Benefits of spiral imaging for Arterial Spin Labeling as compared to EPI

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Audience: RF engineers and MR physicists. **Purpose:** Different imaging methods can be used for pulsed arterial spin labeling (PASL). Often, single-shot 2D echo planar imaging (EPI) is used with PASL techniques, since it is fast at a reasonable resolution. In this study, the PICORE PASL method with Q2TIPS saturation is evaluated with different imaging modules: blipped EPI (bEPI) with different partial-Fourier sampling and spiral EPI (sEPI) with different no. of segments. Shorter readout with partial-Fourier or segmentation can decrease the echo time and thus be beneficial for signal-to-noise ratio (SNR) and image quality by reducing off-resonance distortions. On the other hand, resolution may be sacrificed and physiologically induced segmentation artifacts and subject motion may counteract and dampen the advantages. The comparison of blipped and spiral EPI images itself is not straightforward since different point-spread functions show principally different artifact appearances, like phase-encode shifts for bEPI and radial blurring for sEPI.

The goal of this study was to acquire human PASL data at 3T with the different imaging modules to compare the best ASL quality in terms of SNR and the least artifact levels.

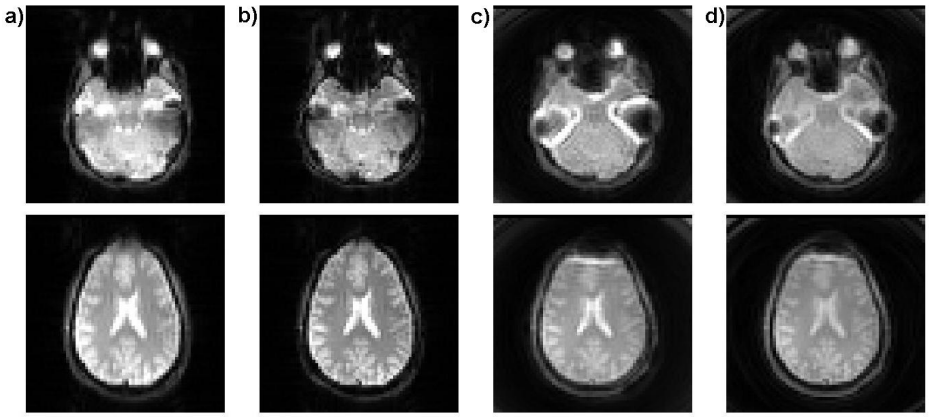

Fig. 1 a) bEPI 6-8, b) bEPI 8-8, c) sEPI single-shot, d) sEPI two segments

Methods: Three subject measurements were done on a 3T MAGNETOM Verio (Siemens, Erlangen, Germany), PICORE-Q2TIPS experiments were performed with TI1 600 ms and TI2 1600 ms and imaging resolution 3.75x3.75x4mm³, FOV 240x240 mm², matrix 64x64 and TR 4000 ms. Blipped EPI was done with full and partial 6/8 sampling: readout duration 32 / 24 ms, TE 21 / 13 ms (bEPI 8-8 / bEPI 6-8). A single-shot and a two-segmented spiral (center-out) were designed matching the bEPI 8-8 nominal resolution: readout duration 20 / 10 ms, TE 3 ms (sEPI / sEPI 2-seg). For motion correction, PACE was done prior to the inline perfusion calculation. 52 label-control pairs (26 for sEPI 2-seg) were averaged. From all subjects, 4 series with bEPI 8-8 and segmented sEPI and 9 measurements with bEPI 6-8 and sEPI were obtained. The base SNR of the images was calculated by dividing the mean of the first image (M0) by the mean of a noise region. The SNR of the ASL image was calculated according to (1). For comparison a regional cerebral blood flow (rCBF) was normalized relative to 55 ml/100g/min with a pixel-wise scaling with the M0 map. From all measurements within each imaging method, mean and standard deviation were calculated.

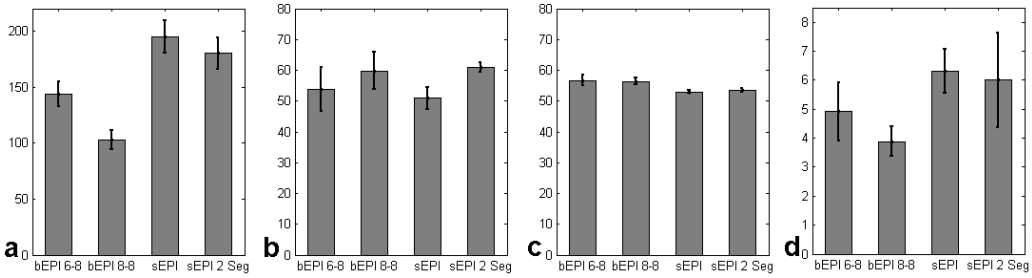

Fig. 2 a) base SNR b) rCBF pixel-wise scaled c) normalized rCBF d) perfusion SNR (stdev over all series/subjects)

Results: In clinical practice, the gain in ASL signal, perfusion SNR and acquisition time is more important than image resolution. bEPI 6-8 (with partial k-space sampling) (Fig. 1a) shows a smoothing compared to the bEPI 8-8 (Fig. 1b). Image artifacts around the ear canal (top row) are much more pronounced for sEPI (Fig. 1c) compared to bEPI; however the segmented spiral (sEPI 2-seg) significantly reduces the off-resonance artifacts (Fig. 1d).

The sEPI shows increased base SNR, 136% compared to bEPI 6-8 and 195% to bEPI 8-8, due to significantly shortened echo time. bEPI 6-8 shows 140% SNR compared to bEPI 8-8, again due to shorter TE (Fig. 2a). The spiral methods induce 6% less rCBF in normalized perfusion-weighted images (Fig. 2c). Since the rCBF is scaled with the M_0 image, this deficit is balanced. The practically most relevant figure is the perfusion SNR (Fig. 2d): single-shot sEPI method has the highest perfusion SNR, 28% more than bEPI 6-8, 62% more than EPI 8-8 and 5% more than the two-segmented sEPI.

Discussion/Conclusions: This work demonstrates that the ASL perfusion SNR can be significantly increased with spiral EPI compared to blipped EPI. With segmented spirals, similar image quality could be achieved compared to single-shot methods. The reduction of readout durations, however, exhibits significantly less blurring artifacts due to B_0 inhomogeneities at the expense of only 5% loss of perfusion SNR which was likely induced by subjects' physiology.

References: 1. Van Gelderen, et al. MRM 2008;788-795, 2. Qian, et al. MRM 2010;543-552