

Multi-parameter MRI assessment of Glioma Response to Radiotherapy

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Target Audience: Scientists and clinicians in the field of oncology, particularly in neuro-oncology.

Purpose

Currently, various functional and molecular MR techniques are being investigated to accurately assess glioma response to therapy.¹⁻² This is crucial for patients who require either the use of additional anticancer therapies or the continuation of current therapy. Although promising, the results have been mixed. In this abstract, we quantitatively compare imaging features of radiated U87 tumors in rats, using a newly developed, protein-based amide proton transfer (APT) method³ and several other MRI modalities, including structural (T_2 and T_1), functional [apparent diffusion coefficient (ADC) and blood flow], and molecular [magnetization transfer (MT)] sequences.

Methods

Ten U87MG tumor-bearing rats, treated using a small animal radiation research platform (single dose, 40 Gy; 10×10 mm²), were scanned with a 4.7-T animal MRI system (slice thickness = 1.5 mm). An ADC map (single-shot trace diffusion weighting; TR = 3 s; TE = 80 ms; b-values = 0-1000s/mm²; NA = 8) was scanned. A CBF map was acquired using an arterial spin labeling (ASL) sequence, with 3-s labeling at a distance of 20 mm away from the imaging slice (TR = 6 s; TE = 28.6 ms; NA = 16). MT imaging and APT imaging were acquired, respectively, using offsets of 10 ppm and ± 3.5 ppm with respect to water (TR/TE = 10 s/30 ms; RF saturation power/time = 1.3 μ T/4 s; NA = 16). In addition, z-spectra were acquired over an offset range of ± 6 ppm with a resolution of 0.5 ppm to identify the specific APT effect.

Results and Discussion

There was a high APT signal at the offset of 3.5 ppm in the tumor baseline MTR_{asym} curve, compared to contralateral normal brain tissue (Fig. 1a-c), presumably due to a higher protein concentration in glioma.⁴ After radiation, the APT effect in tumor gradually decreased, while the contralateral APT effect almost stayed the same (Fig. 1a-d). This APT decrease in tumor may be caused by a decreased mobile protein level due to coagulative necrosis induced by radiation, as observed by H&E histology (not shown).

Quantitative multi-parametric MRI analysis showed that the average ADC signal intensities after radiation (Fig. 2c) increased significantly ($P < 0.05$), except at day 3 post-radiation. The tumor blood flow signals (showing large standard deviations; Fig. 2d) decreased at all time points, but not significantly ($P > 0.1$). The average APT signals intensities (Fig. 2f) decreased significantly at all time points post-radiation, 3 days ($P < 0.05$) and later ($P < 0.001$). There were not significant changes in T_1 , T_2 , and MTR for two earlier time points post-radiation. The results showed that ADC and APT signals were sensitive to the early tumor response to radiotherapy.

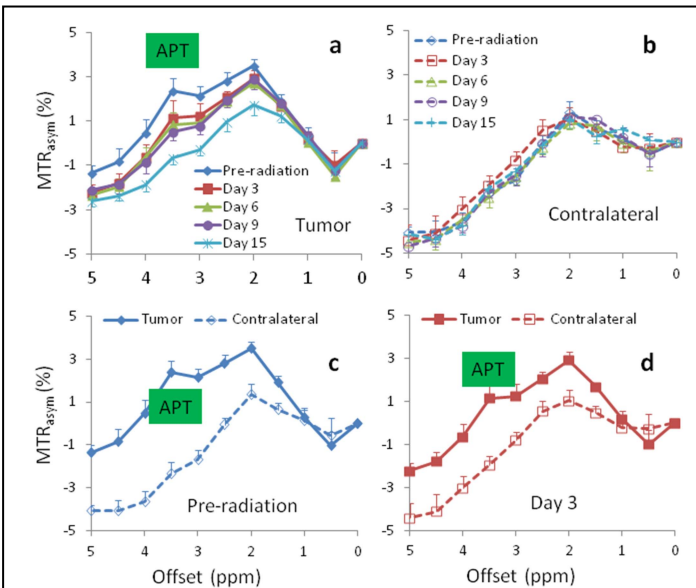


Fig. 1. MTR_{asym} spectra of tumor and contralateral normal brain tissue at pre-radiation and 3-15 days post-radiation.

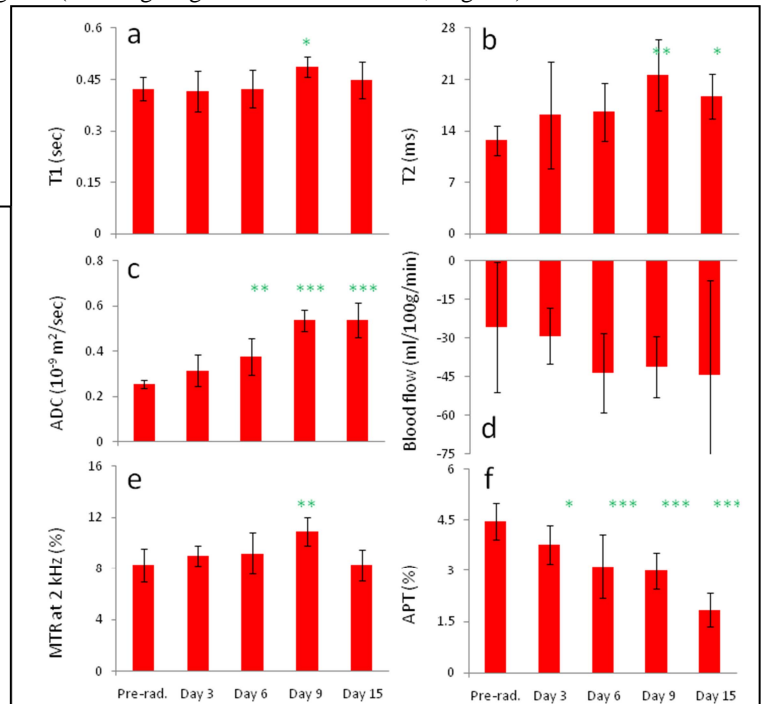


Fig. 2. Quantitative analysis of multi-parametric MRI signal intensities in tumor compared with contralateral normal brain tissue (tumor - contralateral). The statistical significance of the difference compared to pre-radiation: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; not marked = not significant.

Conclusion

The results showed that both ADC and APT can well assess glioma response to radiotherapy and APT-MRI may be a more sensitive biomarker for response assessment in this model.

References

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