cCEST in Multiple Sclerosis at 7T: Investigating the potential to distinguish “unspecific” and “MS” white matter lesions

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INTRODUCTION: Chemical Exchange Saturation Transfer (CEST) imaging provides metabolic tissue information utilizing the exchange of pre-saturated protons in diverse environments and those of the water. Particularly in tumor imaging, CEST has proven to add information on grading, substructure and activity of the tumors. At ultra-high field with high spectral resolution, CEST offers superior metabolic information. The newly developed comprehensive CEST[1] (cCEST) provides the simultaneous reliable measurement of six promising CEST contrasts.

Regarding multiple sclerosis (MS), CEST has been shown to correlate with disability in some cortical regions.[2] The first diagnosis of MS is often difficult and uncertain. White matter lesions (WML) are a hint for MS - but are highly unspecific. We want to investigate the question whether it could be possible to distinguish between multiple sclerosis (“MS”) and non-MS (“unspecific”) white matter lesions via the rich metabolic information in cCEST. Is there a special pattern in the cCEST contrasts in MS lesions that differs from the pattern of unspecific white matter lesions?

METHODS: 6 MS and 11 non-MS subjects were measured at MAGNETOM Terra.X 7T Scanner (Siemens Healthineers, Erlangen, Germany) with an 8Tx/32Rx head coil (Nova Medical, Wilmington, USA). cCEST imaging was realized by a centric 3D snapshot GRE with homogenous MIMOSA pre-saturation using the protocol of Fabian et al.[1]. Evaluation approaches included deepCEST for the low B1 power with which CEST maps were created for amide (3.5 ppm), guanidine (2.0 ppm), dipolar rNOE (-3.5 ppm), and ssMT (3 ppm).[3,4] MTRasym was calculated for Amine (2 ppm) at 2 μT and Hydroxyl (1.5 ppm) at 4 μT. 3D ROIs were created for the white matter lesions using a commercially available AI-based segmentation algorithm (mdBrain, Mediaire, Berlin, Germany). Mean values of the six cCEST contrasts and size per ROI were evaluated. White matter mean of the respective subject was subtracted to cancel out first order effects of age and gender.

RESULTS: One patient had to be excluded due to severe motion during acquisition of offsets near 0 ppm. For minimizing partial volume effects on the one hand and adapting the lesion size between the groups on the other hand, only lesions between 4 and 30 voxels (90 % of the non-MS-lesions were smaller than 30 voxels) were analyzed. Four MS-patients (4 RRMS, 4 male, age mean 22 y, sd 3 y) and 8 non-MS subjects (3 male, age mean 37 y, sd 9 y) showed such lesions. Number of lesions: 112 (77 MS, 35 non-MS).

Regarding Amide, Amine and Hydroxyl, some of the MS-lesions possess values outside the range of the non-MS lesions (figure 1, red circles).

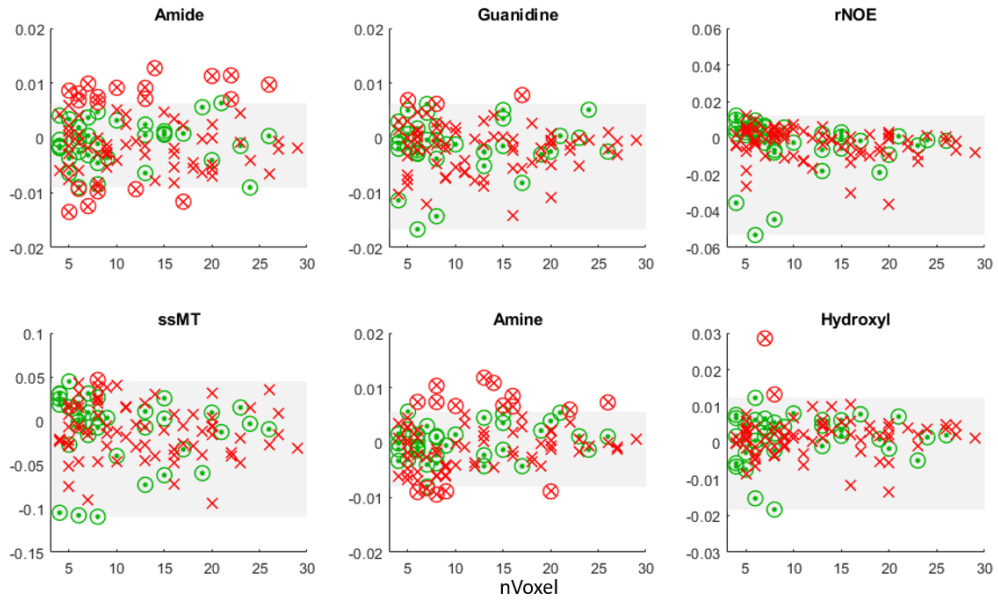

Figure 1. Deviation of mean cCEST within white matter lesions from mean WM in the brain of MS (red crosses) and non-MS (green circles). Amide, Guanidine, rNOE and ssMT are the results of deepCEST[3] trained to output the amplitudes that a 5-pool Lorentzian model would lead. Amine and Hydroxyl are the MTR_{asym} of 2 ppm at 2uT and 1.5 ppm at 4 uT, respectively.[1]
Lightgray background illustrates the range of the non-MS WML and a circle around the MS lesion mean indicates a lesion outside this range. x-axis: size of the respective lesion in voxels of the CEST image (1.8 x 1.8 x 3 mm³)

DISCUSSION: We showed aberrant mean lesion values in MS-lesions in Amide, Amine and Hydroxyl. MS-patients may exhibit both MS-lesions and unspecific lesions. The result is merely for hypothesis generation and has to be proven in larger and age matched patient cohorts. If confirmed, cCEST promises to aid in the diagnosis of MS: If lesions with strongly aberrant values were present in a subject with MS suspicion, MS would be more likely.

CONCLUSION: Mean lesion values outside the range of the values of non-MS white matter lesions have been found in Amide, Amine and Hydroxyl in MS-lesions.

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