Dynamic Contrast-Enhanced Perfusion MRI in Brain Gliomas: Correlation with Methionine Metabolism and Histopathology

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PURPOSE: To evaluate the relation between tumor regional cerebral blood volume (rCBV) maps determined by magnetic resonance (MR) imaging in gliomas, and both tumor histopathology, and tumor metabolism based on carbon-11 methionine (MET) uptake positron emission tomography (PET).

MATERIALS AND METHODS: The study included 19 patients who underwent a stereotactic biopsy for a mass lesion of the brain. Additionally to the stereotactic conventional MR sequences and stereotactic PET study used for the purpose of the biopsy planning, dynamic MR images including first-pass gadopentetate dimeglumine T2*-weighted echoplanar perfusion sequence were also obtained and rCBV maps were calculated. In 14 of 19 patients the PET study with MET was available. The rCBV ratios as well as the MET uptake ratios normalized to the contralateral white matter corresponding values were measured in each tumor. Both maximum rCBV ratios and maximum MET uptake ratios were correlated to the histopathologic grading and each histopathologic component of gliomas. The following histopathologic parameters were assessed in all the samples of each tumor: The vascularity index was assessed on a binary scale of 1 or 2, with 1 = no neoangiogenesis, 2 = presence of neoangiogenesis. Proliferative activity was assessed, based on Ki-67 labeling, on a scale of 1 to 4, with 1 = 0-1% of marked Ki-67-positive cells, 2 = 1-5% of Ki-67-positive cells, 3 = 5-10% of marked Ki-67-positive cells and 4 = more than 10% of marked Ki-67-poitive cells. Cellular atypia was scaled on a scale of 1 to 4 with 1 = absence of atypia, 2 = presence of a few scaltered cells with atypia, 3 = presence of foci of cells with atypia and 4 = presence of large areas with atypia. Endothelial hyperplasia and necrosis were both scaled on a binary scale (1 = absent and 2 = present). Those samples where the highest score was observed in each tumor have been considered for comparison.The maximum rCBV ratios were correlated to maximum MET uptake ratios.

RESULTS: Eleven patients had low grade (grades I and II) and 8 patients had high grade (grades III and IV) gliomas. Both maximum rCBV ratios and maximum MET uptake ratios of high grade gliomas were significantly higher than those of low grade gliomas ($P < 0.05$) (Table 1). Both maximum rCBV ratios and maximum MET uptake ratios were found to be related to vascularity index, proliferative activity and necrosis ($P < 0.05$). There was a significant correlation between maximum rCBV ratios and maximum MET uptake ratios (Graph 1).

CONCLUSION: Tumor vascularization and tumor metabolism are related in human gliomas and beside PET, MR-based rCBV maps are useful for the non invasive characterization and longitudinal monitoring of brain tumors.

Table 1: Correlation between tumor grades and mean values of max CBV ratios and max MET uptake ratios.

Tumor Grade	mCBV ratio ± SD (n)	mMET uptake ratio ± SD (n)
Low Grade	3.03 ± 1.16 (11)	3.08 ± 1.41 (8)
High Grade	4.51 ± 1.68 (8)	4.75 ± 1.07 (6)
P value	0.027	0.014

Graph 1: Spearman rank order correlation between max CBV ratios and max MET uptake ratios.
(r = 0.78, P = 0.001)