OBJECTIVE: Recurrence of glioblastoma multiforme (GBM) arises from areas of microscopic tumor infiltration that have yet to disrupt the blood-brain barrier. We hypothesize that these microscopic foci of invasion cause subtle variations in the apparent diffusion coefficient (ADC) and FLAIR signal detectable with the use of computational big-data modeling.

MATERIALS AND METHODS: Twenty-six patients with native GBM were studied immediately after undergoing gross total tumor resection. Within the peritumoral region, areas of future GBM recurrence were identified through coregistration of follow-up MRI examinations. The likelihood of tumor recurrence at each individual voxel was assessed as a function of signal intensity on ADC maps and FLAIR images. Both single and combined multivariable logistic regression models were created.

RESULTS: A total of 419,473 voxels of data (105,477 voxels of data within tumor recurrence and 313,996 voxels of data on surrounding peritumoral edema) were analyzed. For future areas of recurrence, a 9.5% decrease in the ADC value ($p < 0.001$) and a 9.2% decrease in signal intensity on FLAIR images ($p < 0.001$) were shown, compared with findings for the surrounding peritumoral edema. Logistic regression revealed that the amount of signal loss on both ADC maps and FLAIR images correlated with the likelihood of tumor recurrence. A combined multiparametric logistic regression model was more specific in the prediction of tumor recurrence than was either single-variable model alone.

CONCLUSION: Areas of future GBM recurrence exhibit small but highly statistically significant differences in signal intensity on ADC maps and FLAIR images months before the development of abnormal enhancement occurs. A multiparametric logistic model calibrated to these changes can be used to estimate the burden of microscopic nonenhancing tumor and predict the location of recurrent disease. Computational big-data modeling performed at the voxel level is a powerful technique capable of discovering important but subtle patterns in imaging data.

KEYWORDS: DWI; computational modeling; glioblastoma multiforme; glioma recurrence; voxel-level analysis

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