Evaluation of a multiparamteric qBOLD approach in acute stroke patients

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Introduction

In stroke, Perfusion Weigthed 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 (StO_2), 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 T_2* estimate; a multiple spin-echo experiment for T_2 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/mm^2 to map the apparent diffusion coefficient (ADC).
The final spatial resolution was 2*2*4mm.
Data Analysis. As described in the literature [3], StO_2 maps were obtained pixelwise from a combination of CBV and T_2' where $1/T_2' = 1/T_2^* - 1/T_2$. T_2 and T_2* 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 StO_2 maps: (**i**) ischemic core (ADC ROI (black), Fig. 1b), (**ii**) penumbra (MTT ROI (green), Fig. 1d), (**iii**) hypoxia (StO_2 ROI (white), Fig. 1c), and (**iv**) contralateral ROI (Contralateral ROIs (pink), Fig. 1c). 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

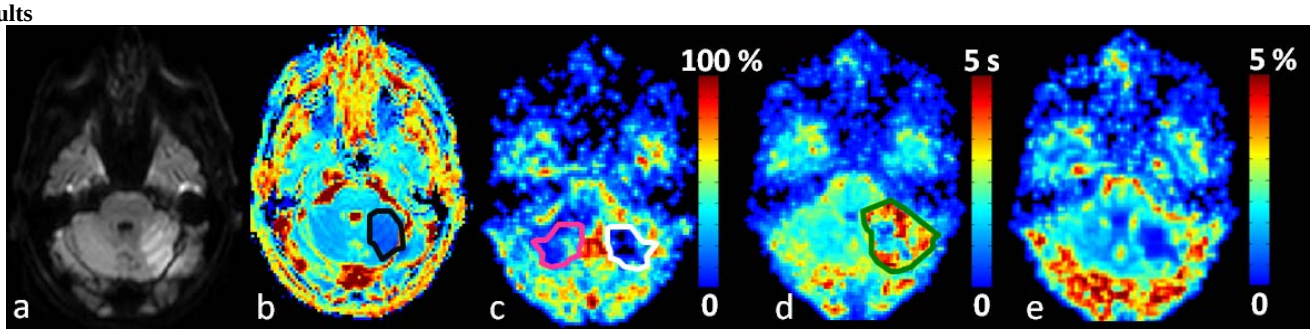

Figure 1. Diffusion weighted imaging (**a**). ADC (**b**), StO_2 (**c**), MTT (**d**) and CBV maps (**e**) from one patient. The four ROIs (cf. methods) are overlaid.

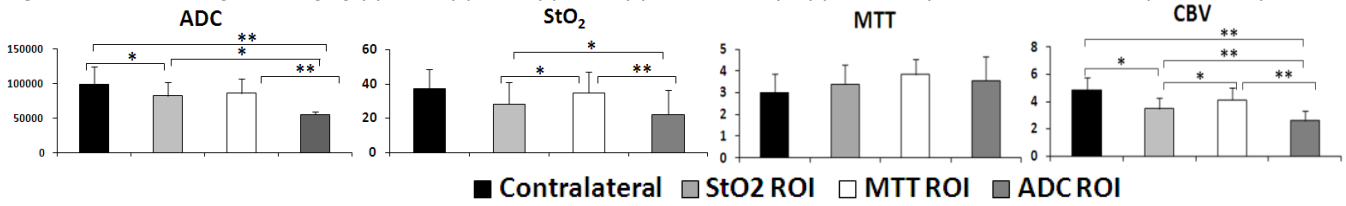

Figure 2. ADC, StO_2, MTT and CBV estimated in the 4 ROIs: contralateral hemisphere (contra, black); hypoxia region (StO_2 ROI, gray) penumbra (MTT ROI, white) and region of decreased ADC (ADC ROI, dark gray) (mean ± SD across the patients). *p < 0.05 **p < 0.01.

Fig. 1 shows representative parametric maps obtained from one patient. Areas of ischemic core (ADC ROI) and penumbra (MTT ROI) ranged from 64.4 to 1123.7 mm^2 and 135.5 to 4452.1 mm^2, respectively, which represent an average of 23.6% and 79.7% of the hypoxic area. On average, the hypoxic area was larger than that of penumbra .
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. StO_2 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 StO_2 obtained with MRI during the acute phase (<6h) and supports the idea that StO_2 could contribute to distinguish the ischemic core and the penumbra. Indeed, StO_2 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

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