Clinical Validation of Non-Contrast Abdominal MRA with Quadruple Inversion-Recovery Prepared 3D b-SSFP

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Purpose: A non-contrast MRA sequence with quadruple inversion-recovery (IR) preconditioning and 3D b-SSFP readout (QIR MRA) has been developed for assessment of abdominopelvic arteries [1]. This method is an extension of an inflow-based technique, employing a single IR pulse for background suppression [2], for renal artery evaluation. However, in QIR MRA the initial inversion is immediately followed by an additional IR pulse which selectively reinverts spins in the aorta to provide extended superior-inferior coverage of abdominopelvic arteries per transmit time (Fig 1). The purpose of this study is to evaluate QIR MRA in a clinical population and assess its diagnostic accuracy for detection of aortoiliac disease in comparison to conventional contrast-enhanced MRA (CE MRA). **Methods:** 21 patients (11 male, mean age 74y) referred for claudication/rest pain (n=14), suspected aortic aneurysm (n=5), suspected renal artery stenosis (n=1), and SMA aneurysm (n=1) were imaged with QIR MRA at 1.5T (Avanto, Siemens). Unenhanced images were obtained in an oblique coronal slab with respiratory bellows triggering (20% end inspiration). Acquisition parameters included: FOV 400x400 mm^2, voxel size 1.3x1.3x1.7 mm^3, 56-66 partitions, nominal slice thickness 1.7mm, slice resolution 65%, TR 1 respiratory cycle, TE 1.7ms, FA 90°, BW 1042 Hz/pixel, 2 shots/partition, GRAPPA factor 2.7, and scan time ~ 5mins. The inversion time that controls inflow of unsaturated arterial blood was heart rate dependent, ranging from 1500-1800ms, selected to ensure arterial inflow over 2 systolic periods prior to data acquisition. Per clinical request, two subjects were imaged only with QIR MRA due to critically low GFR. All other patients underwent additional gadolinium-enhanced imaging with a 3D T1-weighted FLASH sequence (TR/TE 2.9/0.9 ms, FA 25°). The CE MRA scan was the first station of a bolus chase acquisition in 14 cases, performed using 0.15 mmol/kg Gd-DTPA in total, with voxel size 1.4x1.3x1.4 mm^3. In 5 cases, single station CE MRA was performed with 0.1 mmol/kg Gd-DTPA and 1.1x0.9x1.6 mm^3 voxel size. Two blinded radiologists independently evaluated all images. Disease severity (0 = no stenosis, 1 = 1-49% stenosis, 2 = 50-99% stenosis, 3 = 100% occlusion) was evaluated in 10 segments: suprarenal/infrarenal aorta, right/left renal arteries, right/left common iliac and external iliac arteries, right/left internal iliac a. origin. Image quality (0=unevaluable, 1=poor, 2=fair, 3=excellent) and artifacts were recorded on a per-segment basis. **Results:** 370 segments (19 subjects, 2 readers per segment, 1 left renal a. absent due to nephrectomy, 4 segments not in FOV on CE MRA) were assessed with both QIR MRA and CE MRA. In addition, 10 accessory renal arteries were found on CE MRA, of which 9 were correctly identified with QIR MRA. Image quality of CE MRA (2.8±0.3) was superior to that of QIR MRA (2.2±0.4); however, 97% of all evaluated non-contrast segments were judged diagnostic. 86% of QIR MRA segments were rated with fair (50%) or excellent (36%) image quality, while 47 (11%) exhibited poor image quality. 11 segments (3%) were considered non-diagnostic, occurring in the common iliac and the left internal iliac arteries of one patient due to aliasing; in the suprarenal aorta (n=5) due to either banding artifact or reduced signal intensity caused by rapid flow through off-resonance; and in the external iliac arteries (n=4) due to insufficient inflow of unsaturated blood. Respiratory motion was noted frequently, but did not affect diagnostic assessment. 7 (1.8%) segments were non-diagnostic on CE MRA due to mistiming of contrast agent administration. At the reference standard of assessable CE MRA segments with diagnostic quality, hemodynamically significant stenosis (defined as ≥ 50%) was found in 24/363 (7%) segments. Of all evaluable segments with CE MRA available, overall accuracy/sensitivity/specificity of QIR MRA was 93%/75%/95% respectively (averaged over 2 readers).

Conclusion: This study of 21 patients demonstrated good diagnostic accuracy of QIR MRA for detecting hemodynamically significant stenosis in the aortoiliac arteries without gadolinium contrast. When observed, suboptimal image quality predominantly affected the external and internal iliac segments. The technique is particularly reliable for renal artery evaluation (Fig 2). Repeat focused imaging of the pelvic arteries proved a useful option in one patient with endovascular AAA stent and a transplant renal artery (Fig 3). QIR MRA is a safe, easily repeatable, alternative to gadolinium MRA when contrast is contra-indicated due to impaired kidney function (Fig 4) or in the event that CE MRA is compromised (Fig. 5).

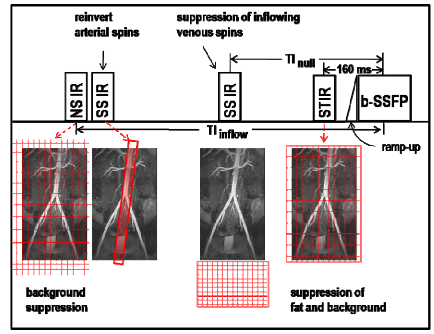

Fig 1 Pulse sequence diagram

References: [1] Atanasova IP, et al., JMRI 2011, 33: 1430-39 [2] Katoh M, et al., Kidney International 2004, 66: 1272-78.

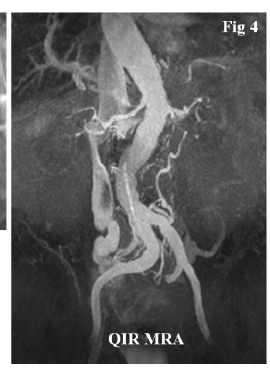

Fig 2. 80yo male with significant (>50%) renal artery stenosis (arrows), identified by QIR MRA (2A) in agreement with CE MRA (2B)
Fig 3. Transplanted renal artery imaged with QIR MRA in a 76yo male with endovascular AAA stent who could not receive contrast
Fig 4. CE MRA was contra-indicated in an 85yo female in renal failure; evaluation for suspected aortic aneurysm was performed with QIR MRA
Fig 5. 80yo male referred for claudication. QIR MRA demonstrated superior quality to CE MRA (not shown) due to failure of the power injector; mild infrarenal atherosclerosis and mild bilateral renal artery stenosis were observed.