CEST MRI Features of Peritumoral Edema: A Promising Prognostic Biomarker for Post-Treatment GBM Patients

Keyi Cai[1,2], Qianqi Huang[1,3], Puyang Wang[1], Jingpu Wu[1,4], Jinyuan Zhou[1], Shanshan Jiang[1]
Departments of [1]Radiology, [2]Biomedical Engineering, [3]Computer Science, [4]Electrical and Computer Engineering, Johns Hopkins University, Baltimore, MD, USA

INTRODUCTION:

Monitoring post-chemoradiotherapy malignant gliomas is a significant challenge in neuro-oncology. The Peritumoral Edema Region (PER), is understudied both in the imaging patterns and the potential mechanism. This research investigates the potential whether CEST MRI patterns in PER can differentiate tumor recurrence from treatment effects.

METHODS:

We analyzed 45 scans from 44 post-chemoradiation patients with malignant gliomas using MTR asymmetry at 3.5ppm(APTw) and 2ppm(CEST@2ppm), along with T1 and T2 values from the peritumoral regions of malignant gliomas with histogram analysis. T2 mapping, FLAIR, and Gd-T1w, as well as APTw and CEST@2ppm images, were co-registered to T1 images. A researcher manually annotated the peritumoral zones characterized by abnormal FLAIR/T2-weighted signal intensities surrounding gadolinium-enhanced tumor core. Relative values for APTw, CEST@2ppm, T1 and T2 values were analyzed after subtracting the values of the normal appearing contralateral white matter. The PER was divided into near PER and distant PER by expanding the PER mask by 1 cm. U tests and ROC analysis were implemented for classifying recurrence from treatment effect.

RESULTS:

20 scans were confirmed as treatment effects from 19 patients, and 25 scans were tumor recurrence from 25 patients. There's no significant difference in T1 or T2 values between recurrence and treatment effect at near or distant PER (**Fig. 1**).

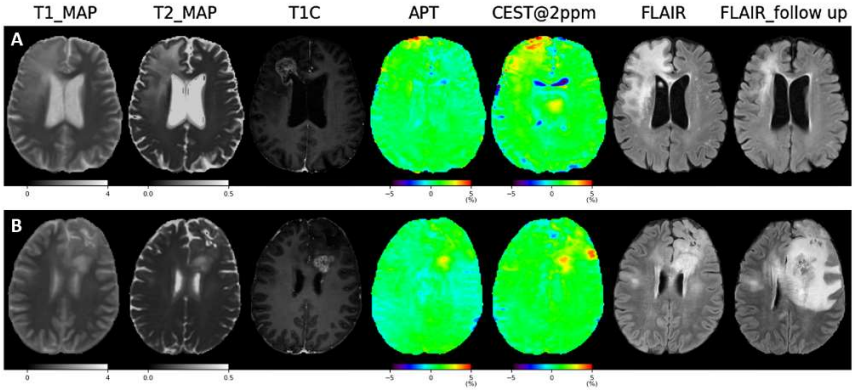

Fig. 1. (A) A patient with high-grade astrocytoma grouped in treatment effect. **(B)** A patient with GBM grouped in tumor recurrence. Both of the follow-up FLAIR images were obtained two months later

Table 1. Histogram parameters from CEST data and the Mann-Whitney test results for near PER. Parameters with statistic significance were marked by *

Histogram Parameters	APTw			CEST@2ppm		
	Treatment Effect	Tumor Recurrence	p value	Treatment Effect	Tumor Recurrence	p value
Mean	2.43 ± 1.55	3.16 ± 0.67	*0.038	2.75 ± 1.82	3.45 ± 0.87	0.095
Mode	1.68 ± 1.59	2.53 ± 1.51	0.070	1.65 ± 1.91	3.22 ± 2.14	*0.013
Skewness	0.40 ± 0.58	0.38 ± 0.71	0.935	0.20 ± 0.79	-0.13 ± 1.05	0.246
Kurtosis	0.31 ± 0.72	0.96 ± 2.23	0.207	0.87 ± 1.76	1.98 ± 4.28	0.272
Peak	4.31 ± 1.91	5.37 ± 1.03	*0.022	4.81 ± 2.14	5.36 ± 1.05	0.267
10th percentile	1.76 ± 1.42	2.39 ± 0.71	0.056	1.96 ± 1.66	2.62 ± 0.90	0.094
25th percentile	2.03 ± 1.47	2.72 ± 0.69	*0.042	2.30 ± 1.75	3.02 ± 0.89	0.079
50th percentile	2.36 ± 1.56	3.11 ± 0.69	*0.035	2.69 ± 1.86	3.42 ± 0.89	0.092
75th percentile	2.78 ± 1.63	3.55 ± 0.69	*0.036	3.17 ± 1.95	3.89 ± 0.92	0.107
90th percentile	3.21 ± 1.66	4.01 ± 0.74	*0.035	3.64 ± 1.94	4.36 ± 1.00	0.115

DISCUSSION:

The invasive malignant tumor cells presenting higher active mitosis and anabolic reaction may be associated with higher signal intensities on CEST@2ppm and APTw MRI, which creates imaging contrast predominantly influenced by the presence of proteins.

CONCLUSION:

APTw and CEST@2ppm MRI results show that near PER had higher signals in tumor recurrence than treatment effects. It might relate to higher protein concentrations from local invasive tumor cells which promote invasion in the PER, thus shows promising potential to apply CEST MRI features as biomarkers for post-treatment GBM patients.

ACKNOWLEDGMENTS:

This work was supported in part by grants from the National Institutes of Health (R01CA228188, R01CA0276221 and R37CA248077). Thanks to Karisa C Schreck, David Kamson, Lindsay Blair, Jaishri O Blakeley, John Laterra, Matthias Holdhoff, Debraj Mukherjee, Chetan Bettegowda, and Peter van Zijl for their contribution.

REFERENCES:

1. Jiang S, *et al*. Clin Cancer Res 2018;1118-1233
2. Park J, *et al*. Eur Radiol 2018;28:3285-3295
3. Ma B, *et al.* J Magn Reson Imaging 2016;44:456-462
4. Meissner J, *et al.* J Magn Reson Imaging 2019;50:1268-1277