Non-Contrast Enhanced Renal MRA

By Thorsten Alexander Bley, MD

Multiple non-contrast-material enhanced MR Angiography (NCE-MRA) techniques have been available for several years, including Time-of-Flight (TOF) MRA, phase-contrast (PC) MRA, and balanced steady-state free precession (FIESTA). Because of recent concerns over the association between gadolinium-based contrast material and nephrogenic systemic fibrosis (NSF), there has been a renewed interest in the use of NCE-MRA. Also, significant improvements in MR scanner technology and sequence design, including parallel imaging techniques, have facilitated tremendous improvements of these methods.

Due to multidirectional flow pattern and respiratory motion, the renal arteries can be problematic for flow-dependent NCE-MRA techniques. In TOF MRA, bright intraluminal signal results from inflowing, unsaturated protons. Stationary protons surrounding the vessel are saturated by repeated RF pulses resulting in signal loss. This technique works well with through-plane flow. In-plane flow, however, becomes saturated, and for this reason, TOF MRA methods are limited for evaluation of renal arteries. For the renal arteries, balanced SSFP (FIESTA) sequences have been shown to be an excellent alternative.

The latest NCE-MRA sequence from GE Healthcare for assessment of the renal arteries, Inhance Inflow IR, combines the benefits of the inflow effects of TOF MRA and the bright luminal signal of the FIESTA sequence. These are combined with an inversion recovery pulse to suppress venous signal.

Inhance Inflow IR is a new angiographic sequence specifically developed to deliver consistent, reproducible images of the renal arteries with excellent ability to suppress static background tissue and venous blood. This 3D FIESTA-based application produces high-quality 3D bright blood images with significantly increased signal-to-noise ratio (SNR). A selective inversion pulse is applied over the region of interest (ROI), which inverts the magnetization of arterial and venous blood, as well as static tissue. Subsequently, during magnetization recovery, another pulse is applied at the time of the null point of venous blood to sample the arterial signal. The net result is an angiographic image with robust background suppression that is virtually free of venous contamination. Spectrally selective inversion recovery fat suppression using an adiabatic RF pulse is implemented to provide uniform fat suppression, while respiratory gating minimizes respiratory motion artifacts in free-breathing renal artery MRA.

In our experience at the University of Wisconsin-Madison, the Inhance Inflow IR technique has reliably produced excellent image quality in both animal studies and clinical MRI examinations in patients. This push-button sequence is very easy to use; simply upload it and choose the correct field of view to include both kidneys and renal arteries. Respiratory motion is eliminated by using the respiratory bellows. The technique is also appreciated by patients as it does not require any breath-holding. This is particularly beneficial with sick or sedated patients who are unable to hold their breath. The image acquisition time is typically four to five minutes followed by data reconstruction for immediate availability of the images for viewing.

Convinced by the excellent image quality and robustness of this technique, our facility has started applying the Inhance Inflow IR sequence in patients for evaluation of the renal arteries. As a result, we have experienced excellent renal artery delineation, which includes the first and second degree branch vessels (Figure 1). This technique can be used to evaluate renal artery stenosis in the workup of renovascular hypertension. Accessory renal arteries can be reliably depicted, which is important for surgical planning (Figure 2). This sequence has also been shown to be feasible in the diagnosis of fibromuscular dysplasia, an entity that requires high quality, high spatial resolution MRA.

It is known that contrast-enhanced MRA (CE-MRA), and to a greater extent, flow-dependent MRA techniques, may produce false positive results by overestimating the severity of stenoses. As vascular radiologists, we are aware of this potential pitfall in MRA. To better understand the performance of the Inhance Inflow IR technique, we conducted in our lab an animal study with surgically produced renal artery stenoses of various degrees (Figure 3). For precise quantification of the true degree of renal artery stenosis, a 3D rotational catheter angiography was obtained. The 3D data set was reformatted to display orthogonal cross sectional images of the stenosis in the renal artery proximal and distal to the stenosis (Figure 4). This study demonstrated that the Inhance Inflow IR sequence produces consistent results. In cases of ambiguous results the Inhance Inflow IR sequence and the CE-MRA were found to overestimate the degree of the stenosis (Figures 5). Just as with CE-MRA, it is important to recognize the properties of the Inhance Inflow IR method, as it does increase our level of confidence when interpreting a normal NCE-MRA of the renal arteries. ■

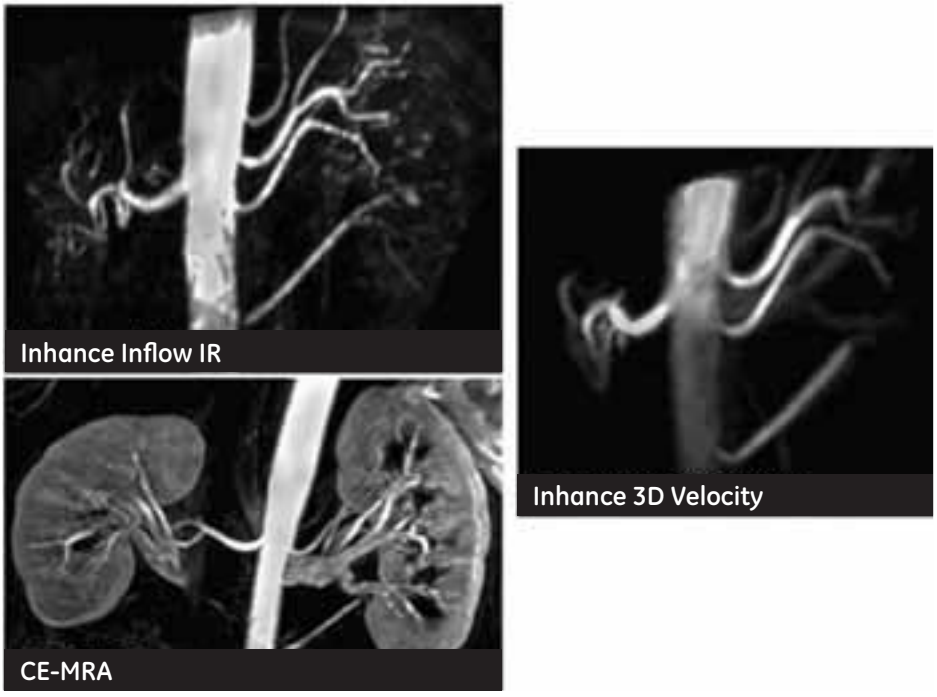

Figure 1. A 27 year-old female patient with severe hypertension was referred for MRA to rule out renal artery stenosis. The two free breathing, non-contrast enhanced sequences Inhance Inflow IR and Inhance 3D Velocity were acquired with a Signa® HDxt 3.0T scanner. Renal artery stenosis was confidently excluded. The renal artery anatomy with three arteries on the left and one single artery on the right are viewed without image degrading artefacts. CE-MRA confirms the findings.

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About the University of Wisconsin-Madison

University of Wisconsin Hospital and Clinics is a 471-bed facility that ranks among the finest academic medical centers in the United States. Frequently cited in publications listing the nation's best healthcare providers, University of Wisconsin Hospital and Clinics is recognized as a national leader in fields such as cancer treatment, pediatrics, ophthalmology, surgical specialties, and organ transplantation.

The University of Wisconsin Hospital and Clinics offers more than 800 active medical staff and more than 80 outpatient clinics. The hospital has six intensive care units (trauma and life support, pediatric, cardiac, cardio-thoracic, burn, neurosurgery) with 74 total beds, and is one of only two organizations in Wisconsin with designated Level One adult and pediatric trauma centers.

Figure 2. A 52 year-old patient with two renal arteries imaged bilaterally. The two MRA techniques, Inhance Inflow IR (top row) and CE-MRA (bottom row), can hardly be discerned. Both techniques reveal the anatomy in excellent image quality. The faint venous signal seen in the suprarenal inferior vena cava and the renal veins can be used to differentiate CE-MRA from the NCE-MRA Inhance Inflow IR sequence.

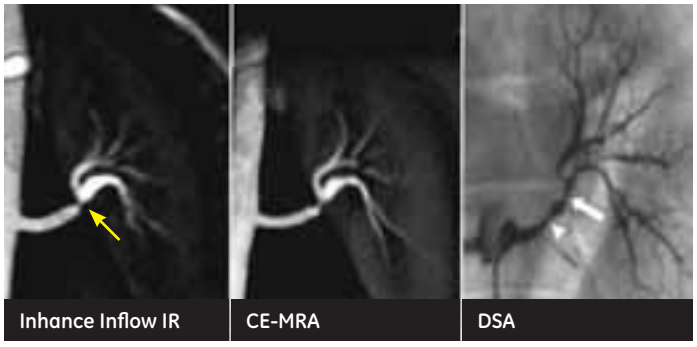

Figure 3. Surgically created stenosis of the left renal artery in a porcine model. Non-contrast Inhance Inflow IR sequence readily reveals the location and severity of stenosis (arrow). Morphology and severity of the stenosis has similar appearance on CE-MRA. Digital Subtraction Angiography (DSA) confirms the finding of an approximately 58% stenosis (arrow). Please note that the vasospasm (arrowhead) proximal to the surgically created stenosis has resolved at the time of MRA.

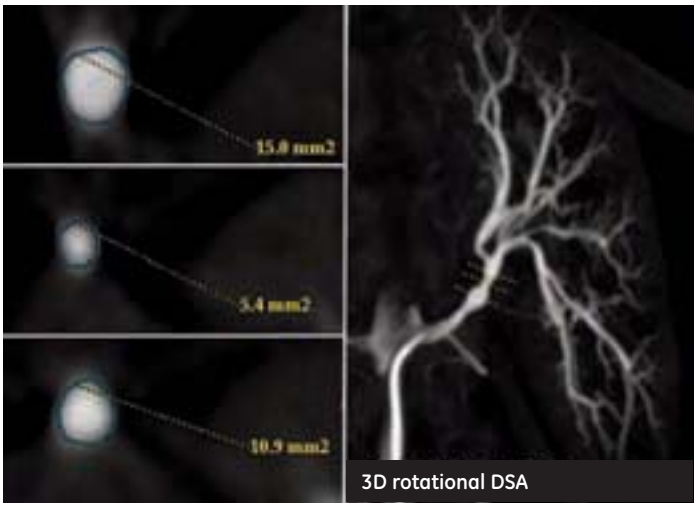

Figure 4. 3D rotational DSA of the same left porcine renal artery was used to precisely quantify the degree of stenosis. Planimetry of orthogonal sections of the renal artery was performed proximal, within the stenosis and distal to the stenosis (as marked on the right by the yellow dotted lines), and revealed a significant stenosis with 58% luminal narrowing.

Figure 5. Surgically created stenosis of the right renal artery in a porcine model. NCE-MRA Inhance Inflow IR sequence readily reveals a significant stenosis. A faint residual lumen can be appreciated on the Inhance Inflow IR and on the CE-MRA. DSA confirms the findings of a 70% stenosis.