Insights into CEST in Human Ischemic Stroke at 7T: Results of different evaluation approaches

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INTRODUCTION: In the past years, Chemical Exchange Saturation Transfer (CEST) imaging has emerged as a promising imaging modality utilizing the apparent exchange of protons of selected molecules and those of the bulk water pool. While many studies have been conducted particularly in tumor imaging, less light has been shed on CEST in ischemic stroke patients, especially at ultra-high field MRI which offers higher spectral resolution. It remains unclear, how different CEST contrast present at ischemic stroke. This study aims to gain insights into CEST in stroke with different evaluation approaches.

METHODS: Approved by the local ethics committee and after obtaining written informed consent, 10 stroke patients were measured within 96 hours after symptom onset at a MAGNETOM Terra.X 7T Scanner (Siemens Healthineers) with an 8Tx/32Rx head coil (Nova Medical, Wilmington, USA). CEST imaging was realized by a centric 3D snapshot GRE with homogenous MIMOSA pre-saturation [1] according to the low power protocol in [2]. Evaluation included the neural network deepCEST [2] and a physics informed conditional autoencoder called PICAE [3, 4]. MTR_{asym} will be complemented shortly. CEST maps were created for amide (3.5 ppm), guanidine (2.0 ppm), dipolar rNOE (-3.5 ppm), and ssMT (3 ppm) at various, reconstructed B1 levels, and z1 maps [4]. 3D ROIs were created for the stroke lesion and contralateral reference. The ratio of stroke vs. reference ROI per approach was evaluated.

RESULTS: 2 females and 8 males (means (±SD): Age 70 (±9.4); lesion volume 68.6 (±140) mL; time between onset and imaging 49.8 (±19.4) hours) were examined. For the deepCEST approach, amide-CEST signal was higher in stroke (.051 vs. .047, p =.015) compared to the contralateral reference ROI while no significant signal alteration was seen for amides in Z1 maps (.099 vs. .097, p =.554). With PICAE, we predicted CEST maps for a B1 of 0.55, 0.7, 0.85, and 1 µT. Amide-CEST only showed significant difference (reduction) at 0.55 µT (.042 vs. .044, p =.004). However, an amide signal increase is observed at 1 µT (.051 vs. .049, p= .094), although not significant. For all remaining CEST contrasts at all other B1 values, a significant signal reduction in the stroke lesion was evident (p <.05), as in the remaining approaches, too.

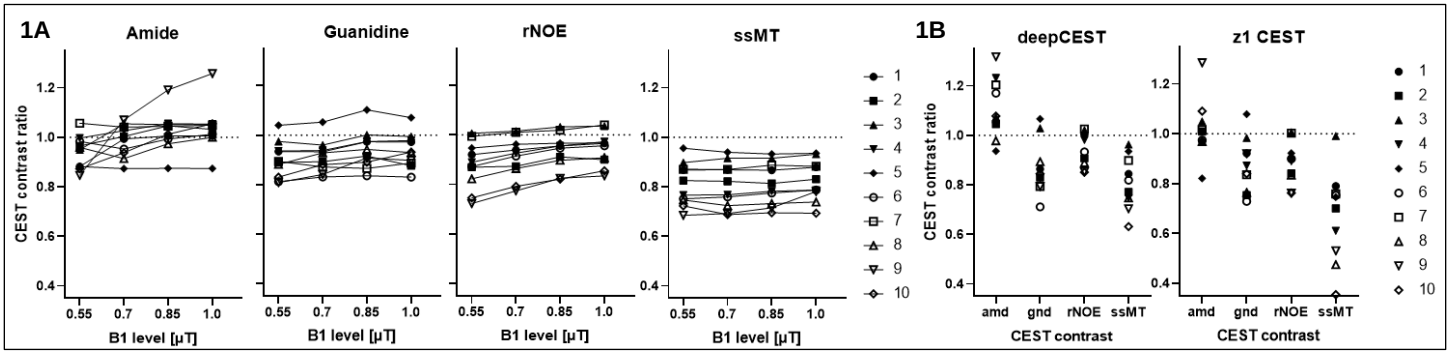

Figure 1A. Different B1 level CEST contrast ratios (lesion ROI divided by reference ROI) from PICAE are shown for each patient (1-10). All rNOE ratios are increased at 1.0 µT compared to 0.55 µT. A similar observation is made in the amide pool, although one patient majorly contributes to the statistically tested mean. **1B. deepCEST and z1 CEST** contrast ratios per contrast are shown for each subject.

DISCUSSION: In the subacute phase of ischemic stroke in the brain, the congruence of signal reduction in guanidine-, rNOE-, and ssMT-CEST at a B1 level ≤ 1 µT as well as other evaluation methods implies overall reduction of the respective exchange rate and pool concentration. The signal of amide-CEST on the other hand depends on the evaluation approach. In simulation, the dependency of amide signal on the B1 level has been shown [5], recently also in rat brain for guanidines [6]. Our results in vivo align with that: We observed an increasing trend in amide signal amplitude from 0.55 (reduced) to 1 µT (increased), see Fig 1A; although the increased signal at 1 µT is not significant. This might be due to small sample size and may prove significant with further patient recruitment.

CONCLUSION: In ischemic stroke, almost all CEST signals present uniformly reduced. To explore the ambiguous amide-CEST signal behavior in stroke, further patient recruitment and acquisition of higher B1 levels are needed.

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