Prospective Comparison of Cartesian Acquisition with Projection-like Reconstruction Magnetic Resonance Angiography with Computed Tomography Angiography for Evaluation of below-the-Knee Runoff

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ABSTRACT

Purpose: To compare prospectively the assessment of stenosis and radiologist confidence in the evaluation of below-the-knee lower extremity runoff vessels between computed tomography (CT) angiography and contrast-enhanced magnetic resonance (MR) angiography in a cohort of 19 clinical patients.

Materials and Methods: The study was compliant with the Health Insurance Portability and Accountability Act of 1996 and approved by the institutional review board. Imaging was performed in 19 consecutive patients with known or suspected peripheral arterial disease; both CT angiography and a more recently developed MR angiography technique were performed within 24 hours of each other and before any therapeutic intervention. Resulting images were randomized and interpreted in blinded fashion by four board-certified radiologists with expertise in CT angiography and MR angiography. Vasculature of the lower leg was apportioned into 22 segments, 11 for each leg. For each segment, degree of stenosis and confidence of diagnosis were determined using a 3-point scale. Differences between CT angiography and MR angiography were assessed for significance using pooled histograms that were analyzed using the Wilcoxon signed rank test.

Results: For assessment of stenosis, there was no difference in CT angiography compared with MR angiography for 20 of 22 segments. For confidence of diagnosis, assessment of popliteal arteries was superior on CT angiography compared with MR angiography ($P < .05$). Confidence in assessment of both tibioperoneal trunks and the left proximal anterior tibial artery was not significantly different between CT angiography and MR angiography. Confidence in assessment of all other 17 segments was superior with MR angiography compared with CT angiography ($P < .02$).

Conclusions: MR angiography using the method described here is a promising technique for evaluating lower extremity arterial runoff. MR angiography had an overall superior performance in radiologist confidence compared with CT angiography for imaging runoff vessels below the knee.

ABBREVIATIONS

CAPR = cartesian acquisition with projection-like reconstruction, MIP = maximum intensity projection, SENSE = sensitivity encoding

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Contrast-enhanced magnetic resonance (MR) angiography and computed tomography (CT) angiography are widely used for noninvasive evaluation of lower extremity arterial vasculature (1–4). With current routine MR angiography methods, the image acquisition time used for imaging the runoff vessels generally extends beyond the arterial phase of the contrast bolus, typically several tens of seconds long. There is a tradeoff in how this time can be used—either forming a single three-dimensional image with very high spatial resolution or apportioning the time into multiple, time-resolved three-dimensional images that have reduced

spatial resolution (5). Also, with time-resolved studies, the possibility of a nondiagnostic study secondary to bolus mistiming to the distal lower extremities is essentially eliminated. More recently, several authors (6–8) have demonstrated that parallel acquisition techniques, such as two-dimensional sensitivity encoding (SENSE) (9) and generalized autocalibrating partially parallel acquisition (10), can be incorporated into time-resolved MR angiography acquisition of the lower extremities. This approach typically results in excellent image quality and correlation to conventional angiography, although to date these techniques typically obtain lower spatial resolution datasets than CT.

Because CT angiography and MR angiography techniques both have potential advantages and disadvantages, the best choice of examination for a specific patient with suspected peripheral vascular disease is unclear. Few data are available that prospective compare the efficacy and accuracy of CT angiography with MR angiography examinations performed using state-of-the-art techniques, particularly for assessment of distal runoff vessels, which can be important to evaluate when determining therapeutic options in patients with critical limb ischemia.

A MR angiography technique has been developed—cartesian acquisition with projection-like reconstruction (CAPR)—to generate high spatial and temporal resolution time-resolved MR angiography images (11–13). The high acceleration provided by two-dimensional SENSE and partial Fourier acceleration, as allowed by the specialized receiver coils, enables imaging the distal runoff vessels with 1-mm isotropic spatial resolution and a frame time of 4.9 seconds and has been shown to provide high fidelity in imaging an advancing contrast medium bolus (14). Initial implementation has demonstrated that this technique can be successfully employed to evaluate lower extremity arterial vasculature (12). We sought to compare prospectively the degree of stenosis assessed by CAPR and CT angiography and the confidence of the radiologist when evaluating patients with known or suspected peripheral vascular disease with both CAPR and CT angiography examinations performed at our institution. The end goal was to establish whether the technical developments achieved in CAPR MR angiography would translate into a clinical tool that compared favorably with our current standard clinical approach in terms of stenosis assessment and radiologist confidence in assessing runoff vessels in the calf.

MATERIALS AND METHODS

This prospective study was compliant with the Health Insurance Portability and Accountability Act of 1996 and approved by the institutional review board, and all subjects provided signed informed consent before enrollment. From March 2009 to December 2009, subjects with known or suspected peripheral vascular disease who were clinically referred for imaging with CT angiography were also recruited as subjects for CAPR MR angiography; no patients were excluded from recruitment as subjects. Both examinations were performed within 24 hours of each other and before any therapeutic intervention. The patients all were clinically referred first to CT angiography and recruited for MR angiography without respect to clinical factors. All subjects had a creatinine clearance calculated within 7 days of the examination, and in all cases the estimated glomerular filtration rate was > 30 mL/min/1.73 m^2 according to the MDRD (Modification of Diet in Renal Disease) formula (15). There were 47 potential participants who met inclusion criteria and were approached for participation, and 19 consented to participation. Mean patient age was 65.8 years (range, 47–85), and there were 7 women and 12 men. Risk factors for vascular disease included current or former heavy smoking in 13 of 19 patients, hypertension in 10 of 19 patients, and type 2 diabetes mellitus in 3 of 19 patients.

The CT angiography technique was performed according to our current standard clinical practice and employed a 64-detector row scanner (SOMATOM Definition; Siemens, Erlangen, Germany) with injection of 145 mL of iodinated contrast agent, iohexol (Omnipaque 350; GE Healthcare, Waukesha, Wisconsin), 25 mL at 5 mL/s and 120 mL at 4 mL/s, followed by 30 mL of saline at 4 mL/s. The CT angiography examination extended from 4 cm above the iliac crest to the bottom of the feet. Parameters included 0.5-second rotation time, pitch 0.8, 15 mm/rotation, 120 kVp, and 250 mAs. Automated triggering and exposure control were employed. CT spatial resolution was $0.6 \times 0.6 \times 2.0$ mm^3. The table speed was 30 mm/s. Per our standard clinical practice, a second run was immediately performed after the first run from the knees to the toes to minimize the chance of missing the contrast agent bolus owing to inflow disease.

CAPR MR angiography followed a previously described technique as follows: 20 mL of gadobenate dimeglumine (MultiHance; Bracco Imaging, Princeton, New Jersey) injected at 3 mL/s followed by 20 mL of saline at 3 mL/s (12). Imaging was performed on a 3T scanner (Signa v. 20.0; GE Healthcare) using a custom eight-element receive array coil designed in-house (13). At the time, gadobenate was the highest relaxivity agent available on formulary at our institution. The MR angiography sequence was a three-dimensional gradient recalled echo sequence with the following parameters: TR/TE = 5.85/2.7 ms; flip angle, 30 degrees; bandwidth, ± 62.5 KHz; field of view, 40 (superior/inferior) × 32 (left/right) × 13.2 (anterior/posterior) cm^3; two-dimensional SENSE with acceleration R = 8; isotropic spatial resolution of 1 mm^3 during acquisition; frame time, 4.9 seconds; and temporal footprint, 17 seconds. The temporal footprint is defined as the time over which data are acquired in forming a single image of the volume. The MR angiography examination covered a single field of view extending from the knees to the ankles. No patients were specifically referred for inclusion in the study for CAPR MR angiography because of suboptimal CT angiography.