SNR Optimized Contrast-Enhanced MRA of the Peripheral Vasculature using Patient Specific Timing Parameters: Comparison between High and Conventional Relaxivity Contrast Agents in Patient Suspected of Arterial Occlusive Disease

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Introduction

Single injection moving table peripheral contrast enhanced MR angiography is increasingly utilized for the evaluation of peripheral atherosclerotic occlusive disease (PAOD). Peripheral MRA (pMRA) is typically performed using a moving table technique during first passage of double to triple dose (0.2-0.3 mmol/kg) extracellular gadolinium chelate. The objective of this study was to compare the first pass imaging properties of a high relaxivity contrast agent (HRCA) with a conventional extracellular agent in patients suspected of peripheral arterial occlusive disease using a previously described SNR-optimized pMRA technique incorporating patient-specific timing parameters[1]. Gd-BOPTA (Multihance, Bracco Diagnostics, Princeton, NJ) is a high relaxation gadolinium contrast agent that has proven advantageous in clinical contrast MRA examinations due to its two-fold greater relaxivity in blood. We compare here optimized pMRA using similar doses (~0.2 mmol/kg) of MultiHance and conventional relaxivity contrast agents (CRCA), as well as smaller doses (~0.1 mmol/kg) of MultiHance.

Methods

Study Design. This was a retrospective study performed in compliance with the guidelines of the local IRB. Three-station moving-table pMRA was performed on 48 clinical patients being evaluated for suspected or proven peripheral vascular occlusive disease (PVOD) – 12 with peripheral ulcers, 36 with claudication. For the 3-station pMRA examination, each patient was administered either conventional gadolinium (Prohance or Magnevist) dosed at ~0.2 mmol/kg (CRCA$_{0.2}$, n=23, 0.18 $\pm$ 0.04 mmol/kg), MultiHance dosed at ~0.2 mmol/kg (HRCA$_{0.2}$, n=20, 0.19$\pm$0.02 mmol/kg) or MultiHance dosed at ~0.1 mmol/kg (HRCA$_{0.1}$, n=5, 0.09$\pm$0.01 mmol/kg).

MR Imaging. All studies were acquired on a 1.5T system (GyroscanNT, Philips Medical Systems, Best, the Netherlands) using a prototype 18 channel peripheral vascular coil. Using the technique referenced[1], an aortic timing bolus and time-resolved lower station MRA were first performed (5-7 cc additional contrast) to determine venous enhancement time and best timing parameters, followed by SNR-optimized 3-station pMRA to make best use of the available "venous free" time and begin lower station acquisition before venous arrival. Parallel imaging was used in all stations, with true acquired resolution of 1.2x2.1x2.6 / 1.2x2.1x2.0 / 1.0x1.0x1.0 mm^3 for the upper/middle/lower stations respectively, and upper and middle acquisition times ranging from 5 to 20 sec. Biphasic bolus injections (50% total volume each phase) were 1.7 $\pm$ 0.3 and 1.3 $\pm$ 0.2 mL/s for the 0.2 mmol/kg patients, and 1.3 $\pm$ 0.3 and 0.8 $\pm$ 0.3 mL/s for the 0.1 mmol/kg patients. Examples are shown in Figure 1.

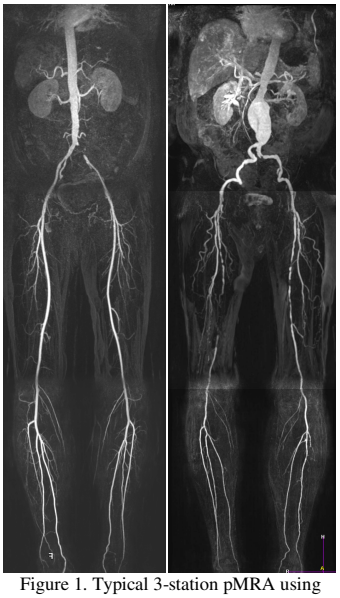

Figure 1. Typical 3-station pMRA using (a) CRCA 0.2 mmol/kg, (b) HRCA 0.1 mmol/kg.

Image Evaluation. Quantitative arterial-to-muscle ratio (CR$_{musc}$), subjective image quality (IQ), and degree of venous enhancement (VE) were scored for each patient. Arterial and muscle signal intensity (SI) in 3-4 separate ROI's were measured for each station. CR$_{musc}$ for each station was then calculated as [SI$_{artery}$ – SI$_{musc}$]/ SI$_{musc}$. SNR was not primarily evaluated because parallel imaging was used, which suffers from inhomogenous noise distribution. For qualitative image assessment, three MIP's (coronal and bilateral obliques) for each case/station were blindly presented to a single radiologist. IQ and VE were rated on a four-point scale (0-3). For IQ, 3 was excellent, 2 good (suffering slightly from lower vessel to background contrast or timing issues but still diagnostic), 1 fair (significant artifacts or vessel-to-background contrast reduction and marginally diagnostic), and 0 non-diagnostic. For VE, 0 denoted none, 1 some superficial venous enhancement not compromising image interpretation, 2 deep venous enhancement not compromising interpretation, and 3 venous enhancement rendering interpretation extremely difficult or impossible.

Statistical Analysis. Analysis of CR$_{musc}$ was performed using a non-paired t-test. The qualitative scores were analyzed for significance using the Mann-Whitney U test for non-parametric data. Both considered a p value < 0.05 significant.

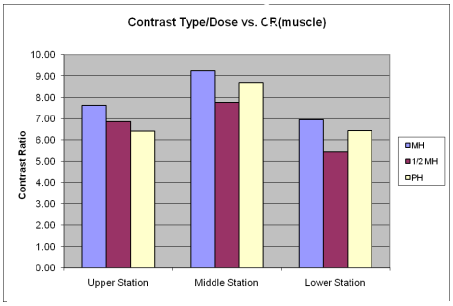

Figure 2. Graph showing CR$_{musc}$ comparison between HRCA 0.2 mmol/kg (MH), HRCA 0.1 mmol/kg (1/2 MH), and CRCA 0.2 mmol/kg (PH).

Findings

All studies were high quality and diagnostic. The average CR$_{musc}$ in the upper station (US) for HRCA$_{0.2}$, HRCA$_{0.1}$ and CRCA$_{0.2}$ was 7.65, 6.42, 6.86 respectively. In the middle (MS) and lower stations (LS) these ratios were 9.25, 8.70, 7.78, and 6.95, 6.43, 5.45 (Figure 2). Although HRCA$_{0.2}$ trended higher (Figure 2), student t-test analysis demonstrated no significant difference (p>0.05) between the 3 contrast groups. IQ and VE also failed to reach significance (p> 0.05), with the average arterial IQ scores for HRCA$_{0.2}$, HRCA$_{0.1}$ and CRCA$_{0.2}$ being 2.4, 2.6, 2.65 in the US, 2.85, 2.8, 2.65 in the MS, and 2.8, 2.8, 2.65 in the LS respectively. The degree of average VE was 0.9, 0.7, 0.8 respectively. Statistically significant difference was only obtained when signal to noise ratio (SNR) was estimated (using the standard deviation of muscle as "noise"), with HRCA$_{0.2}$ superior to both HRCA$_{0.1}$ (p=0.041) and CRCA$_{0.2}$ (p =0.039) in the LS only.

Discussion

The identical dose of ~0.2mmol/kg demonstrated no significant qualitative or quantitative differences between HR and CRCA's for pMRA, except for perhaps improved SNR in the lower station with HRCA$_{0.2}$. This is surprising, as HRCA's are believed and have been shown to be advantageous for CE-MRA. Even more interesting, there was no significant difference between 0.2 and 0.1 mmol/kg dosing for HRCA. This strongly suggests that a.) 0.1 mmol/kg HRCA is the equivalent of 0.2 mmol/kg CRCA for pMRA, and b.) the benefits of increased relaxivity are somehow not being fully exploited, as doubling the dose (and increasing the injection rate) of HRCA does not lead to significant improvement. This finding parallels a recent study showing 0.2 mmol/kg MultiHance inferior to 0.1 mmol/kg MultiHance for renal, pelvic, and carotid MRA[2], perhaps related to T2 relaxivity effects. This result warrants further investigation into how to best dose/administer HRCA's, but nicely demonstrates the efficacy of single injection moving table pMRA using 0.1 mmol/kg MultiHance.

References

1.) Potthast et al. Peripheral moving table CE-MRA using a prototype 18-channel peripheral vascular coil and scanning parameters optimized to the patients individual hemodynamics. In press, *J Magn Reson Imaging.*

2.) Schneider et al. Gadobenate dimeglumine-enhanced MR angiography: Diagnostic performance of four doses for detection and grading of carotid, renal, and aorto-iliac stenoses compared to digital subtraction angiography. *J Magn Reson Imaging*. 26(4):1020-32, 2007.