DISCRIMINATION BETWEEN TUMOR-INFILTRATION AND VASOGENIC EDEMA USING NON-GAUSSIAN DIFFUSION MRI TECHNOQUES: PRELIMINARY EXPERIENCE

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Target audience: neurologist, neurosurgeon, and those interested in q-space imaging

Purpose: Prior studies have applied DTI to distinguish tumor infiltration from vasogenic edema in the peritumoral region of brain tumors[1]. This study aimed to investigate the utility of advanced diffusion MRI techniques including diffusional kurtosis imaging (DKI) and neurite orientation dispersion and density imaging (NODDI)[2], for observation of microstructural changes within the peritumoral region.

Methods: 6 patients (glioblastoma multiforme 2, meningioma 3, metastatic tumor 1) were involved. Multi-b value diffusion MRI data were obtained with Siemens 1.5T scanner (spin echo EPI; b=0,1000, 2000s/mm^2; 30 MPG directions; 3mm iso-voxel; δ/Δ=32.7/37.4ms; TR/TE=5000/88.0ms; acquisition matrix=86×86; 50 axial sections; GRAPPA factor=2; acquisition time=320sec). FA, ADC, mean kurtosis (MK), orientation dispersion index (ODI), intracellular volume fraction (Vic), and isotropic volume fraction (Viso), were calculated (Fig.1). VOIs were placed manually to contain the whole peritumoral region, defined as the region outside the enhancing portion of the tumor with high signal intensity on T2WI. The diffusion metrics from every voxel within the VOIs were plotted on scatter diagrams (voxel-by-voxel), to compare the microstructural characteristics of peritumoral region of glioblastoma with the other tumors. The six diffusion metrics were ranked regarding to their importance for discriminating glioblastoma from the other tumors, using the ReliefF algorithm. Quadratic discriminant analyses were performed using the selected diffusion metrics.

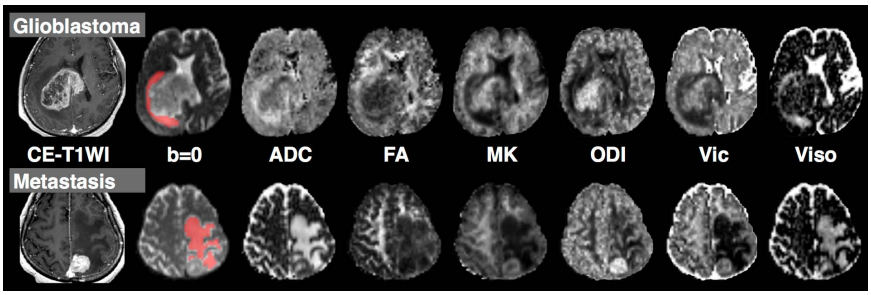

Fig.1. Representative maps of the diffusion metrics in glioblastoma and metastasis. The VOI (red) was placed to contain the peritumoral non-enhanced T2WI hyperintense area.

Results: On the scattered plot, peritumoral region of glioblastoma seemed to behave differently from the pure vasogenic edema in other tumors (Fig. 2). The peritumoral region of glioblastoma tended to show lower ADC. Among the six diffusion metrics, ADC and FA were identified as top 2 discriminating factors, followed by Viso, ODI, Vic, and MK. Discriminant analyses using ADC and FA demonstrated accurate classification in 83.6% of the voxels. The accuracy increased to 90.0% when the NODDI parameters were added. Interestingly, correct classification rate for glioblastoma slightly decreased (from 87.2% to 82.8%), while it markedly increased for vasogenic edema (from 79.7% to 96.4%), when the NODDI parameters were added.

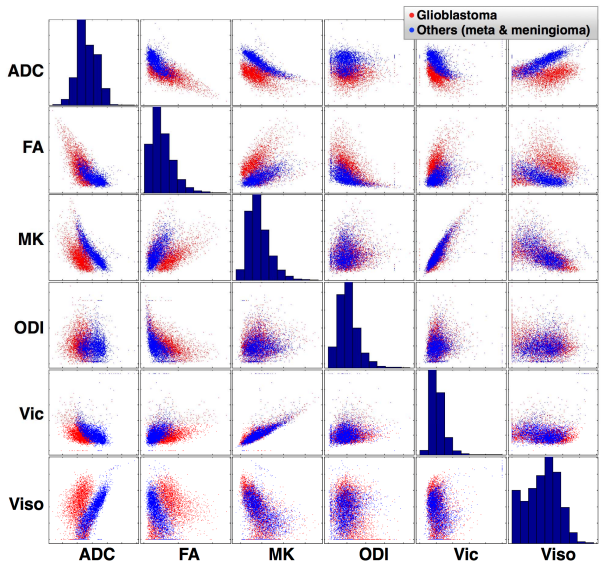

Fig.2. Scattered diagrams of diffusion metrics. ADC and FA shows excellent discrimination on visual inspection.

Discussion: Our results suggest that combination of diffusion MRI metrics can demonstrate differences between tumor infiltration and pure vasogenic edema. Contrary to our expectations, ADC and FA were still more important discriminating factors than NODDI parameters. However, addition of NODDI parameters seemed to improve the specificity for tumor infiltration.

Conclusion: Combination of diffusion MRI metrics appears to be a promising tool for evaluation of the peritumoral region. NODDI parameters can provide additional information to DTI, and may hopefully differentiate the highly-infilatrated area from less- or non-infiltrated area in the future.

References

1. Sternberg EJ, et al. Utility of diffusion tensor imaging in evaluation of the peritumoral region in patients with primary and metastatic brain tumors. AJNR Am J Neuroradiol. 2014;35(3):439-44.

2. Zhang H, et al. NODDI: practical in vivo neurite orientation dispersion and density imaging of the human brain. Neuroimage. 2012;61(4):1000-16.