

# Dynamic Contrast Enhanced T1-weighted Perfusion MRI for Measuring Cerebral Perfusion Increase after Visual Stimulation

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**Introduction:** Being able to measure cerebral perfusion and cerebral blood volume quantitatively is of great importance when it comes to diagnosing and treating various cerebrovascular diseases and other brain disorders. In a clinical setting, MR perfusion imaging is normally performed using dynamic susceptibility contrast imaging. When it comes to absolute quantification, this method has several weaknesses, including susceptibility artefacts and difficulties in obtaining good arterial input functions. A former study has shown that absolute values for cerebral perfusion can be obtained using dynamic contrast enhanced imaging with a T1-weighted sequence (1).

**Purpose:** The purpose of this study was to further develop and validate this new method for quantitative cerebral perfusion measurements, using dynamic contrast enhanced T1-weighted MR imaging. We wanted to evaluate whether the method enabled detection of perfusion changes caused by visual stimulation and if these changes corresponded with literature values.

## Materials and Methods

The study was performed using a Philips 3T Intera Achieva whole body scanner with a transmit/receive circular polarized head coil. 12 healthy volunteers were examined twice. First, a rest study was performed, then a study with visual stimulation using a flickering chessboard (8Hz). Both times a dose of 0.5 mmol/kg gadodiamide (Omniscan, GE Healthcare) was injected as a bolus in a peripheral vein during dynamic imaging. The imaging was performed using a T1-weighted saturation recovery fast field echo sequence with slices placed in order to cover both the internal carotid artery (ICA) and the occipital cortex parallel with sulcu calcarinus. The arterial input function (AIF) was obtained from the ICA. To minimize partial volume effects, a multiplicative rescaling based on the venous outflow function in the sagittal sinus was performed (2). Before the bolus injection, an initial T1 measurement was done in order to convert the signal to concentration of contrast agent.

ROIs were placed in frontal grey matter, frontal white matter and occipital grey matter. High resolution T2-weighted images taken from the same slices were used for placing the ROIs. In addition, CBF maps were calculated and used for placement of ROIs in order to avoid large vessels. Cerebral perfusion (CBF) and cerebral blood volume (CBV) was calculated using Tikhonov's method for deconvolution (1). In order to account for minor offset between experiments, the obtained perfusion values was normalized using proportional scaling, as normally done in PET activation studies. Thus, normalized perfusion was calculated according to  $CBF_{Normalized} = 50 * CBF_{Measured} / CBF_{Global}$  for each subject. The values of CBV was normalized in a similar way according to  $CBV_{Normalized} = 5 * CBV_{Measured} / CBV_{Global}$ .

## Results:

The results are summarized in Table 1, Figure 1 and Figure 2. As shown, mean values for CBF increases in the occipital region during visual stimulation, whereas they seem unchanged in frontal grey and frontal white matter. A paired t-test proved the CBF increase to be significant ( $p=0.005$ ) in visual cortex when stimulation with a flickering chessboard was applied. In Figure 3, an example of a perfusion map obtained when subtracting the rest study from the study with visual stimulation is shown. CBV also seems to increase in visual cortex, but this difference was not found to be significant.

## Conclusion:

To the best of our knowledge it is the first time DCE perfusion imaging has been used in a functional brain activation study. This new method for measuring cerebral perfusion using contrast enhanced MRI, is sensitive enough to detect changes in perfusion in occipital cortex caused by visual stimulation, and the 25.8% CBF increase is in accordance with literature values obtained from PET studies (3).

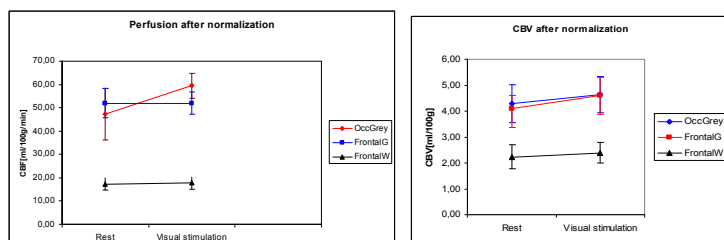


Figure 1

Figure 2

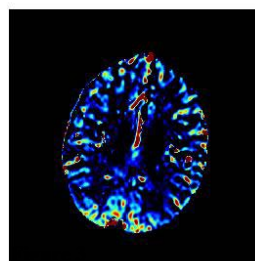


Table 1 Mean perfusion values  $\pm$  standard deviation in different areas after normalization

|                | CBF Rest        | CBF visual stimulation | CBV Rest        | CBV Visual stimulation |
|----------------|-----------------|------------------------|-----------------|------------------------|
| Frontal Grey   | 52.0 $\pm$ 6.2  | 52.0 $\pm$ 4.7         | 4.08 $\pm$ 0.50 | 4.59 $\pm$ 0.72        |
| Frontal White  | 17.3 $\pm$ 2.7  | 17.7 $\pm$ 2.6         | 2.24 $\pm$ 0.46 | 2.39 $\pm$ 0.40        |
| Occipital Grey | 47.2 $\pm$ 11.0 | 59.4 $\pm$ 5.5         | 4.29 $\pm$ 0.71 | 4.64 $\pm$ 1.14        |

References: 1. Larsson HB et al, JMRI 2008, 2. Hansen A et al., MRM 2009, 3. Ito H et. al, J Cereb Blood Flow Metab, 2001