JACC: CARDIOVASCULAR IMAGING
VOL. 10, NO. 10, 2017

ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER
http://dx.doi.org/10.1016/j.jcmg.2016.11.012

EDITORIAL COMMENT

QISS MR Angiography

An Alternative to CT Angiography for Peripheral Vascular Evaluation*

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Obstructive atherosclerotic vascular disease, specifically peripheral arterial disease (PAD) disproportionately affects the elderly and those with diabetes (1) and remains a significant cause of morbidity and mortality. Just as disease prevention and innovative percutaneous therapies have improved outcomes greatly for patients affected by PAD, diagnostic tests to evaluate such patients have become more sophisticated and increasingly noninvasive. It is difficult to imagine nowadays that the mainstay test for diagnosing peripheral vascular disease used to be invasive angiography, which involved percutaneous puncture of the femoral artery with catheterization of the blood vessel of interest. Invasive angiography has been largely superseded now as a diagnostic test by noninvasive techniques such as magnetic resonance angiography (MRA) and computed tomography angiography (CTA).

When contrast-enhanced magnetic resonance angiography (CEMRA) arrived onto the medical imaging scene in the mid 1990s, it promised to supplant invasive angiography as the diagnostic vascular test of choice in almost every part of the human body (2,3). CEMRA was noninvasive, easily tolerated by patients, and extremely versatile, allowing combination with other magnetic resonance (MR) imaging techniques to evaluate organ perfusion, vessel wall morphology, and vascular hemodynamics (4-7). At 1 point, it seemed as if CEMRA would be able to achieve the "holy grail" and replace invasive catheterization of the coronary arteries. MRA seemed to have become the imaging test of choice, until reports began to emerge in the mid 2000s that some patients with class 4 or 5 chronic kidney disease who had been exposed to high doses of gadolinium had developed a severe potentially fatal condition called nephrogenic systemic fibrosis (NSF) (8).

NSF quickly became the focus of the scientific medical community and it was determined that, due to its association with renal dysfunction and gadolinium exposure, all patients should have their renal function assessed before gadolinium administration, resulting in the near elimination of this condition by avoidance of gadolinium use in patients at risk (9). From the point of view of imaging, however, NSF produced 2 main effects: first, there was a move away from utilization of CEMRA towards CTA; second, NSF stimulated a major impetus for the development of noncontrast magnetic resonance angiography (NCMRA) techniques. Computed tomography (CT), particularly with the development of multidetector CT, was undergoing a technological advancement, allowing high-resolution rapid scanning of the entire human body at lower radiation doses than were achievable previously. These advances resulted in much shorter scan times, significantly shorter than MRA, and greater spatial resolution, approximating what could be achieved by conventional angiography (10). There remained concerns with CTA, particularly over the use of potentially nephrotoxic iodinated contrast in renal dysfunction patients (which represented a significant number of the PAD population) and the blooming artifact from heavily calcified vessels precluding assessment of patency (again a problem frequently seen in diabetics). At the same time, many MR investigators began to focus their attention onto the development of novel, clinically applicable NCMRA techniques (11-13). Multiple strategies were developed, including novel pulse sequences, subtractive approaches to enhance arterial signal, or labeling blood flow with arterial spin labeling

*Editorials published in *JACC: Cardiovascular Imaging* reflect the views of the authors and do not necessarily represent the views of *JACC: Cardiovascular Imaging* or the American College of Cardiology.

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techniques. All of these techniques had a number of shared disadvantages: they had limited spatial resolution and were prone to artifact, which meant they performed poorly against the reference standard, digital subtraction angiography. They were also too complex to implement routinely in a busy clinical practice, which resulted in high failure rates. There was a need for an easy-to-use, reproducible, and accurate technique that could perform well compared with digital subtraction angiography and was at least comparable with its competition, CTA.

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The paper by Varga-Szemes et al. (14) in this issue of *iJACC* evaluates the recently developed quiescent-interval single-shot (QISS) technique for noncontrast imaging of the vasculature. QISS is a simple to run NCMRA technique, based on the steady-state free precession MR pulse sequence, and incorporates routine contrast enhancement MR strategies, such as fat saturation and venous suppression (15,16). There is no need for preparatory complex and time-consuming localization, resulting in a near push button set up and acquisition, such that operators of any experience and competency can run it. QISS MRA has been tested at 1.5-T and 3-T, with comparative efficacy reported, despite concerns over worsening artifact at 3-T (17). Additionally, the technique has been evaluated clinically in several vascular territories and has performed well (18). This is the first study at 1.5-T where QISS MRA is compared with CTA for assessing PAD, using digital subtraction angiography as the reference standard. A similar recently published study at 3-T also showed comparable results between QISS and CTA (19). It is notable that the authors chose a state-of-the-art CT scanner and technique as the comparator procedure, thereby making sure that QISS was tested against the best that CTA can provide. It is also worth pointing out that this investigative team are better known for their CTA work, making the results of this MRA study all the more compelling and credible.

There were 3 important findings in this study. First, the sensitivity and specificity of QISS MRA was comparable with CTA, using digital subtraction angiography as the reference standard, even though CTA had comparatively higher spatial resolution (QISS: $1 \times 1\ mm^2$ vs. CTA: $0.6 \times 0.6\ mm^2$). Overall, the results for sensitivity were comparable for both techniques, if not a little lower, than what has been reported by other published studies (16). Interestingly, there were more false positives for CTA than for QISS MRA for detection of significant >50% stenosis (13 vs. 8), although this difference was not statistically significant. Second, the image quality was scored similarly between both techniques. Of note, 2.8% of segments (n = 8) were considered nondiagnostic on QISS MRA, primarily due to stents and artifact. In comparison, 7.8% of segments (n = 42) were considered nondiagnostic on CTA primarily due to heavy calcification in vessels, inadequate opacification, and stents. Of the 8 segments excluded from CTA due to heavy calcification, 7 were diagnostic with QISS MRA. Calcification, particularly in small vessels, is a significant problem with CTA resulting in blooming artifact obscuring the vessel and precluding any assessment of patency. The study by Wu et al. (19) also demonstrated superior performance by QISS over CTA in heavily calcified vessels. Calf vessel calcification is especially common in diabetics and dialysis-dependent renal failure patients, both of whom are evaluated frequently and specifically with CTA. Poor vascular opacification as a cause of inadequate visualization is not surprising as well, because modern CT scanners are so fast that they tend to "overshoot" the contrast bolus. Also, the CTA runoff protocol is a moving table acquisition, similar to the older moving table, bolus chase MRA approach, where asymmetric or slow flow in runoff vessels resulted in inadequate visualization of distal vessels. This is not a concern with QISS MRA because vessel visualization is not dependent on the use of contrast. Third, and most important, the QISS MRA protocol is significantly simpler than the CTA approach. Although the QISS acquisition time was significantly longer that the CTA acquisition time (21.6 min for QISS vs. 4.1 min for CTA), the total procedure time, including patient preparation, was similar for both tests (25.6 min for QISS MRA vs. 24.4 min for CTA). The reason for this is the need for intravenous access insertion and point-of-care creatinine measurement with CTA, both of which are not required for QISS MRA. Additionally, what was not reported in this study was that the QISS software reconstructs the images in line and automatically displays the angiographic MIP images, which can be sent to Picture Archiving and Communications system (PACS), whereas CTA requires an additional 5 to 10 min of image processing by a technologist or physician to produce comparable images. Furthermore, and also not reported, are the cost savings for QISS MRA associated with not using contrast medium, point-of-care testing and an intravenous cannula.

QISS MRA is one of the more promising NCMRA techniques to emerge in recent years, largely due to its simplicity in implementation, but also its proven accuracy compared with standard of care comparable imaging techniques. This study demonstrates that it is at least comparable with CTA, the primary competing

modality for MRA. The lack of a requirement for contrast, intravenous cannula, and point-of-care testing make QISS MRA a cost-effective alternative to conventional CEMRA or CTA. Because QISS MRA is not affected significantly by calcification or vessel visualization due to poor contrast flow, it is arguably the test of choice for patients at greater risk for small vessel calcification, such as diabetics and dialysis-dependent renal failure patients and should be considered first line in "at-risk" patients (e.g., children, pregnant women, those with a contrast allergy). Technological advances are ongoing to improve QISS MRA further and shorten its acquisition time, and as its clinical efficacy continues to be proven in multiple vascular territories, we may see this technique used more frequently as a first-line approach to diagnosing PAD.

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KEY WORDS cardiovascular magnetic resonance, noncontrast magnetic resonance angiography, quiescent-interval single-shot