Classification of tumor components based on DCE and DSC data in patients with glioblastoma

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TARGET AUDIENCE: Scientists and clinicians with an interest in perfusion imaging, multi-parametric classification methods, and therapy response assessment in brain tumors.

PURPOSE:

Antiangiogenic therapies (such as bevacizumab) used for the treatment of patients with glioblastoma (GB), may be associated with a marked reduction in tumor enhancement, yet this change does not necessarily represent an anti-tumoral effect [1,2]. Accurate tumor area classification is thus important for therapy response assessment in these patients. The aim of this study was to classify the tumor area in patients with GB based on dynamic susceptibility contrast (DSC) and dynamic contrast enhancement (DCE) MRI, focusing on the differentiation between permeable tumor area, infiltrative tumor and vasogenic edema components.

METHODS:

Sixteen data sets obtained from eleven GB patients (58±16 years) were included. Five patients were scanned longitudinally, before and 8 weeks following bevacizumab therapy. MR scans were performed on a 3T MRI and included post contrast T_1WI (PCT_1WI), FLAIR, DSC, DCE imaging and MR-spectroscopy (MRS). Image analysis included preprocessing and identification of lesion area (tumor and edema), i.e. areas with abnormal signal on the FLAIR and/or PCT_1WI images, excluding areas of tissue necrosis. To control for intra-subject variability, the signal intensity of the raw DSC and DCE data was normalized relative to the (1) pre-injection images and (2) normal appearing white matter (NAWM) in each data set. Classification of tumor area was performed using *k*-means algorithm. The input data was the concatenated normalized DCE and DSC raw data, and the number of clusters (*k*) set to 4 following optimization. Validation of the classification results was performed using MRS. To evaluate the applicability for clinical use, individual patient basis *k*-mean classification was performed with the obtained clusters centroid vectors serving as starting locations for the tumor classification. Intra class correlations were used to assess classification results of the supervised method, in each patient and for each cluster.

RESULTS AND DISCUSSION:

Classification results: The obtained clusters were classified into 3 tissue types based on their MR signature relative to NAWM (Fig. 1): Permeable tumor area - *PermT* (C1+C2, red)= tumor area with high permeability and high perfusion; Infiltrative tumor area - *InfT* (C3, orange)= area with mild (<10%) permeability and high perfusion, and Vasogenic edema - *VasoE* (C4, green)= area without permeability and with low perfusion[3,4].

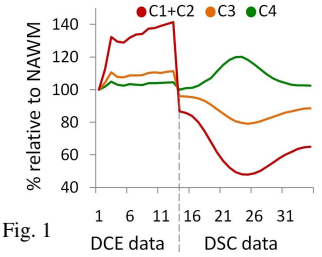

Fig. 1

Validation of segmentation results: Cho/Cr ratio differed significantly (p<0.05) between the three tissue types: *PermT* (C1+C2): 2.34±0.56; *InfT* (C3): 1.71±0.26; *VasoE* (C4): 1.17±0.14.

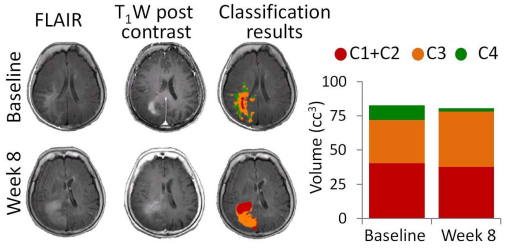

Fig. 2

Assessment of therapy response: Eight weeks following bevacizumab initiation, a decrease in total tumor volume was detected in all subjects. This reduction was mainly attributed to the decrease of the *VasoE* component detected in all five subjects (range 30-92%). The *PermT* component was not changed in 4/5 patients, and was decreased in one patient, while the *InfT* was not changed in other 4/5 patients, and increased in one patient.

Representative data of the classification results is given in Fig. 2. A negative correlation was detected between progression-free survival (PFS) time and changes in the volume of *PermT* and *InfT* components (n=5).

Comparison between unsupervised and supervised classifications: Significantly high correlation was detected between the two methods (r=0.82, p<0.001) with average symmetric RMS surface distance=1.9±1.6mm, absolute relative volume difference=32.7±21.8%, and volumetric overlap error=41.4±19.2%. Representative results in one patient are presented in Fig. 3.

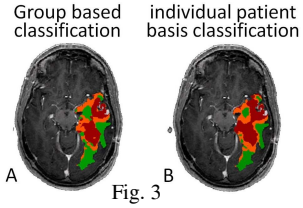

Fig. 3

CONCLUSION:

In this study, tumor classification was performed based on vascular tissue properties, in the temporal domain. Results obtained in patients with GB suggest a non-enhancing tumor progression pattern following bevacizumab therapy, in line with previous reports[1,5-6]. The applicability of this method on an individual patient basis, demonstrates the potential of this method to be integrated in the clinic and to improve therapy response assessment in patients with GB.

REFERENCES: [1]Pope et al. AJNR 2011; [2]Norden et al Neurology 2008; 2001; [3]Kaal et al. Curr Opin Oncol. 2004; [4]Al-Okaili et al. Radiology. 2007; [5]Wen et al. J Clin Oncol 2010; [6]de Groot et al. Neuro Oncol 2010.