Solitary Metastases and High-grade Gliomas: Differentiation by Using Diffusion, Perfusion and Spectroscopic MR Imaging

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Synopsis: Our study is to investigate the role of relative cerebral volume (rCBV), apparent diffusion coefficient (ADC) and spectroscopic imaging in the differentiation of high-grade primary gliomas from solitary metastases using a 3.0-T MR unit. The results reveal statistically significant elevations in Choline-to-creatine (Cho/Cr) ratio and rCBV in the peritumoral regions for high-grade gliomas as well as higher ADC in tumor and peritumoral regions of metastases. Besides the peritumoral rCBV has highest specificity, the peritumoral Cho/Cr ratio on MR spectroscopy has highest accuracy and sensitivity in differentiation between the two tumor groups.

Introduction: Using diffusion, perfusion, spectroscopic MR imaging for evaluating intracranial tumors has been done (1, 2). However, the sensitivity, specificity and accuracy of these techniques have not been evaluated. The purpose of this study is to investigate the potential role of relative cerebral blood volume, apparent diffusion coefficients (ADC) and proton spectroscopic MR imaging in the differentiation of high-grade primary gliomas from solitary metastases on the basis of differences in vascularity, water self-diffusion and metabolite levels in the tumor and peritumoral regions.

Material and methods: In the prospective study between March 2002 and November 2002, using a 3.0-T MR unit, 12 perfusion MR studies (8 high-grade gliomas and 4 metastases) were performed in 26 patients with a solitary brain tumor (14 high-grade gliomas and 12 metastases). All the 26 patients also had proton MR spectroscopy, diffusion imaging and conventional MR imaging. Relative cerebral blood volumes (rCBV; mL/100g) from perfusion, ADC (x10^-9 m^2/sec) from diffusion and metabolite ratios on 2-D chemical-shift imaging (CSI) were measured in the contrast-enhancing tumor and peritumoral regions. The Student t test was used to determine if there was a statistically significant difference in rCBV, ADC and metabolite ratios between the two groups. A p value of less than 0.05 is considered to be statistically significant different. The cut values of rCBV in peritumoral, choline-to-creatine ratio (Cho/Cr) in peritumoral, ADC in tumor and ADC in peritumoral regions are 1.7, 0.5, 2 and 0.67, respectively.

Results and Discussion: Our main findings reveal statistically significant differences in the rCBV in peritumoral region (high-grade gliomas and metastases; 2.33 ± 1.61 [mean±SD] and 0.84±0.33 respectively, p<0.02), Cho/Cr ratio in peritumoral region (high-grade gliomas and metastases; 1.3 ± 0.45 and 0.29±0.51 respectively, p<0.02) (Fig 1 and 2), ADC in tumor regions (high-grade gliomas and metastases; 1.04 ± 0.42 and 1.87±0.73 respectively, p>0.02) and ADC in peritumoral regions (high-grade gliomas and metastases; 1.92 ± 0.50 and 2.41±0.33 respectively, p>0.05). The three diagnostic procedures are compared with the postoperative pathologic diagnoses and reveal the following results: peritumoral Cho/Cr: sensitivity 88 %, specificity 66 %, accuracy 83%; peritumoral rCBV: 66%, 75%, 72%, peritumoral ADC: 85%, 70%, 76% and tumor ADC: 83%, 71%, 77%. Thus the peritumoral Cho/Cr has the highest sensitivity and accuracy while the peritumoral rCBV has the highest specificity compared with the other parameters. The intratumoral rCBV, Cho/Cr, NAA/Cr and peritumoral NAA/Cr ratio in high-grade gliomas do not significantly differ from those seen with metastases. The elevated Cho/Cr ratios were found in the peritumoral regions of high-grade gliomas in keeping with tumor infiltration. No increase in the Cho/Cr ratios was found in the peritumoral region of metastases, which suggests vasogenic edema (3). The rCBV value within the peritumoral region in high-grade gliomas was elevated, which suggests increased perfusion due to tumor infiltration. The low rCBV values surrounding metastases were due to compression of capillaries by vasogenic edema (4). Furthermore, the ADC in peritumoral region surrounding metastases is higher than the ADC in perinormal region around high-grade gliomas, which suggest more fluid production. The ADC in tumoral regions in metastases is higher than the ADC in tumoral regions in high-grade gliomas due to increased intracellular and extracellular water fractions (5).

Conclusion: The peritumoral Cho/Cr ratio has the highest accuracy, sensitivity and peritumoral rCBV has the highest specificity for noninvasive differentiation between the two disease groups. The tumoral ADC and peritumoral ADC values are complementary techniques in the distinction between the two groups.

References:
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Figure 1. A 54-year-old male patient with pathologic proven glioblastoma multiforme having a voxel of interest on the peritumoral region (arrow). The spectrum shows significant elevation of the Cho/Cr ratio to 1.5.

Figure 2. A 55-year-old female patient with a metastatic tumor having a voxel of interest on the peritumoral region (arrow). The spectrum shows no significant elevation of the Cho/Cr ratio.