Non-Contrast Abdominal Angiography Using Continuous Arterial Spin Labeling and Background Suppression

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INTRODUCTION: With the current emphasis on new non-contrast enhanced renal angiography, we explored the application of Arterial Spin Labelling (ASL) to angiography in the abdomen. ASL magnetically labels inflowing arterial water (1), enabling targeted angiographic imaging of blood in the vessel lumen. ASL may have unique advantages for angiographic applications. Continuous labelling (CASL) (2) combined with background suppression (BGS) (3) enables the labelling period to be independent of the nullification of background signal. Signal intensities of inflowing blood and the background are more closely related in other single-inversion-pulse spin-labelling (4) and in-flow techniques (5). This is of potential benefit to the combined robustness of labelling and background suppression in patients exhibiting delayed transit times before blood fills downstream vessels. The subtraction approach of ASL in conjunction with BGS results in images with a dark background, over a wide field of view (FOV), which does not obscure vessels.

METHODS: Pulsed-continuous ASL (pCASL) (6) was used with a labelling time of 3 sec; a labelling plane was positioned axially at the level of the diaphragm, labelling blood in the descending aorta. Labelling was applied continuously up to the start of image acquisition, leaving signal in the vessels. Spatially selective BGS pulses were applied during the labelling period. Periods between BGS pulses were alternated between pCASL 'label' and 'control'; the sequence inverted to give a control condition (Figure 1). Signal acquisition consisted of a balanced Steady State Free Precession (bSSFP) sequence, used for its favourable properties imaging moving spins, and high sensitivity. A half-alpha pulse and 5 dummy-scans were used to initialise the steady-state. 3-D imaging was achieved with centric-ordered interleaves in the slice-encode direction and partial-Fourier, linear, centre-out encoding in the phase-encode direction in order to maximise the sensitivity of the steady-state sequence to the prepared magnetisation. Cardiac triggering was employed to minimise variation in labelling and imaging due to cardiac pulsatility. A large 40x40-cm field of view (FOV) was imaged with a typical matrix size of 256x128 in-plane, giving 1.6x3.1-mm resolution. High resolution 3-D imaging, with, typically, 56 slice-encodes were acquired. Scan times for this method was ~10 min. The subject maintained a breath-held end-expiration position for imaging, breathing at 6 sec intervals between imaging and labelling.

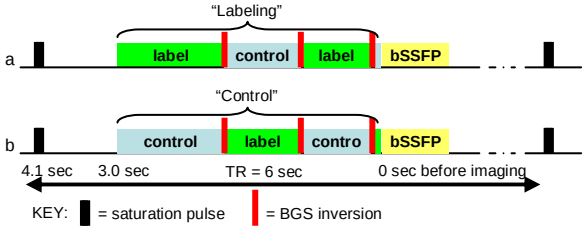

FIG. 1 Labelling diagram, showing label (a) and control (b), with the bSSFP acquisition; saturation and BGS pulses are shown in the 6-sec TR.

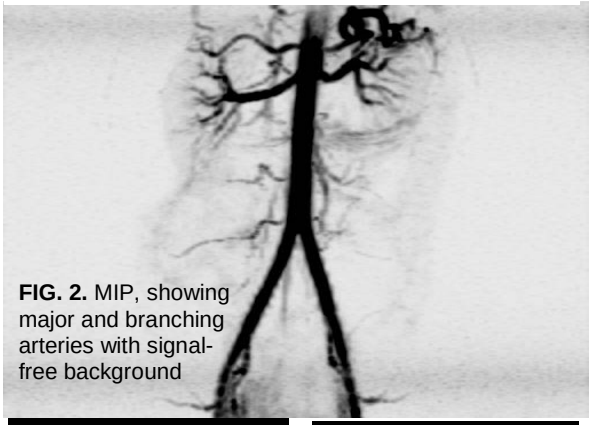

FIG. 2. MIP, showing major and branching arteries with signal-free background

RESULTS: Typical images obtained in healthy volunteers show excellent depiction of the major and branching vessels. A Maximum Intensity Projection (MIP) from a high resolution dataset is shown in Figure 2, indicating the renal arteries, branching vessels in the renal parenchyma, tortuous splenic, hepatic, mesenteric and vertebral arteries. High resolution data has been reformatted and rotated, shown in Figure 3 as a MIP. MIPs of the renal arteries are shown in Figure 4 demonstrating diagnostic quality of this technique for the assessment of renal artery stenoses.

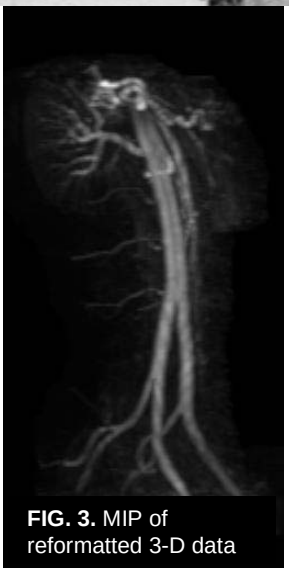

FIG. 3. MIP of reformatted 3-D data

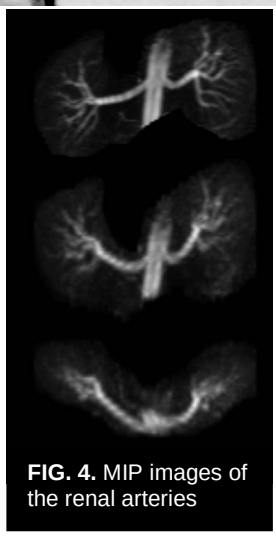

FIG. 4. MIP images of the renal arteries

DISCUSSION: The subtraction-BGS approach employed here permits the acquisition of single projection images in a single breath-hold, which may be of importance for obtaining large FOV angiograms in uncooperative patients. Further developments of interest include the assessment of the robustness of the long labelling time in patients, the investigation of haemodynamics through variation of labelling times, and the speed-up of high resolution imaging with parallel imaging techniques. In summary, ASL techniques show promise for application to non-contrast angiography.

REFERENCES: 1) Williams DS, 1992, PNAS, 89:212-16, 2) Alsop DC, 1998, Radiology, 208:410-16, 3) Ye FQ, MRM 2000, 44:92-100, 4) Kanazawa H, Proc. ISMRM 2002, p.140, 5) Atkinson D, 1994, Radiology, 190:890-4, 6) Dai W, 2008, MRM, in press.