Renal Artery Phase Contrast MRA: Improved Image Quality Using A Vastly Under-sampled Isotropic Projection Reconstruction (VIPR) Technique

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INTRODUCTION: A novel MRA technique for phase-contrast with vastly undersampled isotropic projection reconstruction (PC-VIPR) has been developed.[1] Advantages of PC-VIPR include broader spatial coverage, isotropic spatial resolution, and smaller voxel sizes than conventional three dimensional (3D) Cartesian Fourier Transform (PC-3DFT) imaging. Data acquisition along 3D radial *k*-space trajectories coupled with projection reconstruction may reduce motion and pulsatile flow artifacts, which are often a problem in PC-3DFT. Furthermore, the streak artifacts associated with undersampling in VIPR are not as prominent due to the inherent subtraction involved in PC processing. Promising results have recently been reported with PC-VIPR of the intracranial vasculature.[2] However, no feasibility studies as of yet have been performed with abdominal PC-VIPR MRA. The objective of this study is to compare the image quality of PC-VIPR against PC-3DFT in a prospective, randomized trial for subjects with suspected renovascular disease.

MATERIALS AND METHODS: With institutional review board approval, 20 subjects (7 women, 13 men, ages 31-77, mean age 53.2) referred for possible renal artery stenosis provided written informed consent. All MR examinations were performed on a 1.5-T system (Signa Twinspeed; software version 11; GE Healthcare, Waukesha, WI) with gradients operating in "Whole Body" mode (23mT/m gradient strength, 80-mT/m/msec slew rate). All subjects were administered intravenous contrast (gadodiamide - Omniscan, Amersham, Princeton, NJ), 0.3 mmol/kg at 3 mL/sec. Following our standard contrast enhanced MRA protocol, all subjects underwent consecutive imaging with both PC-VIPR (TR=14.3; TE=6.3; FlipAngle=15^o; BW=15.6kHZ; VENC=40cm/s; FOV=60cm; Matrix=384x384; 384 slices; Slice Thickness=1.56mm; Z-Axis Coverage=19.2cm; Voxel Volume=3.8mm^3; Duration=343sec, 6000 projections) and PC-3DFT (TR=30; TE=6.2; FlipAngle=45^o; BW=15.6kHZ; VENC=40cm/s; FOV=32x24 cm; Matrix=256x128; 24 slices; Slice Thickness=3.6mm; Z-Axis Coverage=8.64cm; Voxel Volume=11.25mm^3; Duration=323sec) techniques. To eliminate possible bias associated with temporal proximity to the administration of gadolinium; PC-3DFT was performed prior to PC-VIPR on even dates and vice-versa on odd dates. Axial complex difference "speed" images were generated. A single blinded reader assessed the axial and maximum intensity projection (MIP) images for each technique independently in randomized order on an image analysis workstation (Advantage Windows, software version 4.2, GE Healthcare, Waukesha, WI). Image quality and degradation from artifacts were assessed on a 5-point scale. Proximal, distal, and segmental vessel conspicuity was assessed based on a 4-point scale. Contrast to noise ratio (CNR) was measured at the parent vessel, proximal aspect, and distal aspect of each arterial segment. The mean CNR was compared using a paired t-Test, while the qualitative scores were analyzed with McNemar's test. An acceleration factor of PC-VIPR over PC-3DFT was calculated as the product of the ratios of voxel volume, relevant imaging volume, & scan duration.

RESULTS: The randomization protocol resulted in PC-3DFT and PC-VIPR performed first in an equal number of studies. A total of 34 arterial segments were analyzed. Six of 20 subjects were recipients of renal transplants. PC-VIPR provided an acceleration factor of 10 for the relevant imaging volume.

Axial PC-VIPR | Axial PC-3DFT | Coronal PC-VIPR MIP | Coronal PC-3DFT MIP | Volume Rendered PC-VIPR

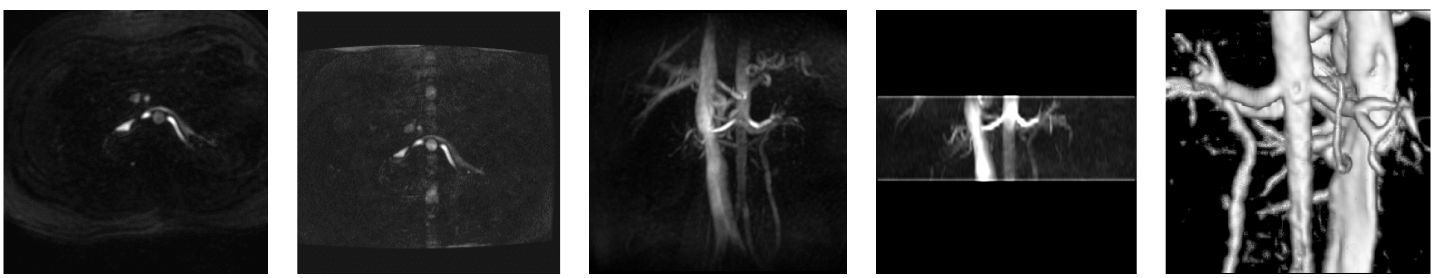

Table 1: Contrast to Noise Ratios

	PC-VIPR [mean +/- STD (range)]	PC-3DFT [mean +/- STD (range)]	
Aorta/Iliac Artery at ostia	33.9 +/- 16.3 (3.5 – 65.8)	16.6 +/- 7.5 (0.7 – 30.1)	P< 0.001
Proximal Renal Artery	41.6 +/- 26.6 (3.4 – 124.0)	17.2 +/- 10.1 (0.7 – 45.3)	P < 0.001
Distal Renal Artery	25.5 +/- 15.4 (0.9 – 69.7)	11.2 +/- 7.5 (1.5 – 35.5)	P < 0.001

The CNR of PC-VIPR was superior to PC-3DFT in 95% (19/20), 91% (31/34), and 88% (30/34) for the aorta/iliac, proximal, and distal arterial segments respectively. PC-VIPR produced a larger proportion of relatively artifact free images (mild/minor or no artifact) 80% (16/20) versus 35% (7/20) (p=0.008). Overall axial image quality was good or very good in 85% (17/20) of cases for PC-VIPR, while in only 55% (11/20) of cases for PC-3DFT (p=0.041). MIP image quality was good or very good in 75% (15/20) for PC-VIPR, while in only 50% (10/20) of cases for PC-3DFT (p=0.073). Although vessel conspicuity scores were generally higher for PC-VIPR, a statistically significant difference was only present for the segmental arteries. The segmental renal arteries were clearly identified for PC-VIPR in 68% (23/34) versus 41% (14/34) for PC-3DFT (p=0.016).

CONCLUSIONS: PC-VIPR produces superior depiction of the renal arteries. In addition, the use of voxels with isotropic resolution facilitates 3D volume rendered display. Our evaluation reveals higher CNR in 88-95% of segments, a larger proportion of relatively artifact free exams, consistently higher image quality scores, improved conspicuity of the segmental arteries, and an acceleration factor of 10 for the relevant imaging volume. Our experience with PC-VIPR also demonstrates little signal loss in areas of complex flow. Therefore, velocity and flow measurement at the site of a stenosis may be possible. Further evaluation is warranted, especially to elucidate whether this promising technique can unleash the potential of phase contrast MRA for evaluating the hemodynamic significance of a stenosis.

REFERENCES:

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