Quantification of Cerebral Perfusion Parameters in Glioblastomas using Independent Component Analysis as a Pre-processing Step.

M-E. CHAND[1], K. BOULANOUAR[1], I. BERRY[2], E. CASSOL[2], E. COHEN-JONATHAN[3], P. CELSIS[1]

[1]Unit 455, INSERM, Toulouse, France, [2]Neuroradiology, CHU Toulouse, Toulouse, France, [3]INStitut Cladius Regaud, Toulouse, France

INTRODUCTION:

Dynamic Susceptibility Contrast-enhanced Magnetic Resonance Imaging (DSC-MRI) is a performing technique in measuring functional parameters of tissue microcirculation, and thus in evaluating tumour angiogenesis. The crucial point is the determination of the Arterial Input Function (AIF), which is necessary for the absolute quantification of perfusion parameters, that conveys more information than the semi-quantitative approaches (1). We considered the case of glioblastomas characterized by their heterogeneous composition and a significant increase of the regional cerebral blood volume. We applied Independent Component Analysis (ICA) to the perfusion-weighted images to obtain both the AIF and the segmentation of the cancerous mass.

MATERIALS AND METHODS:

Our study concerned six DSC-MRI data from patients aged 60-69 (mean, 65 years), with non-operable glioblastomas. We used a conventional 1.5-T MR system (Magnetom Vision; Siemens, Erlangen, Germany) to obtain gradient-echo susceptibility weighted echo-planar imaging sequences. A bolus of Gd-DTPA (0.2mmol/kg) was delivered by a prototype MR-compatible power injector.

We used the fixed-point algorithm (4) for ICA calculation to derive 15 spatially independent images from the initial 34. In every patient, one of the components revealed the brain vessels (fig. 1). The AIF was selected from this component, according to the admitted criteria of maximum height and minimum Full Width Half Maximum (FWHM).

Then, we defined four multislice ROIs in each patient:

- normal regions on the T1-weighted basis: White Matter (WM) in corona radiate and Grey Matter (GM) in basal ganglia.
- tumoral regions according to the segmentation provided by the ICA (fig. 2)
  - * tumoral regions presumed active (AR): areas of positive ICA values,
  - * tumoral regions presumed necrotic (NR): areas of negative ICA values.

In each ROI, we calculated the three-perfusion parameters: Mean Transit Time (MTT), Cerebral Blood Volume (CBV) and Cerebral Blood Flow (CBF) on a pixel-by-pixel basis using the indicator dilution theory (2,3) and the AIF derived from the vessel component.

RESULTS-DISCUSSION:

The absolute values obtained are in agreement with the published data, except for the CBF that is overestimated. We found high values of MTT,CBV and CBF for the "active regions" whereas the "necrotic regions" had the lowest values (table 1), showing the heterogeneity of these tumours. To assess the significance of the differences between the 4 regions, we used an ANOVA analysis followed by post hoc PLSD Fisher test. We found, highly significant differences between "active regions" and "necrotic regions", and between these pathological regions and the normal ones (table 2). MTT and CBV are the most discriminating parameters.. These results suggest the physiological relevance of the segmentation provided by ICA for such heterogeneous tumors. Thus, ICA could improve the role of DSC-MRI at every step of the patient care: first evaluation of the tumor type, guidance of stereotactic biopsy (to reach the most active part of the tumor) and monitoring of the effectiveness of treatment, particularly new anti-angiogenic drugs.

	MTT (s)	CBV (ml/100g)	CBF (ml/100g/mn)
WM	5,36 ± 1,1	3,87 ± 0,4	47,18 ± 12,1
GM	5,07 ± 1	8,97 ± 1,3	115,28 ± 33,7
AR	11,51 ± 2,8	15,94 ± 4,0	92,01 ± 27,8
NR	6,92 ± 1,5	6,25 ± 2,5	65,33 ± 37,2

Table 1: Mean values and standard deviation (average on patients).
WM= White Matter GM= Gray Matter
AR= Active Region in the tumor NR= Necrotic Region.

	MTT	CBV	CBF
WM / AR	0,0018 *	0,0002 *	0,0024 *
WM / NR	0,047 *	0,029 *	0,24
GM / AR	<0,0001 *	0,017 *	0,26
GM / NR	0,018 *	0,026 *	0,022 *
AR / NR	0,026 *	0,0025 *	0,13

Table 2: Statistical significance of the differences (p-values) between the ROIs.
Note that AR and NR are highly distinguishable one from the other and from the normal WM and GM. This demonstrates the relevance of ICA segmentation.

Fig. 1: Image obtained from ICA showing the vessels

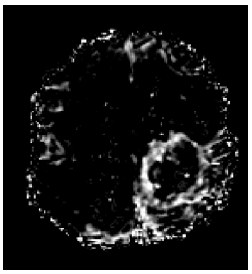

Fig. 2: ICA image showing the peripheral part of the tumor (Active Region)

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