Quiescent Interval Single-Shot (QISS) Lower Extremity MRA for the Diagnosis of Peripheral Artery Disease: Case Presentations

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Introduction

Peripheral artery disease (PAD) affects 12%–14% of the general population and its prevalence increases with patient age [1]. While segmental Doppler pressures and pulse volume recording are the most appropriate techniques for screening symptomatic patients, more sophisticated non-invasive imaging techniques may be necessary for further anatomic evaluation and treatment planning, especially before revascularization [2, 3]. The American College of Radiology (ACR) rates both CT angiography (CTA) and MR angiography (MRA) as "usually appropriate" diagnostic approaches for claudication with suspected vascular etiology [2]. Because many patients with PAD suffer from several comorbidities including renal insufficiency, the administration of either iodinated or gadolinium-based contrast media may be of concern given the increased risk of contrast-induced nephropathy or nephrogenic systemic fibrosis (NSF), respectively [4, 5].

These concerns with the risks of contrast media administration in combination with recent technical advances have led to an increased interest in non-contrast MRA techniques. Although many approaches to non-contrast MRA have been evaluated [6], most of them have limited clinical utility in patients with PAD due to either technical issues (e.g. long acquisition time) or overestimation of mild to moderate stenosis [7, 8].

Quiescent-interval single-shot (QISS) MRA is a recently introduced, robust non-contrast MRA technique [9]. QISS MRA at 1.5 and 3T has shown promising results with reported diagnostic accuracies close to or equal to contrast-enhanced MRA [10-14]. Here, we illustrate some of the benefits of QISS MRA over other modalities through two clinical cases and also provide a brief overview of the literature available for this technology.

Discussion

These cases demonstrate certain benefits of QISS MRA over CTA. As emphasized by ACR guidelines, the two major shortcomings limiting image interpretation of CTA in PAD patients are the relatively difficult acquisition timing following contrast administration due to reduced flow in the stenotic vessels and reduced lumen visibility due to heavily calcified atheromatous lesions [2]. As we have shown, QISS MRA is able to overcome both of these limitations to provide reliable findings comparable to invasive DSA.

The QISS MRA technique was first introduced in 2010 by Edelman et al. [9]. This ECG-triggered technique employs initial saturation pulses followed by a 2D single-shot balanced steady-state free precession readout with a quiescent interval between them.

Case 1

A 55-year-old male was referred for evaluation and treatment of intermittent claudication despite adherence to a regular walking program. The patient was a former smoker and his medical history included hyperlipidemia, hypertension, coronary artery disease, PAD, and ANCA-positive vasculitis. Physical examination revealed diminished femoral and popliteal pulses bilaterally. Posterior tibial and dorsalis pedis pulses were Dopplerable. His ankle-brachial index (ABI) was 0.78 in the right leg and 0.91 in the left leg at rest, while ABI severely decreased post exercise (0.53 and 0.52, respectively). In preparation for revascularization the patient was referred for a lower extremity run-off CTA. CTA demonstrated moderate to severe bilateral iliac and superficial femoral artery stenosis. The evaluation of calf vessels was inconclusive as the slower flow in the stenotic vessels delayed the arrival of contrast and thus acquisition occurred before peak enhancement was reached in these vessels. Prior to intervention, the patient underwent a non-contrast QISS MRA on a 1.5T MAGNETOM Avanto scanner. QISS MRA successfully visualized each arterial segment, including those poorly visualized on CTA. In addition to visualizing the stenosis already found on CTA, QISS MRA was able to delineate infrapopliteal run off to the feet. There was total occlusion of the right peroneal artery and total occlusion of the left anterior tibial and posterior tibial arteries. These findings were confirmed by invasive digital subtraction angiography (DSA).


CTA
QISS
DSA

Two saturation pulses are used: one to suppress the background signal, and one applied inferior to the slice to suppress the venous blood signal. The quiescent interval before the readout allows the inflow of unsaturated arterial spins into the imaging plane. Due to its design, the flow sensitivity of QISS MRA is negligible compared to other non-contrast techniques such as time-of-flight, 3D fast spin echo based approaches, and

ungated ghost MRA [10]. Additionally, single-shot 2D TrueFISP acquisition makes this technique relatively insensitive to patient motion.

Novel technological innovations in development promise to further facilitate the clinical implementation of QISS MRA. QISS MRA can be performed without ECG gating by employing prospective self-navigation based on the detection of the acceleration of blood flow during systole with a reference-less phase contrast navigator [15]. Highly undersampled radial *k*-space readout enables the acquisition of multiple 2D slices in a single cardiac cycle shortening the acquisition time of a complete lower extremity runoff MRA to about 2 minutes [16]. High-resolution QISS MRA provides 1.5 mm section thickness and thus more detailed visualization of the vascular anatomy [17]. Quiescent interval low angle shot MRA provides superior image quality for the external carotid arteries compared to 2D time-of-flight with an average acquisition time of less than 6 minutes [18].

The diagnostic accuracy of non-contrast QISS MRA has been evaluated with non-invasive contrast-enhanced MRA as a reference standard, showing a segment-based sensitivity and specificity of 89.7% and 96.5%, respectively [11]. A subgroup analysis in patients who also underwent DSA showed substantial agreement between QISS MRA and DSA [12]. Similarily high sensitivity (98.6%) and specificity (96%) were reported for QISS MRA versus contrast-enhanced MRA in patients with PAD by Klasen et al. [13]. QISS MRA demonstrated superior specificity for detecting hemodynamically significant arterial stenosis in the lower extremities compared to subtracted 3D fast spin echo MRA and was also found to provide higher image quality and diagnostic accuracy in the abdominal and pelvic regions [19].

While the majority of initial QISS MRA studies were performed at 1.5T [9, 11, 12], QISS MRA has also shown good diagnostic accuracy at higher field strength. 3T QISS MRA has high sensitivity (100%) in the presence of adequate image quality for the detection of peripheral artery stenosis when compared to the DSA as a reference standard [14]. Later studies have confirmed the feasibility of QISS MRA at 3T and reported high diagnostic performance and high image quality, especially in the distal segments [20-22].

Conclusion

Past studies have shown that QISS MRA provides high diagnostic accuracy for the detection of hemodynamically significant arterial stenosis of the lower extremities at both 1.5 and 3T. QISS MRA seems to be a feasible alternative for patients in whom contrast media administration is contraindicated, especially in the light of the new ACR guidelines widening the population considered at risk for NSF to patients with eGFR <40 ml/min/1.73m^2 [23]. Furthermore, QISS MRA may avoid the timing-related difficulties of contrast-enhanced CTA and better visualize heavily calcified arteries. Finally, its relative insensitivity to blood-flow and patient motion simplify the patient workflow by requiring minimal user input during the acquisition.

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Case 2

A 65-year-old man was referred for evaluation and treatment of intermittent claudication. Relevant past medical history included hyperlipidemia, hypertension, carotid artery disease, subclavian artery disease, and PAD. Physical examination was remarkable for normal femoral pulses, diminished popliteal pulses and Dopplerable posterior tibial and dorsalis pedis pulses bilaterally. The patient's ABI in the right leg (0.72) was consistent with moderate ischemia, while ABI in the left leg (0.95) was within normal limits at rest. The patient was referred for a lower extremity CTA to plan for revascularization. This demonstrated occluded right superficial femoral, popliteal, anterior tibial, and peroneal arteries and left popliteal, peroneal, anterior tibial, and posterior tibial arteries. Complete lumen visibility was limited due to the presence of heavy calcification, especially in the superficial femoral arteries. As a result, the length of the occlusion could not be determined. Non-contrast QISS MRA (1.5T MAGNETOM Avanto) was performed and was able to sufficiently visualize the entire lower extremity runoff including the heavily calcified segments. QISS MRA provided superior image quality in the calves, visualizing the three vessel runoff in the right calf and the proximal total occlusion of all three left calf vessels filling via collaterals. QISS MRA findings were confirmed with subsequent DSA results.

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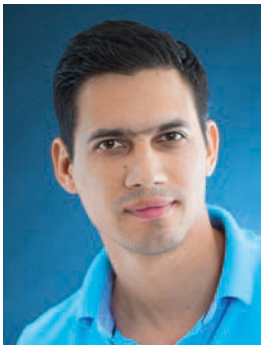

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