MULTIPARAMETRIC CLASSIFICATION OF HYPEROXIA CHALLENGE AND DYNAMIC SUSCEPTIBILITY CONTRAST MAPS: STUDY OF THE HEALTHY BRAIN

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Background / Aims:

Blood oxygenation level-dependent (BOLD) contrast and dynamic susceptibility contrast (DSC) imaging are commonly used to evaluate brain hemodynamics. BOLD contrast can be obtained using hyperoxia challenge, that affects both tissue oxygenation and blood flow[1]. Percent signal change (ΔS) maps can be calculated from this data. In DSC imaging, gadolinium is injected, and a time series of T_2 / T_2*-weighted images is acquired[2]. Kinetic analysis of the DSC data yields several hemodynamic maps such as blood volume and flow (CBV/CBF), mean transit time (MTT) and time to peak (TTP). ***The aim*** of this study was to use unsupervised multimodal classification on a combined data of hyperoxia challenge and DSC imaging, in order to characterize brain tissue vascularity, regional differences between brain lobes and between brain hemispheres in healthy subjects.

Methods:

Subjects and Scan parameters: Eight healthy subjects were included (four females, 28±4 years old). MRI scans were performed on a 3.0T GE scanner. Hyperoxia challenge was applied using T_2* gradient echo-EPI sequence, in a block design paradigm, during which subjects inhaled carbogen (95% O_2, 5% CO_2) through an oxygen mask, with room air at baseline. The DSC images were acquired using a T_2* gradient echo-EPI sequence, during the injection of a double dose, 0.4ml/Kg Gd-DOTA.

Data analysis was performed using SPM5[3] and FSL[4] software. *Hyperoxia challenge* - preprocessing included slice timing and motion corrections. A statistical mask ($p \leq 0.05$) was calculated using a first-level GLM analysis. ΔS maps were calculated only for voxels which passed the statistical threshold. *DSC data* - CBV, CBF, MTT, TTP maps were calculated using the Perfusion graphical user interface software[5]. Signal recovery (SR) maps were calculated using FSL. All calculated maps underwent 3mm smoothing and normalization into the MNI space. A *KMeans*, unsupervised multimodal clustering method (with k=3), was applied for each subject using the FSL automated segmentation tool[6]. CBV, CBF, SR and ΔS maps were used as input data. Volumes of interest (VOI) were defined based on the MNI templates: the right and left hemispheres, and four brain lobes (excluding the cerebellum). The defined VOIs were farther masked by the obtained clusters. Mean and standard deviation values were calculated for all indices for each defined VOI. Mean values of CBV and CBF were calculated relative to the entire brain (rCBV and rCBF).

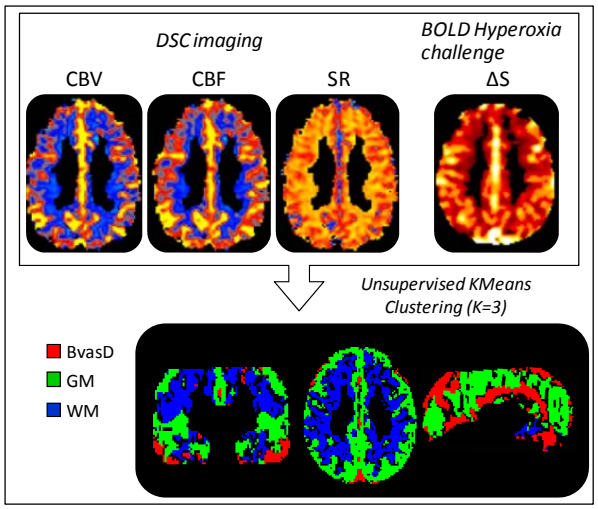

Figure 1. Stream line of data classification

Results and Discussion:

Brain clusters: The results obtained after tissue classification are presented in Figure 1. The three clusters were classified as major blood vessels & dura (BvasD, red), gray matter (GM, green) and white matter (WM, blue), approved by a senior neuro-radiologist. Means and standard deviations of the hemodynamic indices obtained in the three clusters are given in Table 1. GM/WM ratio was higher for the ΔS relative to the DSC data sets: $\Delta S_{GM/WM}$=2.62, $rCBV_{GM/WM}$=2.16 $rCBF_{GM/WM}$=2.09. No significant differences were detected between the GM and WM for the MTT and TTP values.

Hemodynamic index		BvasD	GM	WM
DSC	$rCBV^{*}$ relative units	1.84±0.10	1.14±0.06	0.53±0.02
	$rCBF^{*}$ relative units	1.44±0.11	1.22±0.06	0.58±0.02
	MTT^{+} sec	8.09±1.56	5.5±1.02	5.60±1.22
	TTP sec	10.5±1.37	9.54±0.95	10.16±1.05
	SR^{*} %	72±3	87±2	94±1
BOLD	ΔS^{*} %	7.51±1.45	2.98±0.49	1.14±0.26

Table1. Significant ($p \leq 0.001$) between all clusters(*); between the BvasD to the GM and WM(+)

Brain lobe differences: Significantly ($p<0.001$) longer TTP values were found in the occipital lobe (10.05±1.05sec) relative to all other lobes (range 9.34-9.52sec). Significant differences between brain lobes were detected for the rCBV and rCBF with: Temporal > Occipital > Frontal/Parietal.

Brain hemisphere asymmetry: A trend of higher vascularity was detected in the GM of the right versus left hemispheres, in the rCBV (p=0.05) and ΔS (p=0.06).

Conclusion:

In this study we integrated several hemodynamic parameters obtained from two independent methods in order to study the vascular properties of the healthy brain. This combination of methods provides comprehensive knowledge which may be used by future studies to improve characterization of the hemodynamic features of the healthy and pathological brain.

References: [1]Losert et al. MRM 2002, [2]Ostergaard et al. Magn Reson Imaging 2005, [3]www.fil.ion.ucl.ac.uk/spm/software/spm5, [4]www.fmrib.ox.ac.uk/fsl, [5]PENGUIN: www.cfin.au.dk/software,[6]Zhang Y et al. IEEE Trans Med Imaging 2001