

Evaluation of a multiparametric quantitative BOLD approach to map local blood oxygen saturation in stroke patients

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Purpose/Introduction: Local oxygen saturation maps (ISO₂) may be obtained using a multiparametric quantitative BOLD approach [1] that combines separate estimates of T₂, T₂^{*}, blood volume fraction (BVf), and B₀ inhomogeneities [2]. The aim of this study is to evaluate this approach in stroke patients.

Subjects and Methods: Seven stroke patients with NIHSS score above 10 one month after stroke gave their written informed consent. All images were acquired on a Philips Achieva 3T TX 45 days after the episode.

In addition to a 3DT1 sequence, three sequences were acquired: a 3D multi-gradient-echo sequence to correct for static field inhomogeneities; a multiple spin-echo experiment for T₂ mapping and a perfusion sequence with injection of 0.1mmol/kg of Gd-DOTA (Guerbet, France) for BVf mapping.

For quantification purpose, the mean brain blood volume was normalized to 5% and mean cerebral blood flow to 60ml/100g/min. SO₂ maps were calculated pixelwise using:

$ISO_2 = 1 - (4/3 \cdot \pi \cdot \gamma \cdot \Delta X_0 \cdot Hct \cdot T_2' \cdot B_0 \cdot BVf)^{-1}$ where $1/T_2' = 1/T_2^* - 1/T_2$, γ is the gyromagnetic ratio, $\Delta X_0 = 0.264$ ppm the difference in magnetic susceptibilities between fully oxygenated and fully deoxygenated hemoglobin and $Hct = 0.42$ is the hematocrit fraction.

Three regions of interest were drawn on the T₂^{*} images: the lesion (non necrotic pixels), the periphery and the contralateral area (figure 1a). Mean values of T₂, BVf, ISO₂, and CBF were calculated for each ROI and averaged over the 7 patients. Results are expressed as mean ± standard deviation. Significance between the ROIs was tested with a Student t-test (p<0.05).

Results

The figure presents examples of the parameter maps. T₂ values in the contralateral side are significantly smaller than in the lesion (#) or in its periphery (§) (table). CBF is higher in the contralateral area than in its periphery (§) and in the lesion (#), while BVf values are comparable between the three regions. ISO₂ values are significantly smaller in the lesion than in its periphery (*) or than in the contralateral side (#).

Table	Lesion	Periphery	Contralateral
SO ₂ (%)	41.4 (±2) * #	56.5 (±4.0) *	59.0 (±2.0) #
T ₂ (ms)	153.9 (±27.5) #	131.5 (±31.2) §	93.6 (±14.1) # §
CBF (ml/min/100g)	47.9 (±16.2)	52.3 (±10.4) §	61.8 (±7.9) §
BV (%)	5.7 (±1.0)	4.9 (±0.6)	5.3 (±0.5)
R ₂ ' (ms ⁻¹)	11.6 (±2.8) * #	6.4 (±1.0) *	6.6 (±0.5) #

Discussion/Conclusion: These preliminary results show a reduced ISO₂ in the lesion about 6 weeks after stroke. This lower ISO₂ is consistent with the lower CBF observed in the non necrotic pixels of the lesion. It could reflect a glial inflammatory scar. Methodological issues remained to be addressed since quantitative BOLD approaches have not yielded accurate estimates in white matter areas yet. Our results suggest that 45 days after stroke, brain perfusion remains suboptimal in the lesion core. A longitudinal study is in progress to confirm or not the relationship between perfusion and ISO₂.

References

- [1] X. He and D. Yablonskiy, MRM, 57:115-126, 2007.
- [2] T. Christen et.al, NMR Biomed, 24:393-403, 2011.

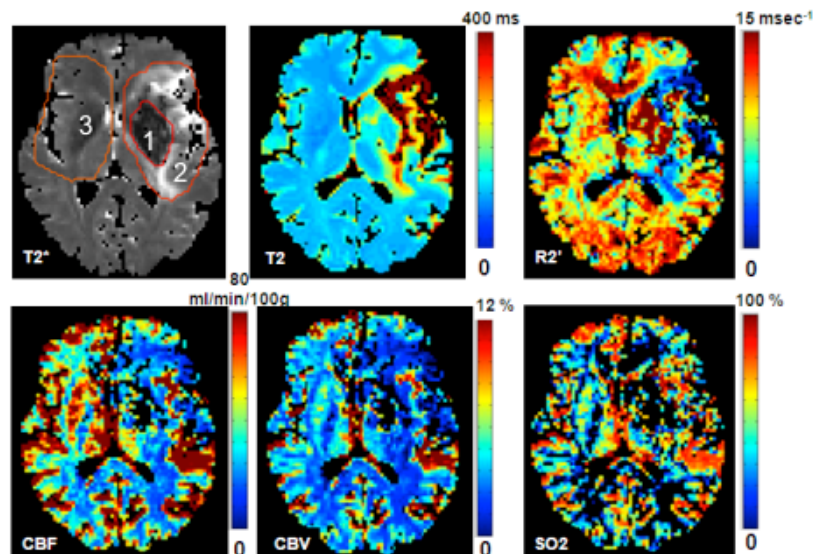


Figure: Axial scan of T₂^{*} weighted sequence demonstrating the region of interest for measurements in the lesion (1), in the periphery (2) and in the contralateral area (3). T₂, R₂' , CBF, CBV and ISO₂ maps obtained in one patient at 3T.