

## Combined renal and peripheral MRA with a new technique at 3.0 T

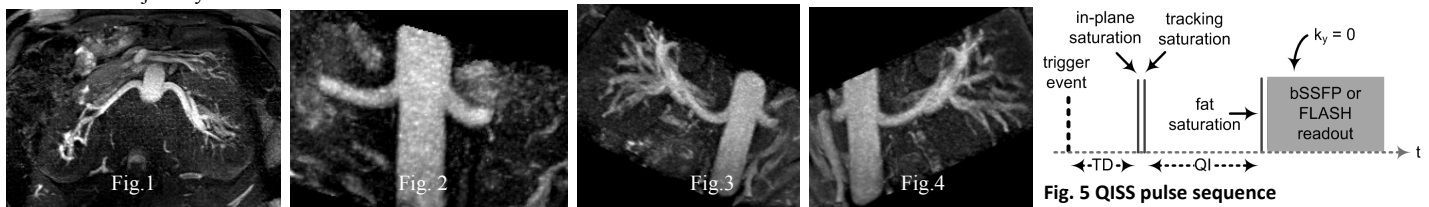
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**Introduction:** The proliferation and increased use of 3.0 T MR Systems offers both potential advantages and difficulties in the implementation of unenhanced MRA techniques. The increased signal-to-noise ratio (SNR) that scales linearly with the field-strength can be utilized in decreasing acquisition time, increasing spatial resolution or a combination of both. The implementation of unenhanced techniques can often be problematic with increased specific absorption rates, increased magnetic susceptibility effects and radiofrequency (RF) field inhomogeneity at higher field strengths. Irrespective of the magnetic field strength, an unenhanced MRA technique should incorporate fast acquisition times and relatively flow independence. We propose a novel unenhanced MRA technique for Renal MRA and MRA of the Lower Extremities employing the quiescent *interval single shot* (QISS) MRA sequence.

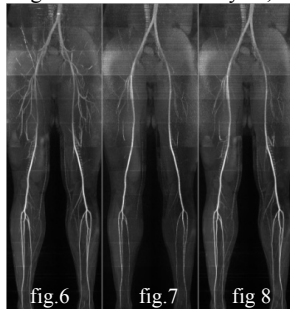
**Materials and Methods:** To perform an initial feasibility study followed by technical optimization of quiescent interval single shot (QISS) magnetic resonance angiography for renal artery and lower extremity evaluation. The study was performed with IRB approval. Seven healthy volunteers underwent combined unenhanced Renal and Peripheral Lower Limb Angiography. The QISS technique acquires data using a modified ECG-triggered, fat suppressed, 2D balanced steady-state free precession pulse sequence incorporating slice selective saturation and a quiescent interval (QI) for maximal enhancement of inflowing blood (Fig.5). The QISS technique for unenhanced Renal MRA was investigated with both a spoiled gradient echo, spgr (FLASH) and balanced steady-state free precession, bSSFP (TruFISP) readout and with ECG and pulse gating for both techniques. Similarly, for its implementation in the peripheries, bSSFP and spoiled gradient echo, spgr readouts were both evaluated at 3.0 T. The effect of increased field strength, increased field inhomogeneity and dielectric effect was initially evaluated with a pulsatile flow.

**Renal MRA Protocol:** Sagittal oblique slab orientation was used to acquire right and left renal arteries to prevent in-plane saturation in orthogonally orientated renal vessels using a breath hold technique. Imaging parameters were as follows: QISS bSSFP technique consists of two sagittal oblique slabs for evaluation of each renal artery. Each slab consists of 20 slices; 15mm slice thickness (1.2 mm effective slice thickness, 0.6 mm slice overlap), TE 1.4ms, TI 350ms, flip angle 44° time, delay (TD) TD=0 for pulse gating, FOV read 400mm, FOV phase 65%, matrix 250 x 384, voxel size 1 x 1 x 3, bandwidth 685 Hz/Px. The QISS spgr sequence parameters consisted of two sagittal oblique slabs for each renal artery. Each slab consisted of 20 slices; 3mm slice thickness (2.4 mm effective slice thickness, 0.6 mm slice overlap), TE 1.5, flip angle of 25°, delay (TD) TD=0 for pulse gating, FOV read 400mm, FOV phase 65%, matrix 250 x 384, voxel size 1 x 1 x 3, bandwidth 685 Hz/Px. Both techniques employed a parallel imaging (PI) factor of two, 5/8<sup>th</sup> partial Fourier using center-to-out trajectory.



**Results: Renal MRA** Qualitative analysis was performed using a Likert scale with a blinded radiologist grading vessel conspicuity. Quantitative analysis was performed only from source images. Renal arterial signal ( $S_A$ ) was measured as the mean signal value contained within the central slice using a circular region-of-interest tool with standard regions of interest. The signal-to-noise ratio (SNR) was computed as  $S_A/\sigma_B$  where  $S_A$  is the signal of the renal artery and  $\sigma_B$  is the standard deviation (SD) of background renal parenchyma. ANOVA analysis of SNR's for the QISS SPGR ECG gated, QISS SRGR pulse gated and QISS bSSFP ECG gated, QISS bSSFP pulse gated techniques confirms feasibility of the QISS technique employing either ECG or pulse gating and using either readout. QISS with spoiled gradient echo readout with ECG gating had consistently higher signal to noise ratios with an average SNR of 17.1 than the other three techniques. (Fig. 1 Axial MIP QISS bSSFP ECG Gating, Fig.2 Coronal MIP peripheral gating, Fig.3 Right renal artery, Fig.4 Left renal artery)

**Peripheral MRA Protocol:** The QISS run-off technique is ECG gated. After performing, technical optimization, stations one through five, abdominal to distal SFA, were imaged using QISS with spgr. A dedicated peripheral array coil was used to receive signal. Each station consisted of 40 slices, 3.0mm slice thickness (2.4 mm effective slice thickness, 0.6 mm slice overlap), bandwidth 676 Hz/Px, voxel size 1.1 x 1.1 x 3.0 mm, FOV read 400mm, FOV phase 64.8%, matrix size 352 x 352, TD (Time delay=100ms), TE 1.5, TR gated to one cardiac cycle, TI 350 ms, flip angle of 25°, voxel size 1 x 1 x 3 mm. Stations five through thirteen were imaged with QISS using bSSFP readout. Each station consisted of 40 slices, 3.0mm slice thickness (2.4 mm effective slice thickness, 0.6 mm slice overlap), bandwidth 836 Hz/Px, voxel size 1.1 x 1.1 x 3.0 mm, FOV read 400mm, FOV phase 64.8%, matrix size 352 x 352, TE 1.36, TR gated to one cardiac cycle, TI 350 ms with a variable flip angle.



Initial implementation of the QISS Peripheral MRA protocol involved running the two, QISS spgr and QISS bSSFP scans to allow qualitative assessment of variation in signal intensity (SI) and SNR from abdominal to pedal stations in early studies. The QISS trueFISP technique demonstrated repeated decreased SI and SNR particularly in the right common iliac artery and right proximal femoral artery owing to  $B_1$  inhomogeneity (fig.6). The QISS FLASH technique by comparison suffered decreased SI and SNR in calf vessels of all subjects (fig 7.). Motivated by decreased signal in the pelvis and abdominal stations due with bSSFP readouts and in the calves with spgr readout, we propose a hybrid technique for QISS unenhanced MRA. Stations 1-5 (aorto-iliac to distal SFA) uses spgr readout while stations 5-13 use bSSFP readout (fig.8).

**Conclusion:** We propose the QISS as a potential MRA technique for combined dual Renal and Lower extremity unenhanced MRA