

# Non Contrast Enhanced (NCE)-MRA of the Renal Transplant Vessels: A comparison between IFIR and VIPR-SSFP

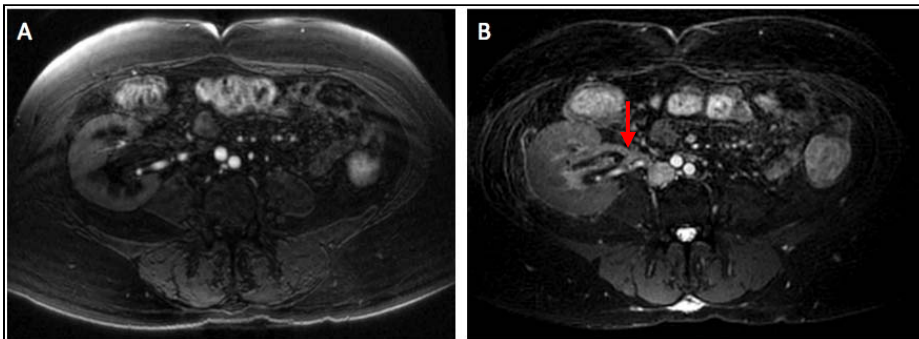
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**Purpose:** To compare the utility of two non-contrast enhanced MR angiographic (NCE-MRA) techniques for visualization of the renal transplant vessels. **Introduction:** There has been renewed interest in the development of NCE-MRA methods to image the renal transplant vasculature due to recognition of gadolinium contrast agents as major risk factors for Nephrogenic Systemic Fibrosis in patients with impaired kidney function. In this study, two distinct NCE-MRA sequences were evaluated for their ability to visualize the renal transplant vasculature: InFlow Inversion Recovery (IFIR)<sup>1</sup> and Vastly undersampled Isotropic Projection Reconstruction-SSFP (VIPR-SSFP)<sup>2</sup>. The IFIR sequence utilizes an inversion pulse to null magnetization in the imaging volume, which after a relatively long TI (>1000ms) is followed by a spectral fat saturation pulse and a balanced SSFP readout. Because the inversion pulse also nulls magnetization inferior to the imaging volume, inflow of venous blood during the inversion time is suppressed; as a result, inflow enhancement is limited to arterial blood alone. IFIR thus provides excellent contrast in arterial vessels, but suffers two significant shortcomings: first, the lack of signal from venous blood limits evaluation of the transplant renal vein anastomosis; additionally, the spectral fat-sat pulse used by IFIR is sensitive to B<sub>0</sub> inhomogeneities, which can lead to incomplete fat saturation when imaging the vasculature of renal transplants in the pelvis.

The second NCE-MRA sequence evaluated in this study was VIPR-SSFP<sup>2</sup>, which uses balanced readout gradients to acquire two radial half-echoes during each TR. By selecting a center frequency halfway between the fat and water resonances and acquiring data from two complete passes of k-space – one without RF phase cycling and one with a phase increment of  $\pi$  for each RF pulse – a linear combination (LC) of k-space data can be generated in which the stopband of the SSFP spectral response is centered over the fat resonance<sup>3</sup>. This technique is termed LC-SSFP, and provides robust fat suppression in anatomic regions where B<sub>0</sub> inhomogeneity is a concern. Although VIPR-SSFP images are not inflow-weighted, both arterial and venous blood have high contrast relative to background tissue, whose signal is diminished due to the T<sub>2</sub>/T<sub>1</sub> weighting of SSFP. We therefore sought to investigate whether VIPR-SSFP provides superior visualization of the renal transplant veins versus IFIR while maintaining adequate visualization of the transplant renal arteries.

**Methods:** For this IRB-approved retrospective study, twenty-one renal transplant patients were identified who received NCE-MRA exams with these two sequences between May 2008 and October 2010. Most of the patients underwent MR imaging to rule out transplant renal artery stenosis as a cause of significant increases in blood pressure. All patients were imaged on a 1.5 T scanner (Signa HDxt; GE Healthcare; Waukesha, WI). Scan parameters for the VIPR-SSFP sequence included:  $\alpha=30^\circ$ , TR=2.6ms, TE=0.3ms and 1.8ms, FOV=36cm spherical, and BW=  $\pm 125$ kHz with a 256x256 matrix and slice thickness of 1.4mm (total scan time was approx. 5 min). Scan parameters for the IFIR sequence included:  $\alpha=70^\circ$ , TR=4ms, TE=2ms, TI=1200ms, FOV=36cm, and BW= $\pm 75$ kHz with a 256x256 matrix and slice thickness of 2mm (total scan time was approx. 4 min). IFIR and VIPR-SSFP images for each of these patients were scored by two radiologists. The readers were instructed to assess four criteria in each set of images: overall image quality, quality of fat suppression, quality of arterial visualization and quality of venous visualization (focusing on the ability to identify the vessel anastomoses as well as renal arterial stenoses, if present). Each criterion was scored on a 1-4 Likert scale (4 = excellent, 1 = non-diagnostic). Readers were instructed to score arterial and venous visualization quality at 2 or below if the vessel anastomosis or suspected vascular pathologies could not be visualized with confidence. Scores for each criterion were compared using the Wilcoxon signed-rank test, and p-values were calculated for each comparison.



**Figure 1:** Representative (A) IFIR and (B) VIPR-SSFP images demonstrating the quality of renal vein visualization (red arrow) and fat suppression provided by the VIPR-SSFP sequence.

Mean Score by Criterion	IFIR	VIPR-SSFP
Overall Image Quality	3.52	3.43
Quality of Fat Suppression	3.40	3.69
Quality of Arterial Visualization	3.71	2.97
Quality of Venous Visualization	1.00	3.13

**Table 1:** Scores for the four criteria averaged across all patient images and between the two reviewers. VIPR-SSFP demonstrates statistically superior fat suppression and venous visualization, while IFIR provides superior arterial visualization. Note that no IFIR images were scored as being in the diagnostic range ( $\geq 3$ ) with regard to quality of venous visualization.

**Results & Discussion:** VIPR-SSFP was determined to be significantly superior to IFIR with regard to quality of venous visualization (Table 1;  $p = 0.00007$ ). Neither reviewer scored any of the IFIR images as providing quality sufficient to evaluate the renal vein anastomosis, or to evaluate venous pathology if present. This is not surprising as the IFIR sequence is designed to null signal from venous vessels. VIPR-SSFP also provided improved fat suppression versus IFIR within the margin for statistical significance ( $p=0.028$ ). As seen in Fig. 1, residual fat due to B<sub>0</sub> inhomogeneity has a much more benign, distributed appearance in the VIPR-SSFP image relative to the coherent ghosting of fat in the phase-encoding direction with IFIR. However, the quality of arterial visualization provided by IFIR was statistically superior to VIPR-SSFP ( $p=0.005$ ). Because IFIR focuses on enhancing arterial contrast at the expense of signal from venous vessels and background tissue, it provides somewhat improved arterial visualization versus VIPR-SSFP (mean score 3.71); nonetheless, the mean score for the VIPR-SSFP arterial quality (2.97) remained significantly above the threshold of diagnostic adequacy.

**Conclusions:** VIPR-SSFP provides significantly improved renal transplant vein visualization versus IFIR, but IFIR provides somewhat better arterial visualization. Future work will focus on modifying the VIPR-SSFP sequence to improve the quality of both arterial and venous visualization.

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**References:** 1. Braendli, et al. AJR 180:725-728(2003). 2. Lu, et al. JMRI 19:117-123(2004). 3. Vasanawala, et al. MRM 43:82-90(2000).