Influence of RF saturation parameters and CEST quantification metrics on human brain tumor contrast

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INTRODUCTION:

The choice of RF saturation parameters and CEST quantification metrics highly affects CEST tumor contrast. For example, APT signal intensities rely on the RF field strength (B_1) and preparation design, in terms of RF pulse shape, pulse number, and timing. In addition, inconsistent results have been recently reported by different research groups due to the choice of different CEST analysis methods[1-3]. The goal of this study is to evaluate the effect of RF saturation parameters and CEST calculation metrics on human brain tumors.

METHODS:

In vivo data was obtained from nine high-grade glioma patients. The study was approved by the IRB, and written consents were obtained from all participants before scanning. Twenty-two saturated images were acquired from +80 to -80 ppm with two B_1 values of 0.5, and 2 µT, saturation times (Ts) of 1 and 2 s, and relaxation delay times (Td) of 2.5 and 3.5 s. Several APT imaging calculation metrics, including MTR asymmetry-based APT-weighted (APTw) imaging[1], apparent exchange-dependent relaxation (AREX) imaging[2], and extrapolated semisolid magnetization transfer reference (EMR)-based $APT^{\#}$ imaging[3], were calculated and compared to evaluate brain tumor contrast.

RESULTS:

Figure 1A shows the dependence of the APTw and $APT^{\#}$ contrast on the RF saturation strength and duration, and relaxation delay time in brain tumors. The $APT^{\#}$ image provided higher tumor contrast (peritumoral edema) than conventional MTR asymmetry images, particularly at 2 µT. In the resection cavity, higher APTw signals were observed at 0.5 µT, but not at 2 µT. Figure 1B demonstrates APT contrasts obtained from different CEST quantification metrics. Overall APTw, $APT^{\#}$, and MTR_{Rex} of the tumor core (Gd-enhancement area) and peritumoral edema were higher than those of the normal tissue at 2 µT. However, the $APT^{\#}$ image at 2 µT was more sensitive for tumor core localization.

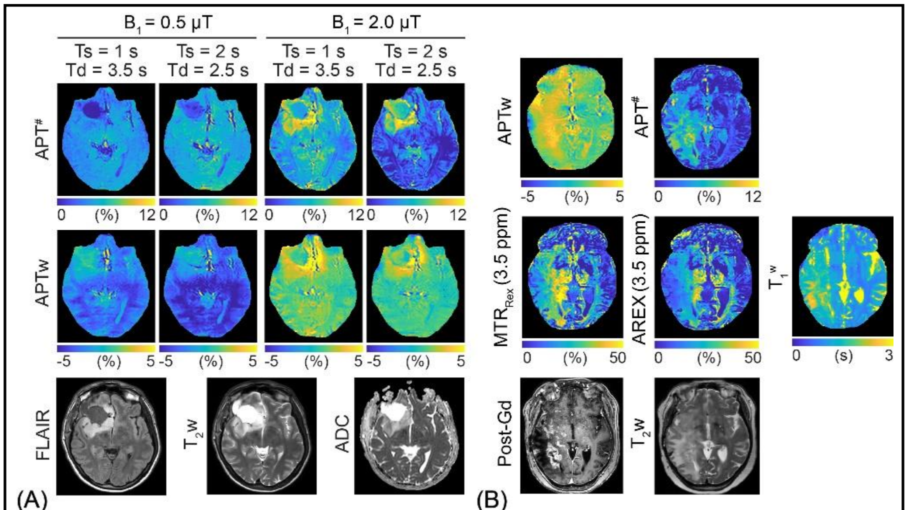

Figure 1. Different APT images from glioblastoma patients using various RF saturation parameters and analysis methods. (A) The RF saturation parameter dependence of the APTw and $APT^{\#}$ contrast in tumors. (2) The CEST quantification metric dependence of the APT contrast (B_1 = 2 µT, Ts = 2 s, Td = 2.5 s) in tumors.

DISCUSSION:

Brain tumor and peritumoral edema have longer T_1 relaxation times, which allow the saturated protons transferred to the free water pool to remain longer. Therefore, APT imaging may benefit from a longer water T_1 effect, particularly at low B_1. On the other hand, APT signals could be relatively insensitive to the T_1 effect at a higher B_1, presumably because higher water content in tumor extravascular-extracellular spaces leads to a reduction in saturation in Z-spectra and in APT saturation effects[4,5]. The AREX metric designed for water T_1 correction could be used at relatively lower B_1 strengths.

CONCLUSION:

The choice of CEST metric must be carefully considered according to RF saturation parameter settings, particularly B_1 field strengths.

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