#### Can arterial spin labeling detect white matter perfusion?

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# Introduction

Recently there has been much discussion about the capabilities of arterial spin labeling (ASL) to quantify white matter (WM) perfusion and/or to detect perfusion deficits in the WM.<sup>1</sup> Several new advances in ASL methodology, like the introduction of pseudocontinuous ASL and background suppression, have led to increases in the SNR of the resulting perfusion maps.<sup>2,3</sup> Furthermore, Wong et al have introduced a technique, velocity selective ASL, that is less sensitive for delay effects that affect especially perfusion measurements in the deep WM.<sup>4</sup> The goal of the current study was to investigate whether WM perfusion imaging by ASL becomes feasible by employing these advances. This was investigated in healthy volunteers as well as in patients with arteriovenous malformations (AVM).

### **Methods**

Pseudo-continuous ASL (labeling duration 1.65 s, postlabeling delay 1.525 s with background suppression, 15 slices, voxel size 3x3x7 mm, duration 10 min) and velocity selective ASL (cut-off velocity of 2 cm/s, postlabeling delay 1.6 s, background suppression, 15 slices, voxel size 3x3x7 mm, duration 10 min) were performed on 5 volunteers (age 24-49 years). Table 1: Percentage WM voxels with significant signal

Additionally, a second pseudo-continuous ASL was performed (n=4) with a longer labeling and delay time (resp. 2.5 s and 1.9 s, scan duration kept constant) to make the Psacquisition less delay-sensitive. Finally, a pseudo-continuos ASL scan was made with the labeling plane located above the imaging slices as a control experiment to identify potential subtraction errors. All images were registrated to correct for

motion. Hereafter, it was tested for every voxel (double sided t-tes p<0.05) whether the ASL signal over time was significantly different from zero. Based on a quantitative  $T_1$  scan, acquired at the same resolution as the ASL images, a conservative WM mask wa created (see Figure 1) and the percentage voxels that showed AS signal significantly different from zero was determined. Finally pseudo-continuous ASL was performed in a patient with an AVM (same parameters, scan duration 4 min) and compared to DS perfusion MRI (bolustracking MRI).

# Results

Table 1 shows that the majority of WM voxels showed ASL signa that is significantly larger than zero. Subtraction errors cannot explain these findings, since labeling above the imaging resulted 5% voxels unequal to 0; which corresponds to the used p-value 0.05. Increasing the labeling and delay time of the pseudo continuous ASL sequence did not lead to improved perfusio imaging in the WM. In an AVM patient, bolus-tracking perfusio MRI showed no CBF perfusion deficits in the WM, but did show late contrast agent arrival in the WM (see yellow arrows). The AS images show clear hypo-intense signal in the corresponding WI regions (see white arrows in Fig. 2, ASL signal is only 25% of th contralateral WM).

# **Discussion and conclusions**

Both the measurements in normal volunteers and in an AVM patient, show the capabilities of ASL to detect WM perfusion. The applied imaging sequence has a relatively low spatial resolution, therefore some partial volume effects would occur near the cortical



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Bolustracking perfusion MRI (upper two rows) do not show CBF deficits in the white matter, but an increased delay in contrast agent arrival (yellow arrows). The region of increased delay is depicted as a hypo-intense region in the ASL data (see white arrows).

gray matter. To avoid this confounding effect we used a rather conservative segmentation of the WM (e.g. see Fig. 1). Finally, the ability to identify hemodynamic changes in the WM of an AVM patient can be considered to be the ultimate proof that ASL can identify perfusion deficits. However, DSC-MRI showed that these hypo-intensities are probably not attributable to decreased CBF but rather to increased transport times of the labeled spins.

References: <sup>1</sup>Van Gelderen, ISMRM 2007 (p. 1416) <sup>2</sup> Wu MRM 1020-1027 (2007) <sup>3</sup>Ye, MRM 92-100 (2000) <sup>4</sup>Wong MRM 1334-1341 (2006)