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Temporospatial tumor dynamic changes in glioblastoma during radiotherapy

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Abstract

Introduction: Glioblastoma (GBM) management post maximal-safe resection consists of concurrent chemoradiation (CRT) and adjuvant chemotherapy. MRIs are historically performed post-operatively and/or at treatment planning. Continuous interfractional changes during CRT have not been adequately characterized. MR-guided radiation therapy (MRgRT) allows for detailed imaging of tumor volumes during the course of treatment. This is a preliminary initial report evaluating temporal and spatial changes that occur in GBM, in order to model tumor dynamics.

Methods: Five GBM patients enrolled onto an institutional biorepository registry underwent treatment with our 0.35T MRgRT workflow. Target volumes were delineated based on T2/FLAIR (GTV_46Gy) and T1 gadolinium-enhanced MR (GTV_14Gy) sequences. Weekly post-contrast MRIs were performed during CRT with the 0.35T magnet to monitor target volume dynamics.

Results: Thirty-five MR scans were evaluated. The median time from surgery to CRT was 32 days (range: 28-40), with a median of 13 days (range: 12-14) from simulation to CRT. We found median volume reductions of 40.0% (range: 8.3-86.5%), and 37.1% (range: 15.0-67.5%) for GTV_46Gy and GTV_14Gy, respectively. The bulk of these changes occurred early, within the first 3 weeks of the 6-week treatment, with significant reductions observed between baseline and week 1 -32.6% for GTV_46Gy and 17.9% for GTV_14Gy. Separately, statistically significant volume reductions for the cavity volume ($F = 59.43$, $p < 0.05$) were observed. Compared to baseline, centroid migrations of the target volumes were also noted: the median GTV_46Gy centroid migration was 7.4 mm (range: 2.0-10.8 mm) and the median GTV_14Gy centroid migration was 3.6 mm (range: 1.3-8.8 mm).

Conclusions: Our pilot study suggests that weekly MRgRT imaging for GBM patients undergoing long course CRT reveals significant GTV reductions and centroid migrations, especially during the first 3 weeks of treatment. A more detailed understanding of which patients are at highest risk for tumor change and migration is needed to best apply these imaging parameters to clinical practice.

Keywords: Adaptive radiation therapy; Centroid migration; Chemoradiation; Glioblastoma; MR-Linac; MR-guided radiation therapy; Tumor volume dynamics.