SUPERFICIAL FEMORAL ARTERY OCCLUSIVE DISEASE SEVERITY CORRELATES WITH MR CINE PHASE CONTRAST FLOW MEASUREMENTS

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INTRODUCTION

MRA has advanced to the point where stenoses and occlusions are diagnosed with 83-99% sensitivity and 87-98% specificity using conventional DSA as the standard of reference. However, accurate depiction of the arterial lumen may not be sufficient to determine the hemodynamic significance of a particular lesion. With cine phase contrast (PC) technique, pulsatility (the variation of flow between systole and diastole), flow volume and flow velocity might help evaluate stenoses. In this study we retrospectively analyzed 2D cine PC flow data obtained above and below arterial disease in the thigh for patients with peripheral vascular disease (PVD) undergoing routine peripheral bolus chase MRA and at similar locations in normal subjects.

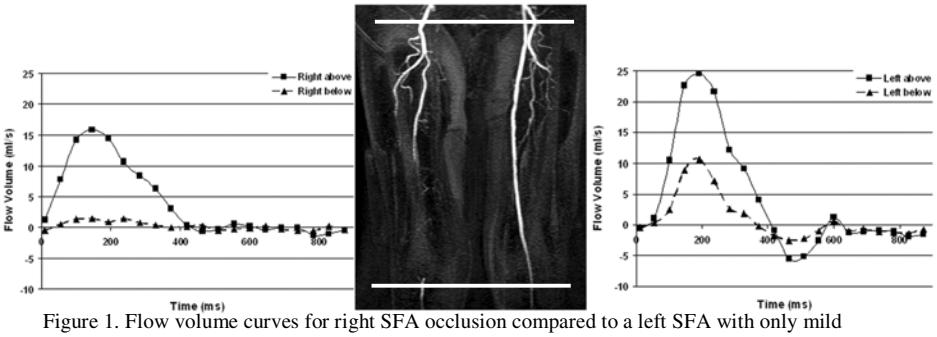

Figure 1. Flow volume curves for right SFA occlusion compared to a left SFA with only mild narrowing. Note the loss of triphasic flow and markedly decreased flow volume with SFA occlusion.

MATERIALS AND METHODS

Forty-eight patients with suspected PVD underwent routine bolus chase peripheral MRA with cine PC flow measurements for each leg. 2D cine PC flow measurements were also obtained in 9 healthy volunteers. All imaging was performed on the same 1.5 T MR scanner (GE Signa EXCITE). Flow data was obtained at the proximal and distal thigh with the following parameters: TR/TE/flip = 6.9/3.3/30°, FOV = 32 cm; 6 mm slice thickness; matrix = 256 x 256; NEX = 1; venc = 100 cm/s. A pulse oximeter on the index finger was used for peripheral gating. Imaging parameters for the volunteer study were identical to patient study except that NEX = 4 to compensate for absence of Gd and the venc = 150 cm/s.

Table 1. Cine PC flow parameters versus SFA disease

Disease Severity	Peak Velocity Ratio	p value	# of Arteries with Peak Delay	p value	Flow Volume Ratio	p value
Normal (n = 18)	1.4 ± 0.2		1 (5.6%)		2.3 ± 0.9	
Mild stenosis (n = 26)	1.5 ± 0.5	0.56	6 (23%)	0.12	2.3 ± 1.3	0.89
Mod-to-Severe (n = 35)	1.9 ± 1.0	0.01	17 (49%)	< 0.001	2.5 ± 1.7	0.61
Occlusion (n = 35)	2.0 ± 1.0	0.003	33 (94%)	< 0.001	3.9 ± 4.4	0.04

The severity of atherosclerotic disease in between the two flow measurement levels was graded as normal, atherosclerotic but no significant lesion (stenosis < 50%), moderate-to-severe stenosis (≥ 50%) or occlusion based upon 3D Gd MRA images in all patients or 2D time-of-flight in the normal volunteers. All 2D cine PC data were post-processed using Medis flow analysis software to obtain flow velocity and flow volume curves above and below the lesions and correlated to disease severity. The statistical significance of flow volume ratio and peak velocity ratio at proximal and distal level was determined using students t-test. Spearman correlation coefficients were calculated to evaluate the relationship between different variables and disease severity.

RESULTS

In normal volunteers, triphasic flow rate curves were obtained in all the 18 arterial segments. For the 96 arterial segments in 48 patients, 26 had no significant lesion, 35 had moderate-to-severe stenosis, and 35 were occluded. In 84% of arterial segments (n = 21) with mild disease, the flow patterns at the lower level were unchanged. In 21 out of 35 (60%) segments with moderate-to-severe stenosis, flow patterns changed from triphasic above to biphasic (n = 7) or monophasic (n = 3) below the lesion or from biphasic to monophasic (n = 11) indicating lower capillary resistance below these stenoses. Below occlusions, 74% (n = 26) were monophasic (Figure 1) and there was a small number with a biphasic flow pattern (n = 7). Data on peak velocity ratio, incidence of peak delay and flow volume ratio from 9 normal volunteers and 48 patients are shown in Table 1. Compared to normal arteries, severe stenoses and occlusions had significant increases in peak velocity ratio ($p = 0.01$ and 0.003 respectively) and the number of arteries with peak delay was significantly higher ($p < 0.001$). Two variables showed significant positive correlation with the severity of arterial disease, including existence of peak delay ($r = 0.65$, $p < 0.001$) and peak velocity ratio ($r = 0.31$, $p < 0.001$).

DISCUSSION

When evaluating arterial occlusive disease, detecting functional significance of stenoses is often more important than determining percentage narrowing of the lumen. In the absence of a trans-stenotic pressure gradient, revascularization techniques will not augment blood flow, but still pose the risk of procedure-related complications. Thus, an important goal of MRA techniques is to noninvasively determine the hemodynamic significance of each stenosis.

MR flow measurement on PC images shows high accuracy and excellent correlation with direct flow measurements. Arterial flow parameters including the flow waveform pattern, flow velocity, flow volumes have been utilized to evaluate hemodynamic significance of arterial occlusive disease. Data in this study are similar to the expected flow based on prior studies. Combining cine PC data with MRA may reduce interobserver variability on stenosis grading. Quantitative flow data may help to increase the sensitivity and negative predictive value thus yielding higher confidence when interpreting 3D MRA images.

In conclusion, 2D cine PC flow measurements add functional information to the peripheral MRA examination without substantially prolonging scanning time or requiring additional contrast injection. This may help to improve therapeutic planning, simplify the amount of catheter manipulation required at the time of interventional procedures and ultimately improve management of peripheral vascular disease patients.

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