Differentiation of Radiation Necrosis from Recurrent High Grade Glioma Using Multiparametric MRI

Kambiz Nael, James Knitter, Adam Bauer, William Erly, Michael Lemole, Baldassare Stea
Correspondence: Kambiznael@gmail.com

Purpose: Distinguishing radiation necrosis from tumor recurrence in the follow-up of adjuvantly treated high-grade gliomas (HGG) remains a diagnostic challenge. The purpose of this study was to evaluate diagnostic accuracy of multiparametric MRI using a combination of MR perfusion and diffusion biomarkers to differentiate recurrent HGG from radiation necrosis and to compare the results with surgical pathology.

Material and Methods: Inclusion criteria for this retrospective study were: 1) Patients with HGG who developed a new enhancing mass 4-6 months after completion of their standard treatment (gross total resection, radiation and temozolomide) with clinical question of recurrence vs. radiation necrosis. 2) Pre-operative MRI including DWI, dynamic contrast-enhanced (DCE) and DSC perfusion followed by surgical pathology to be used as gold standard. The arterial input function was selected automatically and multi-parametric perfusion maps were calculated using an extended toft model[1] for DCE and Bayesian probabilistic method[2] for DSC. Using coregistered images, voxel-based ADC, K^{trans} and rCBV values were obtained using volume-of-interest (VOI) analysis of the enhancing lesion. Data were analyzed by logistic regression and analysis of variance. Receiver operating characteristic (ROC) analysis was performed to determine the optimal parameter/s and threshold for prediction of recurrence vs. radiation necrosis.

Results: Fifteen patients had recurrent HGG and 7 patients had radiation necrosis confirmed by surgical pathology. The mean ± SD of imaging biomarkers for recurrent HGG vs. radiation necrosis were 4.5 ± 1.9 vs. 1.7 ± 0.4 for rCBV ($p<0.01$), 0.25 ± 0.13 vs. 0.14 ± 0.08 (1/min) for K^{trans} ($p=0.07$), 1125 ±

248 vs. 1398 ± 324 x 10^{-6} $mm^{2/s}$ for ADC (p=0.04). The results of ROC analysis including area under the curve (AUC), optimal threshold value and corresponding sensitivity/specificity of for imaging biomarkers to differentiate radiation necrosis from recurrent HGG are summarized in **Table 1**. The best discriminative power was obtained in from a combination of imaging biomarkers/threshold values of rCBV (1.89), K^{trans} (0.13 1/min) and ADC (853 x 10^{-6} $mm^{2/s}$) resulting in an AUC of 0.98 with sensitivity/specificity of 100/97%.

Conclusion: Multiparametric MRI using a combination of rCBV, K^{trans} and ADC can differentiate recurrence from radiation necrosis with an AUC of 0.98 superior to any individual or combination of other classifiers.

Table 1. ROC analysis for differentiation of radiation necrosis vs recurrent HGG using rCBV, ADC and K^{trans}

	AUC	Threshold	Sensitivity	Specificity
rCBV	0.91	2.47	88%	97%
ADC (10^{-6} $mm^{2/s)}$	0.74	1368.8	38%	85%
K^{trans} (1/min)	0.76	0.13	81%	71%

References:

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2. Boutelier T, Kudo K, Pautot F, Sasaki M. Bayesian hemodynamic parameter estimation by bolus tracking perfusion weighted imaging. *IEEE Trans Med Imaging.* Jul 2012;31(7):1381-1395.