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[1-3]. 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[4], 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, who 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/mm^2) 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.

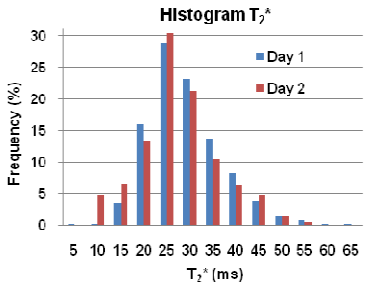

Figure 1: T_2 histogram of a tumor on day one and two.*

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, -12.90ms and 11.90ms, -20.92ms and 16.31ms, for P16, mean, and P84 T_2* values (fig. 2).

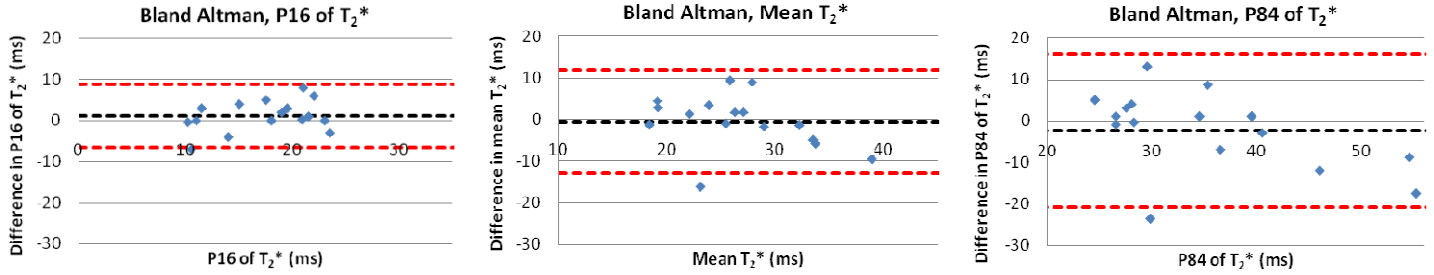

Figure 2: Bland Altman analysis of the 16th percentile, mean T_2 values, and the 84th percentile values. The dashed black lines indicate the mean difference and the red dashed lines indicate the limits of agreement.*

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 values 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.

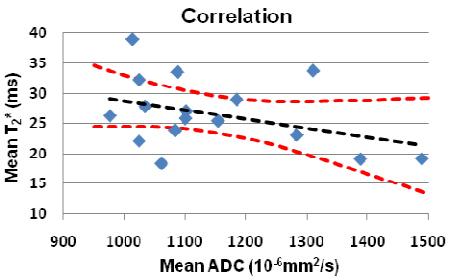

Figure 3: Scatter plot of mean ADC versus mean T_2. Averages of day 1 and day 2 were taken. The dashed black line shows the linear correlation. The dashed red lines show the 95% confidence interval.*

References: [1] Cui Y et al. Radiology 2008;248:894-900, [2] Padhani AR et al. Clin Radiol 2001; 56: 607-620, [3] van Laarhoven HW et al. J Magn Reson Imaging 2003;18:315-320. [4] Zweifel et al ISMRM 2010.