# Non-Contrast Enhanced Renal MR Angiography with PC VIPR

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**Introduction:** Phase-contrast vastly undersampled projection reconstruction (PC VIPR) has been shown to provide both anatomical and functional velocity information, with high spatial resolution and large coverage in a reasonable scan time [1]. The use of the 3D radially undersampled VIPR trajectory overcomes several of the limitations of Cartesian PC MR acquisitions, most importantly the lengthy scan time required to achieve adequate resolution, which also dramatically decreases artifacts from intravoxel dephasing. Since no contrast agent is required, this technique is of particular interest in light of increasing concerns for nephrogenic systemic fibrosis (NSF) which has been associated with gadolinium based contrasts agents in patients with diminished renal function and pro-inflammatory conditions [2]. While previous animal studies have validated anatomical and hemodynamic parameters obtained with PC VIPR including trans-stenotic and intraaneurysm pressure gradients [3-5], the approach has failed in renal artery imaging because of the presence of respiratory motion. Here we present our initial experience with a modified PC VIPR sequence with adaptive respiratory gating to provide high resolution isotropic non-contrasted enhanced angiograms of the renal arteries.

**Methods:** We have developed a dual-echo PC VIPR acquisition with a PILS reconstruction [6] and respiratory gating on a 3 T clinical system (Signa HDx TwinSpeed; GE Healthcare, Waukesha, WI). Respiratory gating is based on real-time bellows readings with an adaptive acceptance window. The technique was evaluated in 12 consecutive volunteers of whom 6 were also imaged with a contrast-enhanced (CE) MRA for comparison, and in 10 consecutive patients who also had a routine CE-MRA. The study was conducted with approval from our IRB and after obtaining informed consent. Common imaging parameters for PC-VIPR include: receiver bandwidth = ±62.5 kHz, subject adapted VENC of 20-100 cm/s, imaging volume = 320 x 320 x 320 $mm^3$, TR/TE = 9.5/3.6, isotropic spatial resolution = (1-1.25 $mm)^3$, scan time: approximately 10 min scan time with 50% respiratory gating efficiency.

**Results:** Fig. 1 demonstrates the effect of respiratory gating on the image quality, here shown as coronal MIPs. Although scan time is doubled for a 50% acceptance of the adaptive gating window, small branch vessels are well visualized (thin arrows) and the overall SNR and contrast improves (fat arrow) because of an improved consistency in the projection dataset. Fig. 2 shows that the smaller voxels decrease intravoxel dephasing and, therefore, poststenotic signal loss is minimized. Other representative results of the respiratory gated acquisitions are shown in Fig. 3. Note the large coverage and isotropic spatial resolution. In addition to the average flow data (a-c), individual cardiac frames may be reconstructed visualized with advanced software (d). While the veins are also visible in the PC VIPR data, smaller segmental arteries can be visualized because of the inherent subtraction of static tissue. The presence of high venous signal is not problematic because of the high spatial resolution allows vessels to be clearly distinguished from one another when reviewing images in multi-planar reformatted (MPR) images.

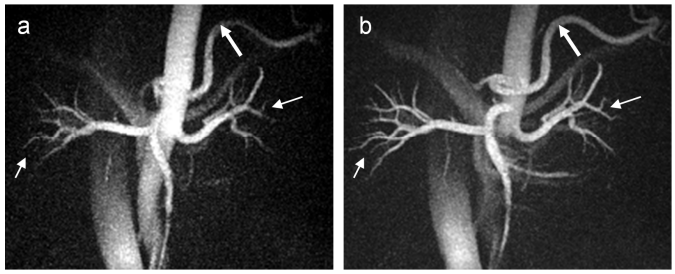


***Fig. 1:*** *PC VIPR acquisition without (a) and with adaptive respiratory gating. Scan times: 5:03 min (a) and 10:40 min (b).*

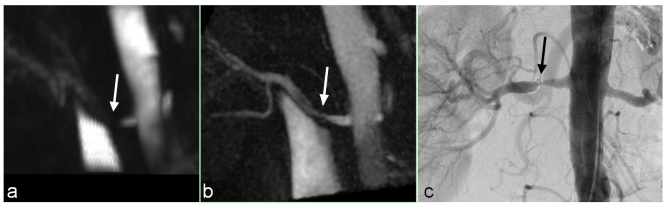


***Fig. 2:*** *Reformats from patient with right renal artery stenosis. The product 3D PC sequence reveals post-stenotic signal loss (a) while the PC VIPR sequence (b) shows the stenosis confirmed by DSA (c).*

**Conclusion:** The respiratory gated PC VIPR method provides high spatial resolution and high quality renal artery angiograms. Compared to Cartesian 3D cine flow measurements with the same scan time, the small voxel volumes minimize intra-voxel dephasing effects. This approach requires no contrast agent and, therefore, PC VIPR provides an excellent alternative for patients that are excluded from CE-MRA otherwise. In animal studies, we have previously demonstrated that this technique can be used to measure trans-stenotic pressure gradients non-invasively in carotid and iliac arteries with good agreement to endovascular measurements [3-5]. This combination of anatomical and functional information has the potential to improve the non-invasive evaluation of hemodynamic significant renal artery stenosis and spare patients avoidable invasive procedures. Further evaluation in a broad patient base is currently under way.

**Acknowledgements:** We gratefully acknowledge GE Healthcare for their assistance and support.

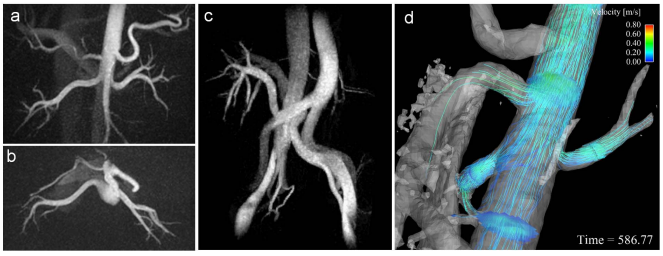


***Fig. 3:*** *Average flow data of a renal PC VIPR exam displayed as coronal (a) and axial (b) MIP for a volunteer and coronal MIP for a transplant patient (c). Example Ensight visualization of flow dynamics.*

**References:** [1] TL Gu *et al*, *AJNR* 26(4), 743-9, 2005 [2] L. Sadowski et al., *Radiology* 243(1), 148-57, 2007. [3] AS Turk *et al, AJNR* 28(1), 111-5, 2007. [4] R Moftakhar *et al*, *AJNR* 28:1710-1714, 2007. [5] D Lum *et al*, *Radiology* 245(3),2007 *[6]* KM Johnson *et al, ISMRM 2007,Abstract #3116*.