# Transient effects in arterial CBV quantification

Kathrin Lorenz[1], Toralf Mildner[1], André Pampel[1], and Harald E. Möller[1]
[1]*Nuclear Magnetic Resonance Unit, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Saxony, Germany*

**Target Audience.** Researchers interested in CBV measurement and quantification, researchers interested in VASO, sequence programmers.

**Purpose.** Recently, the inflow-based vascular-space-occupancy (iVASO) approach [1] was extended to measure absolute values of arterial cerebral blood volume (aCBV) [2,3]. Purpose of the current study is to investigate transient effects in aCBV quantification by exploring the dependency of the obtained aCBV on the inversion time (*TI*) and the spatial extents of the employed inversion pulses. Variation of these parameters yields information on the delivery of blood by vessels of variable size.

**Methods.** An iVASO-type pulse sequence as previously described [2] was implemented at 3T (MedSpec 30/100, Bruker, Ettlingen, Germany). Briefly, iVASO contrast is obtained from pairs of images. During the "null condition", inflowing blood is nulled at *TI* by application of a non-selective inversion pulse that is immediately followed by a slice-selective inversion pulse. During the "control condition" blood nulling is omitted because two slice-selective inversion pulses are applied. For imaging, a transmit/receive birdcage head coil and an echo-planar imaging readout (bandwidth 100 kHz, nominal in-plane resolution 3×3 $mm^2$, single slice) were used. Three young healthy subjects were studied. In a first kind of experiments, two series of acquisitions (5 *TI*/*TR* pairs each; 80 repetitions for each pair) were performed with a thickness of the slice-selective (double) inversion band of 2.8 mm and 5.6 mm and a slice thickness of 2 mm. This corresponds to "inversion gaps", that is, minimum distances the label has to travel to reach the imaging slice, of 0.4 mm and 1.8 mm, respectively. In order to study the influence of blood supply in small vessels, additional bipolar flow-weighting (FW) gradients along the *z*-axis ($b$ = 2 s/$mm^2$) were applied in these scans. In a second kind of experiments the contamination of the aCBV values by "fresh" (i.e. non-inverted) arterial blood was studied by modifying the width of the (non-selective) inversion pulse during the null condition. Three series of acquisitions (as above; slice thickness 4 mm) were performed, in which the width of the inversion pulse was reduced from maximum (as defined by the transmit profile of the RF coil) to 16 cm and 8 cm. Here, no FW gradients were applied.

**Results.** At the longest *TI*, similar aCBV maps were obtained for both inversion gaps, whereas, at shorter *TI*'s, an earlier inflow of the inverted blood is visible for the smaller inversion gap (Fig. 1). In addition, inflow in the territory of the posterior cerebral artery (PCA) occurred more slowly as compared to the territory of the medial cerebral artery (MCA). Figure 2 contains results regarding the fresh blood contamination. Upon reduction of the inversion width from maximum to 16 cm, aCBV values measured in the MCA territory were significantly reduced whereas no change was found in the PCA territory. With even further reduction to 8 cm, aCBV estimates were strongly diminished in both territories and yielded similar values.

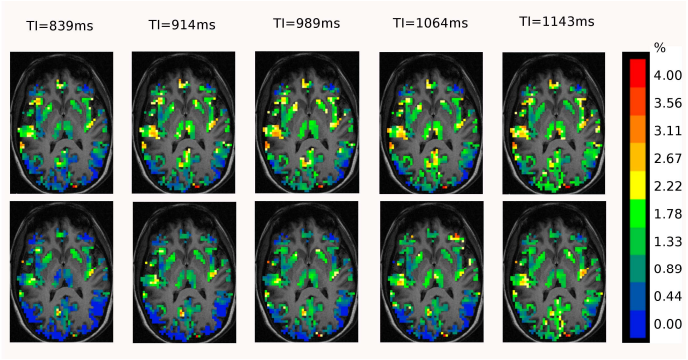


**Fig. 1:** *TI* dependence of aCBV obtained with FW gradients at inversion gaps of 0.4 mm (top) and 1.8 mm (bottom).

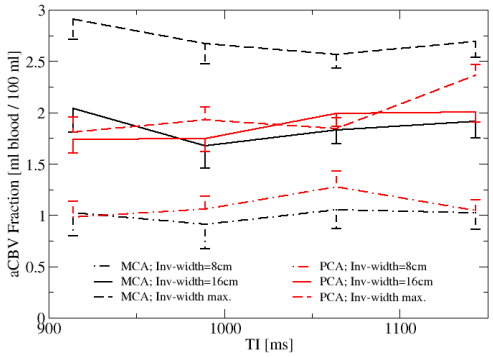


**Fig. 2:** Average *TI* dependence of aCBV for the MCA (black) and PCA (red) territories at variable inversion pulse widths.

**Discussion.** With smaller inversion gap, supply of inverted blood from smaller vessels starts earlier to reach the imaging slice, which explains the faster filling of the vasculature. This process is driven by the cerebral perfusion pressure (CPP). If CPP varies regionally – as indicated by the different dynamics between the PCA and MCA territories in Fig. 1 – or between subjects, such filling might not be completed even at the longest *TI*. By reducing the width of the inversion pulse, the contamination by signal from fresh blood was (artificially) amplified which led to underestimated aCBV values. The stronger susceptibility of the MCA territory to such contamination is easily explained by a shorter arterial transit time (ATT) in the medial circulation. This type of experiment could be of importance, e.g., when a local transmit coil is used instead of a body coil.

**Conclusion.** Transient effects in aCBV quantification which are related to the blood delivery by vessels of variable size were addressed by dedicated experiments with variations of the spatial extents of the employed inversion pulses. Such effects potentially lead to biased values in the aCBV measurement and were shown to vary between different regions in the human brain.

**References.** [1] J. Hua et al. Inflow-Based Vascular-Space-Occupancy (iVASO) MRI. Magn Reson Med 2011; 66: 40–56. [2] M.J. Donahue et al. Absolute arterial cerebral blood volume quantification using inflow vascular-space-occupancy with dynamic subtraction magnetic resonance imaging. J Cereb Blood Flow Metab 2010; 30:1329–1342. [3] J. Hua et al. Measurement of absolute arterial cerebral blood volume in human brain without using a contrast agent. NMR Biomed 2011; 24: 1313–1325.