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).

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)

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

<table>
<thead>
<tr>
<th>Model</th>
<th>Percent error in tumor volume</th>
<th>Concordance correlation coefficient</th>
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<tbody>
<tr>
<td>2-species</td>
<td>-2.4%</td>
<td>0.75</td>
</tr>
<tr>
<td>3-species</td>
<td>7.4%</td>
<td>0.63</td>
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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

REFERENCES

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