Glioma Grading by Proton MR Spectroscopy: a Comparison with Perfusion-weighted MR imaging

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Introduction

Magnetic resonance (MR) images can reveal the diffuse neoplastic proliferation of glial cells while preserving anatomical architecture. The degree of enhancement due to the absence of a normal blood-brain barrier function is a useful clue in radiological grading of gliomas; however, glioblastoma multiforme (GBM) does not always generate contrast enhancement. On the other hand, some low-grade gliomas demonstrate strong enhancement. Therefore, the degree of enhancement does not always reflect the grade of the glioma. Perfusion-weighted MR imaging (PW-MRI), which focuses on the microcirculation of the tumor, is more useful in predicting glioma grade (1-3). Proton MR spectroscopy (MRS), which focuses on the metabolic environment of the tumor, may also be useful in predicting glioma grade (4, 5). Since a metabolically aggressive malignant tumor is likely to be supported by a larger blood supply than a dormant tumor, we hypothesized that the indexes from MRS and PW-MRI should correlate according to tumor aggressiveness.

In this study, our aim was to compare the choline level of gliomas estimated by proton MRS with tumor blood volume information provided by PW-MRI, and to confirm that the choline level is related to the blood volume obtained from the same tumor location.

Methods

Thirteen consecutive patients (4 men and 9 women, aged 16-77 years) with gliomas were investigated. For proton MRS, single-voxel spectra were acquired using the point-resolved spectroscopic pulse (PRESS) sequence (TR/TE=2000/136 ms, NEX=128, 20x20x20 mm^3 voxel) using a 1.5 T MR system. Voxels of interest were located in the solid portion of the tumors. For quantitative analysis, the choline level was estimated by LCModel (S-Provencher, V6.02). For the perfusion study, we used a gradient-echo EPI sequence (TR/TE: 1849/42 ms, flip angle: 20 degrees, matrix: 64 x 64, FOV: 22 x 22 cm, slice thickness: 7 mm, number of slices: 7). After the bolus administration of Gd-DTPA, a dynamic series of EPI images was obtained at 2-s intervals for approximately 2 min. From the PW-MRI data, blood volume maps were generated for each subject. For quantitative analysis, blood volume was measured in the corresponding ROI in MRS. The blood volume was normalized by the volume of the reference tissue (contra-lateral white matter) to generate an index of tumor vascularity. We compared tumor blood volume with the choline level. In all patients, the presence of gliomas was histologically verified by surgical resection or needle biopsy after MR studies.

Results

Eleven cases were diagnosed as WHO grade II, and 2 cases were diagnosed as grade III. The tumor blood volume calculated by PWI ranged from 0.77 to 6.30 (2.25 ± 1.39: means ± SD). The choline level ranged from 2.41 to 7.15 (3.80 ± 1.31). The correlation between tumor blood volume and choline level was statistically significant as shown in Figure 1 (r^2=0.74, P<0.005). A representative set of data, including MR spectrum, perfusion map and anatomical post-Gd T1-weighted images in a patient with glioma are shown in Figure 2. In this case, increased tumor blood volume, an enhanced choline peak and the lack of a lactate peak are visually apparent.

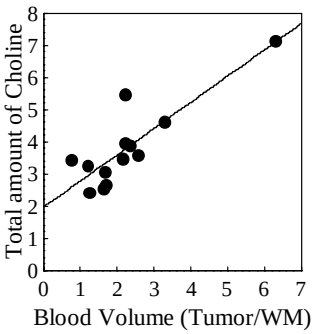
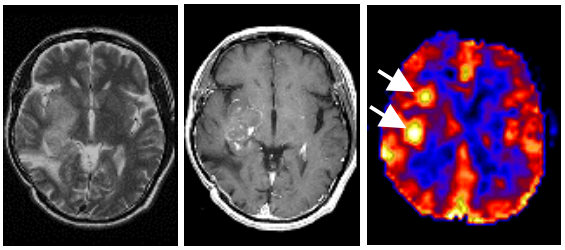


Fig 1. Scatter plot of tumor blood volumes versus choline levels. Tumor blood volumes show a significant correlation with choline levels (r^2=0.74, P<0.005).



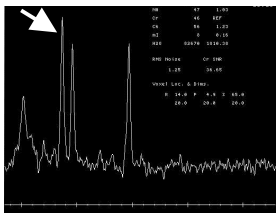


Fig 2. 55 yrs female. Grade II glioma case. T2-weighted image (top left), contrast-enhanced T1-weighted image (top middle), corresponding blood volume map (top right), and MR spectroscopic data (bottom left). Note that increased tumor blood volume (white arrows), an enhanced choline peak (white arrow) and the lack of a lactate peak are all apparent.

Discussion and Conclusion

Choline is a metabolite of phosphatide, which relates to cell membrane metabolism. Since an increased choline level may indicate the breakdown or enhancement of cell membrane metabolism, choline may be a useful index of malignancy in conjunction with proliferation potency and the cell density of neoplastic cells. The current study has demonstrated a significant correlation between choline levels and tumor blood volumes, findings that are very consistent with previous reports about the usefulness in tumor grading using MRS and T2*DSC, respectively.

Although our number of patients was limited, we could tentatively conclude that both MRS and tumor blood volume indexes may be consistently useful for glioma tumor grading and may provide more precise information when used in conjunction with each other.

References

1. Sugahara T, et al. AJR 1998; 171:1479.
2. Knopp EA, et al. Radiology 1999; 211: 791.
3. Uematsu H, et al. AJNR 2001; 22: 1915.
4. Meyerand ME, et al. AJNR 1999; 20:117.
5. Law M, et al. AJNR 2003; 24: 1989.