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Automatic detection of perfusion abnormalities based on an Arterial Spin Labeling template

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Target audience : Medical doctors, computer scientists.

PURPOSE : Arterial Spin Labeling (ASL) is a valuable tool to study perfusion in both healthy subjects and patients. In recent years, a large number of studies has demonstrated that this technique is able to outline patterns of abnormal perfusion at the group level. At the individual level, however, identification of patient-specific abnormal patterns of perfusion usually relies on visual inspection or manual delineation of region of interests. These are time-consuming approaches, qualitative and expert-dependent. The aim of this study is to provide a robust method to automatically outline abnormal perfusion patterns at the individual level based on a novel quantitative statistical analysis.

METHODS : From a dataset of 36 healthy subjects, we built a model of normal perfusion (ASL template), by computing the mean and variance of the ASL Cerebral Blood Flow (CBF) maps and taking into account both the between-subject σ_{pop}^2 and within-subject $\sigma_{sub,tpl}^2$ variances :

$$Perf \sim N(\mu_{pop}, \sigma_{pop}^2 + \sigma_{sub,tpl}^2)$$

Then, by means of an *a contrario* approach [2], and using the background model defined by the ASL template, we were able to outline the hypo- and hyper-perfusions.

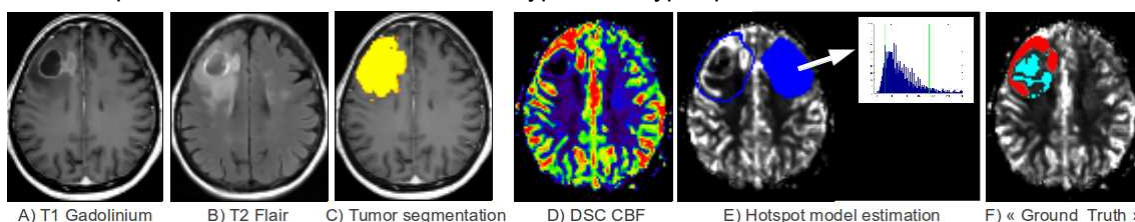


Figure 1: Hypo and hyper-perfusions « ground truth » estimation from a DSC CBF map

Quantitative assessment of the detections is a challenging task as the ground truth is not clearly stated. For validation purposes, we applied our approach in the context of brain tumors since abnormal perfusion patterns have been extensively studied in the clinical literature [3]. In order to get an idea of the specificity and sensitivity of our method, we estimated the hypo- and hyper-perfusion ground truth based on anatomical and perfusion information extracted from T1-Gadolinium, T2-Flair and Dynamic Susceptibility Contrast (DSC) CBF images as displayed in fig.1. The ground truth estimation was performed in two steps :

1. According to clinical knowledge, in the absence of metastasis, the perfusion abnormalities should be confined to the affected tissue. We therefore segmented the tumor and its edema (C), identifiable on the T1-Gadolinium (A) and T2 images (B).
2. Then, using a method similar to the hotspot technique – used in clinical practice to find the grade of a tumor – we compared the level of perfusion inside the tumor to its contralateral counterpart in the DSC CBF map (D,E). Voxels with values overtaking the first and last percentile were identified as hypo and hyper-perfusions (F).

RESULTS : Figure 2 displays the perfusion template : the mean, group standard deviation and first-level standard deviation. We can observe that areas showing the largest variance correspond to the main arteries and sinuses.

In fig.3, the T1 Gadolinium map of two patients is displayed along with the ground truth and the detections provided by our method. We can see that all the hyperperfusions and most of the hypoperfusions are correctly detected. Overall, with the complete dataset including 23 patients we achieved a specificity of 74% and a sensitivity of 98%.

DISCUSSION: With our *a contrario* approach, areas of hyper-perfusions are correctly detected, with a good specificity. The validation is successful, our approach is therefore well suited to detect perfusion abnormalities.

CONCLUSION : In future research we will apply our method to other clinical contexts in order to detect more subtle patterns of abnormal perfusion at the patient level. In addition, we believe that this method would be a useful tool in clinical practice in order to guide the radiologists in patient diagnosis.

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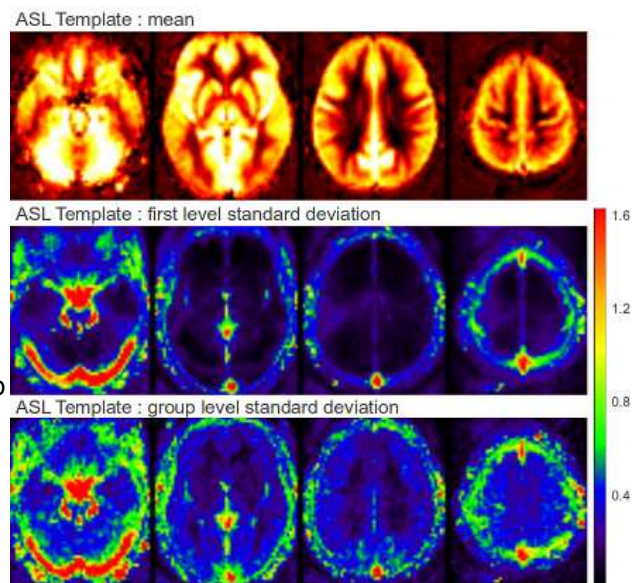


Figure 2: ASL template

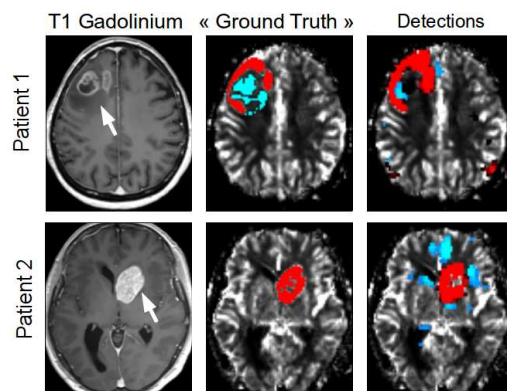


Figure 3: Hypo- and hyper-perfusion detections on 2 patients