Diagnostic Accuracy of Time-Resolved MRA for Calf and Pedal Arterial Disease in 52 patients

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Introduction: Magnetic resonance angiography (MRA) is increasingly utilized for diagnosis of peripheral vascular disease, but accuracy for the infrapopliteal arteries can be diminished due to their small size and venous contamination. One way to eliminate venous contamination in the calf is with time-resolved MRA. 2D projection MRA accelerates data acquisition by eliminating the slice encoding and allows images to be obtained every 1~2 seconds with high spatial resolution. Furthermore, the high temporal resolution ensures at least one pure arterial phase image for every calf is obtained without the need for bolus timing even when there are differential flow rates between two legs. In this study the accuracy of time-resolved 2D projection MRA is assessed by comparing to X-ray DSA in those patients who underwent selective X-ray DSA within 30 days of MRA.

Subjects and Methods: Over three years, 52 patients (28 males, 24 females) underwent routine peripheral MRA including 2D projection MRA of the infrapopliteal arteries followed by X-ray DSA correlation. The average interval between MRA and X-ray DSA was 22.1 days. Only symptomatic extremities underwent DSA so this retrospective analysis involves only 59 legs in the 52 patients. All MRA examinations were performed on a 1.5 T GE Signa MR scanner using a head coil for signal transmission and reception. A 2D fast gradient echo sequence was used with ~2-second temporal resolution using TR/TE/flip angle = 9/2/50°, NEX = 1, slice thickness = 50-160 mm, FOV = 30-32 cm, matrix = 256 × 192 with a 2D spatial resolution of 1.2 x 1.6 mm. For each extremity, 3 blinded expert reviewers independently analyzed 10 native arterial segments for each MRA and DSA exam. The degree of stenosis was graded as no significant stenosis (< 50%), significant stenosis > 50%, occlusion and a consensus grade was determined. Arterial segments with discrepancies between X-ray DSA and MRA consensus readings were re-reviewed to determine the reason. Sensitivity and specificity of time-resolved 2D projection MRA for the detection and grading of significant lesions, defined as both significant stenosis and occlusion, and for the detection of occlusive disease, were determined with use of the consensus X-ray DSA readings as the gold standard. Unweighted Cohen's kappa was calculated for the correlation of consensus MRA readings with consensus DSA readings for each arterial segment.

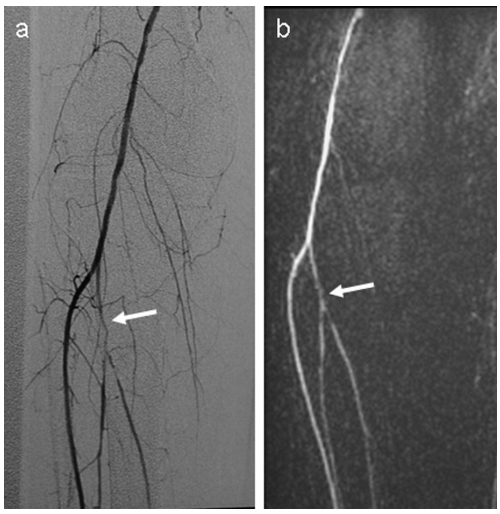

Figure 1. Coronal XRA (a) and MRA (b) of the right trifurcation in a 46-year-old female with right calf cellulitis show a stenosis of the tibio-peroneal trunk (arrow) graded not significant on MRA but significant on XRA.

Results: A total of 542 infrapopliteal segments were analyzed on 2D projection MRA and X-ray DSA, of which 232 (43%) were identified by X-ray DSA as occluded and 72 (13%) segments as significantly stenotic. Unweighted Cohen's kappa was 0.44-0.92 indicating fair to good agreement between X-ray DSA and MRA. Inter-observer disagreement occurred in 20% (n = 110) of the arterial segments on X-ray DSA vs. only 16% (n = 85) on MRA (P < 0.05). The data in 59 symptomatic extremities demonstrate that time-resolved MR angiography tracks the passage of Gd contrast through the infrapopliteal arteries producing high quality arterial phase images with a high degree of accuracy (Table 1). Overall sensitivity/specificity for 2D time-resolved MRA to detect significant stenosis was 84%/94% for the calf and 79%/71% for the foot. When diagnosing arterial occlusion, even higher sensitivity and specificity were achieved (89%/95% for the calf, and 79%/86% for the foot). As expected, arteries in the calf were more accurately depicted than arteries in the foot due to difficulty in resolving the small pedal arteries with MRA and due to foot motion. Re-review of images for the 105 segments with discrepancies between MRA and X-ray DSA showed the difference in interpretation was mainly due to borderline lesions that could easily be graded either way in 43 segments. In 22 segments, it was felt that MRA was more likely to be correct than X-ray DSA when X-ray DSA was poor quality (n = 3) and when the bolus timing was different between MRA and X-ray DSA, with MRA tending to identify vessels that never opacified adequately on X-ray DSA.

Discussion: These data in 59 symptomatic limbs show time-resolved MRA is accurate for evaluating infrapopliteal vascular disease. Higher interobserver agreement for MRA than X-ray DSA (84% vs. 80%) and 22 discrepant segments with MRA more convincingly the truth than DSA suggest that X-ray DSA is not a perfect reference standard. MRA tended to have a longer bolus duration that allowed more time for filling of infrapopliteal arteries especially when proximal occlusive disease forced arterial enhancement to occur in a retrograde fashion. The pattern of reduced accuracy in smaller arteries (especially pedal arteries) suggests that higher spatial resolution MRA may improve accuracy. Improvement of post-processing techniques and techniques that share peripheral k-space from multiple time points may improve accuracy for small distal vessels by increasing the resolution and extending the data set into the third dimension to allow reformatting to multiple projections. These techniques include 3D TRICKS, VIPR and 3D spiral with sliding window reconstruction.

Table 1. Comparison between Time-resolved MRA and X-ray DSA.

		Calf X-ray DSA (n = 399 arterial segments)			
		Insignificant	Significant	Occlusion	Total
MRA	Insignificant	159	26	10	195
	Significant	7	27	9	43
	Occlusion	4	7	150	161
	Total	170	60	169	399

		Foot X-ray DSA (n = 143 arterial segments)			
		Insignificant	Significant	Occlusion	Total
MRA	Insignificant	48	7	9	64
	Significant	11	3	4	18
	Occlusion	9	2	50	61
	Total	68	12	63	143

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