Reproducibility of $T_2^*$ MR imaging and correlation with diffusion MR imaging in liver metastasis of colorectal cancer

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Introduction: Colorectal cancer is one of the most frequently occurring cancers. About 50% of the patients with this cancer develop distant metastasis, mainly in the liver. Early response monitoring is desirable as only 40% of patients receiving chemotherapy responds to this potentially toxic treatment. Diffusion weighted MRI (DWI) and dynamic contrast enhanced MRI (DCE-MRI) provide potential biomarkers to monitor early treatment response. More specifically the apparent diffusion coefficient (ADC), reflecting membrane (cell) density and $K_{trans}$, reflecting vascularity have been explored for this purpose. There is an increasing interest in magnetic susceptibility or $T_2^*$ MR imaging to replace or complement DCE-MRI for vascular assessment of therapeutic interventions as this circumvents the need for contrast agent administration. $T_2^*$ MR contrast arises from local inhomogeneities of the magnetic field mainly due to the tissue level of blood deoxyhemoglobin next to specific tissue characteristics. This level of deoxyhemoglobin is governed by blood volume and flow and tissue $O_2$ consumption. For this reason a relationship between $T_2^*$ and ADC might be expected.

Aim: To study the reproducibility of $T_2^*$ MR imaging in colorectal liver metastases. In addition the correlation between $T_2^*$ and ADC is assessed.

Methods: Up till now sixteen patients with one or more liver metastases of colorectal cancer, or were scheduled for metastasectomy were included and analyzed in this study. Examinations were performed on a Siemens 1.5T MR system, with a spine- and body phased array coil. All scans were repeated within one week. After conventional $T_1$- and $T_2$-weighted imaging, $T_2^*$ imaging was performed using a FLASH 2D sequence. Every image slice was obtained with a TR of 225 ms and multiple TE values (4.76, 9.53, 14.29, 19.06, 23.82, 28.58, 33.35, 38.11, 42.88, 47.64, 52.40 ms). $T_2^*$ calculated maps were generated by fitting the data to a mono-exponential curve, using in-house built software. After $T_2^*$ imaging, DWI was performed in three orthogonal directions (b-values: 50, 300, and 600 s/mm²) using an EPI sequence. ADC-maps were calculated using Siemens Syngo (VB17) software. On the ADC- and $T_2^*$ calculated maps, 3D ROI's were drawn around each tumor. Voxel values inside the ROI's were extracted and analyzed in a histogram (fig. 1). Reproducibility was assessed using Bland Altman analyses for the mean $T_2^*$, the 16th and 84th percentile (mean ± one standard deviation in a normal distribution) values. The correlation between mean $T_2^*$ and mean ADC values was also assessed.

Results: Sixteen metastases from twelve patients were analyzed. The coefficients of reproducibility of liver metastases were 7.56, 12.39 and 18.62 for P16, mean, and P84 $T_2^*$ values, respectively. The mean $T_2^*$ of the liver metastases was 26.6ms. The limits of agreement were -6.45ms and 8.68ms, for P16, mean, and P84 $T_2^*$ values, respectively. The mean $T_2^*$ showed both good mean- and histogram reproducibility. Only in two patients with relatively small tumors moderate reproducibility was observed. A trend towards a negative correlation between the mean $T_2^*$ and mean ADC was observed. Low ADC values reflect cell dense tissue and high $T_2^*$ values represent high oxygenation. Areas with dense tissue require a high level of oxygenation by blood, explaining why high $T_2^*$ values in these areas are observed. Conversely, in areas with low oxygenation levels (low $T_2^*$) necrotic tissue (high ADC) will evolve.

Correlation analysis between mean $T_2^*$ and mean ADC values showed (fig. 3) a trend towards a negative correlation ($r = -0.34$, p = 0.14).

Discussion and conclusion: On average $T_2^*$ showed both good mean- and histogram reproducibility. Only in two patients with relatively small tumors moderate reproducibility was observed. A trend towards a negative correlation between the mean $T_2^*$ and mean ADC was observed. Low ADC values reflect cell dense tissue and high $T_2^*$ values represent high oxygenation. Areas with dense tissue require a high level of oxygenation by blood, explaining why high $T_2^*$ values in these areas are observed. Conversely, in areas with low oxygenation levels (low $T_2^*$) necrotic tissue (high ADC) will evolve.