MRI changes in newly diagnosed glioblastoma during treatment with chemoradiation and adjuvant temozolomide

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OBJECTIVE: Characterize anatomic and functional MRI changes in patients with newly diagnosed glioblastoma (nGBM) to more accurately measure impact of treatment

BACKGROUND: The standard of care for nGBM is maximal safe resection, six weeks of concurrent chemoradiation (CRT), followed by adjuvant monthly TMZ. FLAIR and T1 post-contrast sequences are frequently used to assess treatment response but poorly reflect underlying tumor behavior with respect to tumor cellularity, vascular permeability, and perfusion.

METHODS: Following IRB approval, patients with nGBM underwent MR imaging before treatment, during week 6 of CRT, four weeks post-CRT, and before cycle 2 of adjuvant TMZ (“pre-cycle 2”). We measured FLAIR and contrast-enhancing (CE) volumes, apparent diffusion coefficient (ADC; reflecting tumor cellularity), $K_{\text{trans}}$ (reflecting vascular permeability), and relative cerebral blood volume (rCBV) and flow (rCBF; reflecting perfusion) on spin echo (SE) and gradient echo (GE) sequences ($rCBV_{\text{SE}}$, $rCBF_{\text{SE}}$, $rCBV_{\text{GE}}$, $rCBF_{\text{GE}}$, respectively).

RESULTS: Eight patients were included. Percent changes during treatment were compared to pretreatment values. Within the CE region of interest (ROI), the respective median percent changes during CRT, post-CRT, and pre-cycle 2 were: CE volume 14.68%, 7.44%, 102.67%; ADC 24.78%, 38.11%, 28.64%; $K_{\text{trans}}$ 24.05%, 22.48%, -11.33%; $rCBV_{\text{SE}}$ -14.24%, -11.19%, -5.70%; $rCBF_{\text{SE}}$ -14.39%, -8.89%, -32.64%; $rCBV_{\text{GE}}$ -2.98%, -5.31%, -18.83%; and $rCBF_{\text{GE}}$ -13.10%, -3.48%, -17.33%. Within the peritumoral FLAIR ROI, the respective median percent changes during CRT, post-CRT, and pre-cycle 2 were: FLAIR volume 26.56%, 52.45%, 92.69%; ADC 8.09%, 15.22%, 12.10%; $K_{\text{trans}}$ 15.49%, -12.18%, -6.77%; $rCBV_{\text{SE}}$ -16.75%, -36.77%, -16.97%; $rCBF_{\text{SE}}$ -4.99%, -29.03%, -18.09%; $rCBV_{\text{GE}}$ 5.52%, -2.99%, -31.46%; and $rCBF_{\text{GE}}$ 19.75%, 3.71%, -29.82%.

CONCLUSIONS: Chemoradiation in nGBM results in decreased tumor cellularity; increased edema and permeability, likely related to inflammation in the tumor and peritumoral area; and decreased perfusion in small vessels. ADC, $K_{\text{trans}}$, and perfusion parameters may thus aid in evaluating treatment effects on tumor microenvironment and optimizing combination therapies.