Predicting High-Grade Glioma Response to Chemoradiation via MRI-Calibrated Mechanistic Models

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INTRODUCTION

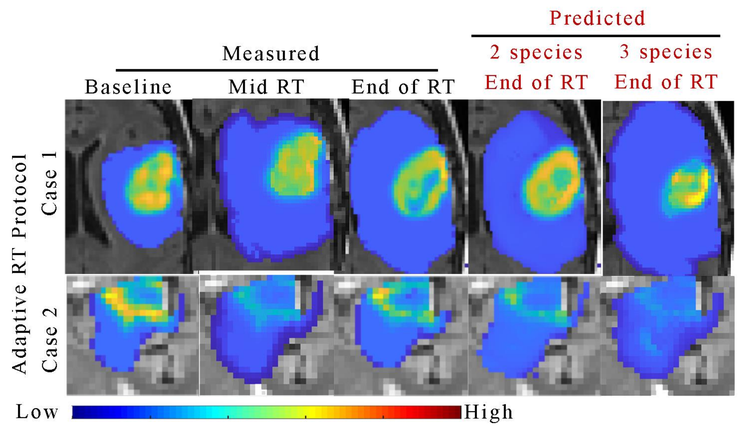
High-grade gliomas (HGG) are aggressive brain cancers that can progress during chemoradiation (CRT), resulting in underdosing of the tumor. While adaptive radiotherapy (RT) can **react** to tumor changes, **spatially-resolved predictions** of progression could enable **anticipatory** modifications of RT and improve tumor control.

AIM

We aim to create **personalized spatiotemporal forecasts** of HGG response to chemoradiation via a family of 60 **mechanism-based mathematical models** calibrated using serial multi-parametric magnetic resonance imaging (mpMRI).

RESULTS

- The 2 most parsimonious models described the enhancing and non-enhancing disease with (3-species) or without (2-species) vasculature dynamics, each with a spatially varying proliferation rate and the efficacy of RT coupled to perfusion
- Low percent errors in tumor volume were observed across both models
- High CCC values were observed for the 2-species model



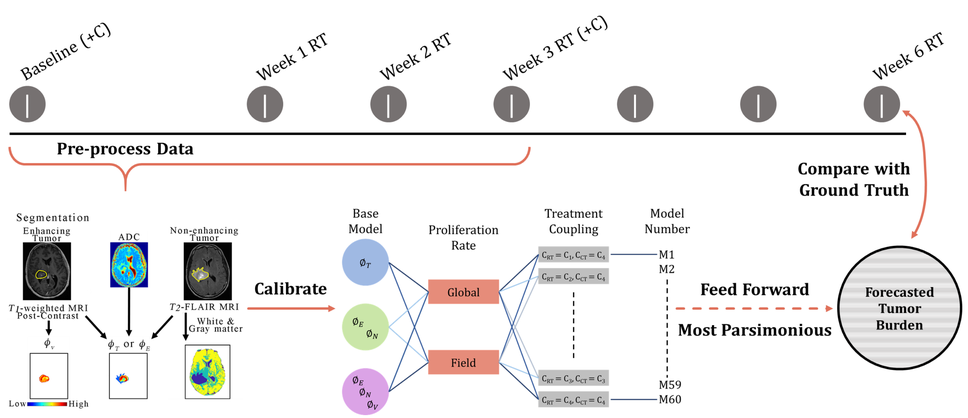
	Model	Percent error in tumor volume	Concordance correlation coefficient
Case 1	2-species	-2.4%	0.75
	3-species	7.4%	0.63
Case 2	2-species	12.1%	0.77
	3-species	-2.51%	0.61

CONCLUSIONS

- We observed good agreement on both the global (percent error in tumor volume) and local (CCC) levels
- This preliminary data demonstrates the plausibility of **spatially predicting HGG response to CRT**
- Future modifications, such as the inclusion of advanced perfusion imaging, should further inform spatiotemporal dynamics
- Accurate and reliable predictions may eventually enable **anticipatory, adaptive radiotherapy** and improve clinical outcomes

METHODS

- Serial mpMRI was acquired for 2 patients with HGG following surgical resection
- Tumor extent and physiological heterogeneity were assessed from baseline to week 3 of CRT
- Patient-specific model parameters were calibrated using imaging data for each variation of the 3D reaction-diffusion model
- The 2 most parsimonious models were selected using the Akaike information criteria and employed to forecast tumor response at the end of CRT
- Forecasts were compared to ground truth imaging data using percent error in tumor volume and concordance correlation coefficient (CCC)



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