Differentiation of Low from High Grade Oligodendrogliomas by 1H Magnetic Resonance Spectroscopy Imaging and Perfusion Weighted Imaging

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Introduction

Oligodendrogliomas have genetic and physiological characteristics that are different from other gliomas and are classified as low-grade [Grade II] and high-grade [Grade III] neoplasms based on vascular proliferation, mitosis, and necrosis[1]. Non-invasive determination of histologic grade of these tumors may be useful for prognosis and treatment planning.[1] Perfusion weighted imaging (PWI) and ^{1}H magnetic resonance spectroscopy imaging (MRSI) provide functional and metabolic information that might assist in noninvasive grading of gliomas.[2,3] However, the success of dynamic contrast-enhanced and continuous arterial spin labeling (CASL) perfusion techniques to predict tumor grade of oligodendrogliomas has been limited.[4,5] The purpose of this study was to ascertain whether the combined use of CASL and ^{1}H MRSI can characterize the two grades of oligodendrogliomas.

Materials and Methods

In this retrospective study, eleven patients (7M/4F, 19-65 years) with histopathologically confirmed oligodendrogliomas (6 Grade II, 5 Grade III) underwent magnetic resonance imaging (MRI). MRI was performed on all subjects using a 3T MR scanner equipped with a standard clinical quadrature head coil. MRI protocol included routine anatomical imaging, CASL (TR/TE 4000/17) with 12 contiguous axial sections and a post-labeling delay of 1200 ms. ^{1}H MRSI was performed using a spin echo sequence with 2D phase encoding and outer volume saturation pulses for lipid suppression (TR 1700ms, TE 30ms, n=3, 20mm slice thickness, FOV 20x20cm, voxel size 12.5 x 12.5 x 20 mm). Cerebral blood flow (CBF) maps were generated using IDL software and were co-registered with T1-weighted MPRAGE images using statistical parametric mapping software. Mean and standard deviation of CBF measurements were measured in various regions of interest (ROIs) placed in normal white matter (NWM). Different portions of the tumors were then categorized as hyper-perfused if average CBF was more than 1 standard deviation (25.65 ml/100g/minute), hypo-perfused if less than one standard deviation (20.75) or iso-perfused if CBF was within one standard deviation of the mean value of CBF in NWM (20.75-25.65). While drawing the ROIs, care was taken to exclude the areas of blood vessels, hemorrhage and cerebrospinal fluid. Average CBF from different solid parts of the tumor were normalized to the contralateral WM and reported as $CBF_{T/W}$. ^{1}H MRSI data were analyzed similarly from voxels that encompassed the regions used for the CBF analysis. Absolute concentrations of metabolites were measured using the LC Model software and the data were normalized to contralateral WM.

Results

The results are summarized in Table 1. It was not possible to separate high-grade from low-grade oligodendrogliomas based on the $CBF_{T/W}$ values alone ($p > 0.05$). However, on MRSI $Cho_{T/W}$ and $Lip/Lac_{T/W}$ were significantly higher in hyper-perfused grade III oligodendrogliomas compared to grade II ($p < 0.05$, Fig1). There was no significant difference in other metabolites between the two grades in the hyper-perfused areas. The metabolite ratios from the hypo-perfused or iso-perfused regions also did not exhibit any significant differences between the two groups.

Table1: CBF and metabolite ratios from different regions of oligodendrogliomas

Tumor Regions	Grade II			Grade III		
	$CBF_{T/W}$	$Cho_{T/W}$	$Lip/Lac_{T/W}$	$CBF_{T/W}$	$Cho_{T/W}$	$Lip/Lac_{T/W}$
Hyper-perfused	1.83 ± 0.66	1.25 ± 0.25	4.03 ± 1.23	2.08 ± 0.63	2.06 ± 0.58*	6.02 ± 0.91*
Hypo-perfused	0.61 ± 0.15	1.35 ± 0.21	3.2 ± 0.65	0.69 ± 0.19	1.68 ± 0.42	3.51 ± 0.76
Iso-perfused	0.85 ± 0.22	1. 60 ± 0.34	1.82 ± 0.31	0.94 ± 0.24	1.63 ± 0.38	2.44 ± 0.44

*Significantly higher ($p<0.05$) compared to Grade II

Discussion and Conclusion

Our preliminary results are consistent with the literature reports in that perfusion MRI alone cannot reliably differentiate between low and high-grade oligodendrogliomas[4, 5]. Increased Cho in high-grade oligodendrogliomas may reflect neoplastic cell membrane synthesis[6] while apoptosis, microscopic cellular necrosis and cell proliferation may all contribute to accumulation of lipids[6] As a substantial overlap of metabolite ratios was observed from hypo- and iso-perfused areas of the tumors, it seems that restricting the analysis of ^{1}H MRSI, to the hyper-perfused regions of these tumors may be helpful in distinguishing low from high-grade oligodendrogliomas.

References

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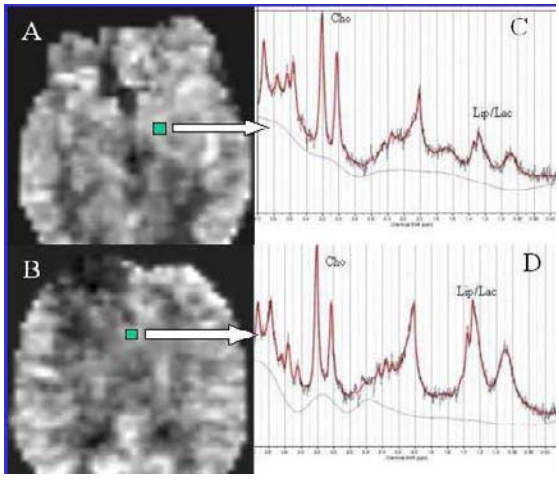

Figure 1: CBF maps of representative case from Grade II (A) and Grade III (B) oligodendroglioma showing the voxels analyzed from the hyper-perfused region. C and D are the proton spectra from these voxels exhibiting the various metabolites.