Non-contrast MRA in PAD Patients: Diagnostic Comparison of QISS, ECG-FSE, and QIR Techniques

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Purpose: To determine what combination of different non-contrast MRA techniques at the 3 different stations of a peripheral MRA exam best compare with gadolinium MRA (Gd-MRA) for evaluation of peripheral arterial disease (PAD).

Introduction: Several methods for non-contrast MRA have shown promise for evaluating PAD compared to Gd-MRA, with advantages of reduced costs, obviating the risks of nephrogenic systemic fibrosis associated with gadolinium, and lack of radiation exposure or contrast-induced nephropathy associated with CTA. Clinical adoption of these non-invasive MRA techniques requires a robust, reproducible technique that can perform well even in the presence of significant pathology, including slow blood flow, vessel stenosis and occlusion. Non-contrast techniques may not perform equally in each station of an MRA or with pathology. Here, for the first time, we compare 2 different combinations of non-contrast MRA techniques against each other in the same PAD patients using Gd-MRA as standard: (i) ECG-gated fast-spin echo (ECG-FSE) and quadruple inversion-recovery (QIR) [2] b-SSFP MRA and (ii) quiescent-interval single-shot (QISS)[1].

Methods: All MRA were performed on a 3T system (Siemens Trio). Claudicating PAD patients were recruited through University/VA Vascular Clinics and all had ankle-brachial-index<0.9. 11 PAD patients (9M/2F; 63.5+/-6.8) were imaged in 1 or 2 sessions using QISS, QIR, and ECG-FSE non-contrast techniques along with gadolinium MRA. QIR was performed for station 1 only. ECG-FSE was performed for stations 2 and 3 only. High permittivity dielectric padding[7] was utilized to reduce B1 inhomogeneity over the right thigh for ECG-FSE and Gd-MRA acquisitions (not found to be helpful for QISS)[7]. QISS and Gd-MRA were performed for all stations except in 3 patients (no QISS in station 1 due to patient discomfort or inability to fit coil). Total scan time was recorded based on start/end sequence times. Image sets were anonymized and randomized for evaluation. A single experienced body radiologist evaluated segments based on a Likert scale including length visualized (entire, >50%, <50%, non-visualized), stenosis severity (no stenosis, <50%, >50%, occluded), and confidence (None, little, some, fairly, or very confident). Sensitivity, specificity, NPV, PPV, and accuracy were based on >50% stenosis compared to Gd-MRA which was read by the same reader.

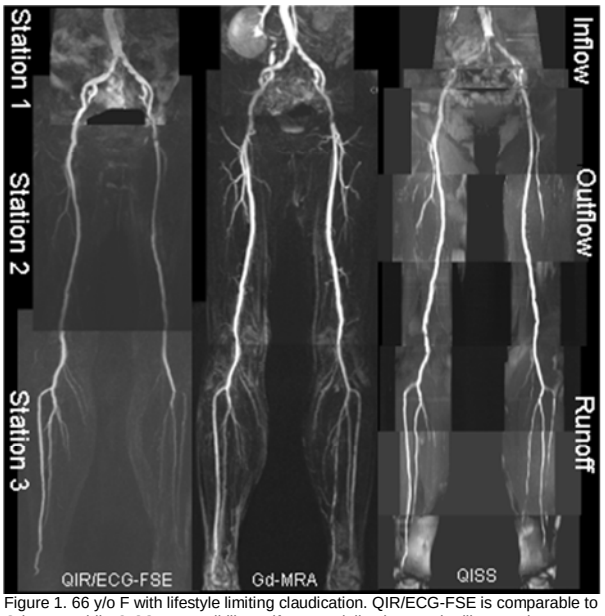

Figure 1. 66 y/o F with lifestyle limiting claudication. QIR/ECG-FSE is comparable to Gd-MRA, while QISS susceptibility artifacts partially obscure the iliac arteries.

	% Segments without Confidence			
	Inflow	Outflow	Runoff	Total
Gd-MRA	0.0%	0.0%	1.7%	1.0%
QIR/ECG-FSE	8.7%	10.6%	5.1%	7.1%
QISS	7.1%	4.7%	2.9%	4.1%

Table 1. Segments without confidence in each station.

Results: 11 PAD patients underwent 3 station peripheral MRA (Figure 1), and arterial trees divided into 29 segments per patient, for a total of 77 QIR, 126 ECG-FSE, and 294 QISS segments. The total scan time was not significantly different between QISS (43.8 ± 9.8 min) and QIR/ECG-FSE (45 ± 4.6 min) MRA. Excluding preparation time, Gd-MRA time was significantly ($p<0.001$) less than non-contrast MRA (19.1±1.9 min). Less than 1% of segments were not visualized due to artifact and this was not different between non-contrast techniques. Confidence levels for the 3 stations are shown in Table 1. Statistical comparison of QISS and QIR/FSE compared to gadolinium MRA are summarized in Table 2. QIR does well within the abdominal station, but may have difficulty when poor fat saturation occurs in anterior pelvis, limiting external iliac and common femoral vessel evaluation., Additionally, QIR, an inflow technique, has difficulty with complete occlusion, as one case had false positives in the external iliac and femoral vessels due to total common iliac vessel occlusion with delayed collateral flow. In the presence of suboptimal fat saturation, QISS images may result in false negatives, which occurred in the right proximal superficial femoral artery in 2 cases.

	QIR/ECG-FSE				QISS			
	Total	Inflow	Outflow	Runoff	Total	Inflow	Outflow	Runoff
Sens	87.3%	88.9%	100.0%	71.4%	80.0%	100.0%	87.5%	66.7%
Spec	94.5%	91.7%	97.5%	94.8%	93.4%	98.0%	90.0%	92.8%
NPV	97.2%	91.7%	100.0%	96.1%	95.8%	98.0%	92.3%	95.3%
PPV	77.4%	61.5%	96.2%	65.2%	71.4%	83.3%	84.0%	56.0%
Accuracy	93.2%	91.3%	98.5%	92.0%	91.2%	98.2%	89.1%	89.7%
Total Segments	309	69	65	175	294	56	64	174
Patients	11	11	11	11	11	8	11	11
% seg evaluated	97%	90%	98%	99%	99%	85%	97%	99%

Table 2. Statistical data on segments evaluated for non-contrast sequences.

Discussion: Based on our preliminary data, QISS and QIR/ECG-FSE techniques have comparable sensitivity, specificity, NPV, PPV, and accuracy. However, small sample size and few readers limit current data. Differences in confidence levels suggest quality of subtraction with ECG-FSE and fat suppression may be important. Reducing inhomogeneous fat suppression may help optimize all three non-contrast techniques at 3T. In addition, undersampling methods, such as compressed sensing will help reduce scan time to maximize adoption of these techniques clinically.

Conclusion: Currently, a combination of QIR (for abdomen) and ECG-FSE (for thigh/calf) OR QISS (for all three stations) at 3T can substitute for Gd-MRA in PAD patients with contraindications to Gd. All three techniques will benefit from improved fat suppression and acceleration of imaging for optimal clinical application.

Acknowledgements: Supported with resources from the George E. Wahlen Dept. of Veterans Affairs Medical Center, Salt Lake City, Utah.

References: *1*. Edelman et al. MRM. 2010 Apr;63(4):951–8. *2.* Atanasova et al. Eur J Radiol. 2014 Sep;83(9):1612–9. **Grants:** NIH 5 R01 HL092439