Evaluation of a multiparametric qBOLD approach in acute stroke patients

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Introduction
In stroke, Perfusion Weighted Imaging (PWI) allows the identification of hypoperfused tissues. MRI characterization of the ischemic penumbra, defined by the diffusion-perfusion mismatch, can delineate penumbral and irreversibly infarcted fields with a similar degree of reliability to the gold standard, positron-emission tomography (PET) [1]. The presence of a diffusion-perfusion mismatch could justify thrombolysis therapy beyond 3h [2]. The assessment of the penumbra using MRI remains controversial, however. The aim of this study is to evaluate how tissular oxygen saturation (StO2), assessed with a multiparametric qBOLD approach [3], fits between diffusion and perfusion acute stroke patients.

Materials and Methods
Groups. Eight acute (<6h) stroke patients (4 males/4 females) were studied after written informed consent was obtained (approved by local IRB). Acquisition. Imaging was performed on a 3T TX Achieva MR scanner (Philips Healthcare®) using a whole-body RF transmit and 8-channel head receive coils. Three sequences were acquired with a FOV of 224x20x184mm: a 3D multi gradient echo (GE) sequence to obtain a T2* estimate; a multiple spin-echo experiment for T1 mapping; a perfusion sequence with injection of a bolus of Gadolinium-DOTA (0.1mmol/kg, Guerbet, France) to map cerebral blood volume (CBV) and mean transit time (MTT). In addition, diffusion-weighted images were acquired with six combinations of diffusion gradient vectors using b value of 1,000 s/mm² to map the apparent diffusion coefficient (ADC).

The final spatial resolution was 2*2*4mm.

Data Analysis. As described in the literature [3], StO2 maps were obtained pixelwise from a combination of CBV and T1\* where 1/T1\* = 1/T1 - 1/T2 and T2* maps were calculated by fitting a monoexponential decay to the corresponding MR images.

A neurologist, blinded to the diagnosis, selected manually four regions of interest (ROI) for each subject from ADC, MTT and StO2 maps: (i) ischemic core (ADC ROI (black)), (ii) penumbra (MTT ROI (green)), (iii) hypoxia (StO2 ROI (white)), and (iv) contralateral ROI (Contralateral ROIs (pink)). For two patients, lesions were too small to be observed by the neurologist without clinical information and thus no ROIs were delineated. Differences were evaluated with a paired Student t-test.

Results
As expected, a decreased ADC was observed in the ischemic core and was significantly different the ADC of other ROIs (Fig. 2). As expected, no difference in ADC was observed between penumbra and contralateral. StO2 values in the ischemic core, penumbra and hypoxic areas were 22.1±14.3%, 34.8±12% and 28.3±12.4% respectively. For MTT, no difference was observed across the ROIs, possible because of the heterogeneous content of the MTT ROI. A trend towards an increase in MTT was observed, however. Average CBV values measured in ADC ROI (2.6±0.7%) MTT ROI (4.1±14.3%) and StO2 ROI (3.4±0.8%) were significantly different.

Discussion / Conclusion
This study is the first report of StO2 obtained with MRI during the acute phase (<6h) and supports the idea that StO2 could contribute to distinguish the ischemic core and the penumbra. Indeed, StO2 seems to provide new information about the tissue which surrounds the ischemic core. The size of the hypoxic region differs from that of the penumbra assessed by MTT alteration. The multiparametric qBOLD method could become a non-invasive way to investigate patients eligible for thrombolysis and to distinguish metabolically active and inactive tissues within hypoperfused regions under oxygen challenges [4].

References