG-PET and MT-MRI could be present in NSCLC. Therefore, MT-MRI may impact non-invasive lung tumor characterization as well as target volume definition in radiation therapy treatment planning for NSCLC patients.

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