

3D Angiography with Psuedo Continous Arterial Spin Labeling(PCASL) and Accelerated 3D Radial Acquisition

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INTRODUCTION: While Time of flight (TOF) angiography is commonly used to depict the cerebral vascular, its sensitivity to flow saturation results in reduced conspicuity of vessels with slow or delayed filling common to aneurysms and stenoses[1]. The benefits of 3D arterial spin labeling (ASL) insensitivity to slow filling, common used for perfusion imaging, has not been available in 3D ASL angiography. ASL angiography is particularly difficult to perform in 3D due to its low acquisition efficiency and difficulties in determining optimal tagging delays. However, the high levels of static and venous signal suppression provided by ASL creates a sparse imaging volume where undersampled k-space trajectories may accelerate acquisition. In this work, we combine a recently developed, tag delay insensitive, psuedo-continuous ASL tagging scheme[2-3] with 3D radial sampling patterns[4] for accelerated imaging of the entire cerebral vasculature.

METHODS: PCASL uses pulsed radiofrequency (RF) and gradients as illustrated in Fig. 1, such that spins passing through a thin labeling plane undergo adiabatic inversion. Within the tag duration, blood must travel from the labeling plane to a vessel segment for it to be visible. Previously, ASL angiography has been performed using a 2D thick projection volume covering the entire head [3]. Here, imaging is performed immediately after tagging with an efficient balanced steady state free precession (bSSFP) 3D radial acquisition. To reduce the strong signal from CSF, we applied a selective inversion pulse (referred as BGS in fig1) right before PCASL for background suppression. A highly undersampled 3D radial trajectory (vastly undersampled isotropic projection (VIPR[4]) is used to dramatically reduce the number of TRs that is needed for data acquisition. Feasibility studies have been done on healthy volunteer in a 1.5T MRI scanner (GE Healthcare) with a 8-channel head coil. A transverse labeling plane was positioned 7 cm below the imaging center. The scan lasted 7.5 minutes. Relevant PCASL parameters include (TR=1.2ms, flip angle=30, average gradient=0.078 G/cm, maximum gradient = 0.7 G/cm, average B1=0.0163G), Imaging was performed with a FOV=240x240x140mm³, 0.94 mm isotopic resolution, TR/TE=4.1ms/1.9ms, and 50° flip angle). To compare the sensitivity to filling time, a routine TOF scan was performed with only a single slab encompassing the same imaging volume.

RESULTS: Representative transverse, coronal, and sagittal MIPs generated from a single 3D ASL angiography are shown in Fig 2. The intracranial arteries can be seen along their entire length with high contrast and SNR. Subtraction and background suppression is highly effective with minimal signal from stationary tissue. Veins are not visible since only spins flowing from inferior to superior across the tagging plane were labeled. Compared to 3D TOF, 3D PCASL angiogram images show significantly more distal vasculature demonstrating substantially improved visualization of vessels with longer transit times from outside the imaging volume.

DISCUSSION AND CONCLUSION: Instead of previously shown thick 2D projection ASL angiography, we have demonstrated 3D angiography with PCASL tagging. A radial sampling pattern shows great promise for non-contrast enhanced angiography with large coverage and high resolution. The VIPR radial trajectory and inherently sparse image data available with PCASL are particularly well suited for further acceleration utilizing compressed sensing and constrained reconstruction. Further work will include improved image quality with a 3T acquisition, where the inherently higher signal and longer T1 of blood provides sustained signal from tagging. Furthermore, unilateral selective inflow tagging of vessels supplying the brain is possible. Lastly, time-resolved imaging may be possible by altering the tag duration, at the expense of imaging time.

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REFERENCES: [1] Vaphiades et al. Survey of Ophthalmology 2005, 50(4):406 [2] Dai et al. MRM 2008, 60(6):1488 [3] Robson et al. Radiology 2010, 257:507 [4] Barger et al. MRM 2002, 48:297

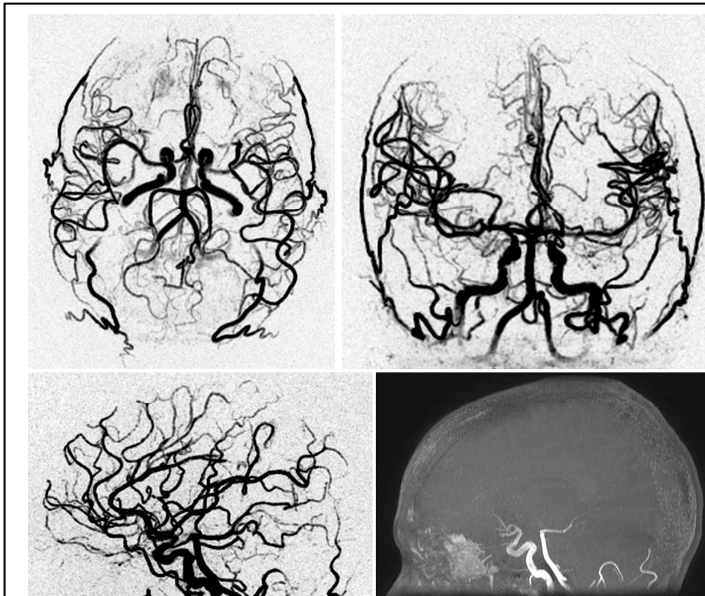
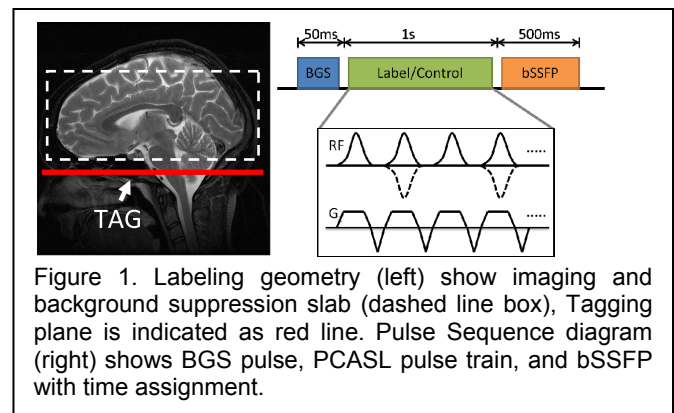


fig 2. Axial (top left), coronal (top right) MIP images of 3D ASL angiography; sagittal MIP of half of the brain are compared in parallel between single slab ASL (bottom left) and single slab TOF (bottom right) covering identical imaging volumes.