Comprehensive assessment of cerebral hemodynamic parameters (Y, CVR, CBF, OEF and CMRO2) and perfusion territories for patients with cerebrovascular disease.

Jill Britt De Vis[1], Jeroen Hendrikse[1], and Esben Thade Petersen[1]
[1]*Radiology, University Medical Center Utrecht, Utrecht, Utrecht, Netherlands*

Introduction

In patients with cerebrovascular disease hemodynamic parameters, such as cerebral blood flow (CBF), cerebrovascular reactivity (CVR), oxygen extraction fraction (OEF) and cerebral metabolic rate of oxygen ($CMRO_2$), can be affected. In the last years, non-invasive MR techniques have been developed to evaluate these parameters. Here we present the first results of a comprehensive study protocol designed to evaluate a wide range of cerebral hemodynamic parameters in patients with cerebrovascular disease.

Materials and methods

MR imaging, in line with institutional guidelines, was performed in 5 healthy volunteers; mean age 27 years [range: 24-33] (Table1). MR imaging (~45 min) consisted of MP-RAGE, T2-FLAIR, DWI, respiratory-calibrated pseudo-continuous ASL (pCASL)[1], T2 Prepared Blood Relaxation Imaging with Inversion Recovery (T2-TRIR)[2], territorial selective ASL and an oxygen saturation sequence (T2-BIOS)[3]. Scan parameters of the pCASL sequence were; TR/TE1/TE2: 4000/13.79/36.25, label time 1650 and postlabel delay 1550 ms. Concurrently, a respiratory paradigm (Figure 1A) was run using the Respiract™ device (Thornhill Research Inc, Toronto, Canada)[4]. Scan parameters of the T2-TRIR sequence were; TR/TE/ΔTI/TI1= 1500/20/150/130 ms and eTE=0,40,80 and 160ms. Scan parameters of the T2-BIOS sequence were; TR/TE: 4385/6.86, postlabel delay 60ms and eTE=0,40,80 and 160ms. The respiratory-calibrated pCASL sequence allowed for evaluation of CBF, CVR, CBV, OEF and $CMRO_2$[1]. The T2-TRIR sequence was used to measure venular saturation in the sagittal sinus[2] and from this global OEF and $CMRO_2$ were estimated[5]. The T2-BIOS sequence targeted the intravascular compartment by labelling moving blood and applying a short postlabel delay. An oxygen saturation map (Y) was derived from the data.

Results

Figure 1B shows example images of one subject. For all subjects gray matter (GM) CBF, GM-CVR, GM-OEF and GM-$CMRO_2$ were calculated based on the pCASL data. The results are shown in Table 1. Mean GM-CBF was 51.4 ml/100g/min [range: 47-56 ml/100g/min]. Mean GM-CVR was 22% [range: 14-33 %]. Mean GM-OEF was 37.8 % [range: 30-51%]. Mean GM-$CMRO_2$ was 161,6 µmol/100g/min [range: 123-237 µmol/100g/min].

Discussion and conclusion

We presented a comprehensive protocol for non-invasive assessment of cerebral hemodynamics which will allow us to examine oxygen consumption and vascular reserve capacity in vascular diseased patients. Preliminary results are shown for Y, CVR, CBF, OEF, and $CMRO_2$ measured using the above mentioned sequences. This protocol will be applied to patients with (a)symptomatic steno-occlusive disease of the internal carotid arteries and symptomatic occlusion of the middle cerebral artery. In this way we will be able to study the influence of cerebrovascular disease on hemodynamic parameters.

Acknowledgements

This research is supported by the Dutch Technology Foundation STW, applied science division of NOW, the Technology Program of the Ministry of Economic Affairs and ZonMW Electromagnetic Fields and Health program.

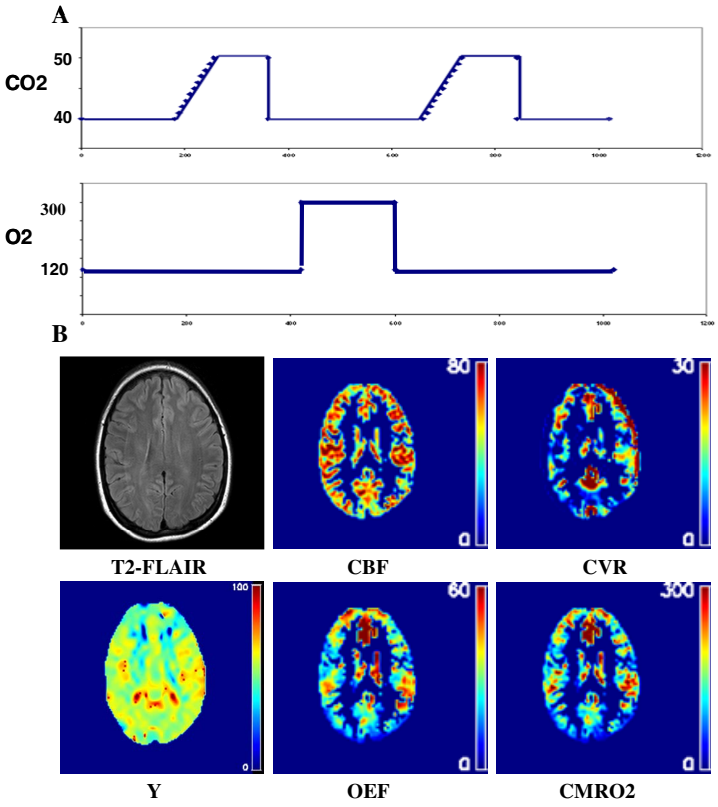

Figure 1: *A) Schematic drawing of the respiratory paradigm. Upper graph shows the shifts in end- tidal CO_2 during the pCASL sequence. Lower graph shows the concurrently occurring shifts in end-tidal O_2.* ***(B)*** *Example images of one subject. CBF-, CVR-, OEF- and $CMRO_2$ maps are obtained from the respiratory-calibrated pCASL images. The Y map represents the oxygen saturation measured with the T2-BIOS sequence. The colorbar gives quantitative information; for CBF in units of ml/100g/min, for CVR, Y and OEF in % and for $CMRO_2$ in units of µmol/100g/min.*

Table 1: *Subject characteristics are shown. For all subjects gray matter CBF, CVR, OEF and $CMRO_2$ are shown.*

Subject	Age	Gender	GM-CBF (ln ml/100g.min)	GM-CVR (ln %)	GM-OEF (ln %)	GM-CMRO2 (ln µmol/100g.min)
1	33	F	53	21	37	166
2	27	M	47	14	40	157
3	24	F	51	18	30	125
4	26	F	56	33	51	237
5	28	M	50	24	31	126

References

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