Inhance (Inflow Inversion Recovery) Non-contrast Renal MRA in the assessment of renal artery disease.

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**Purpose**

The two main non-invasive imaging modalities for the evaluation of renal artery diseases are CT angiography (CTA) and contrast-enhanced MR angiography (CE-MRA). It has been well described that iodine-based contrast agents can cause deterioration in renal function associated with contrast-induced nephropathy (1,2). Gadolinium-enhanced MR imaging had increasingly replaced CT angiography in patients with reduced renal function before the strong association between Nefrogenic Systemic Fibrosis (NSF) and gadolinium was reported in 2006 (1,2,3).

For these reason, unenhanced MR angiography may be a better approach to prevent the potentially severe adverse effects associated with contrast materials. One limitations of unenhanced MRA is the overestimation of stenosis caused by severe signal loss immediately distal to the stenosis secondary to reduced inflow or to intravoxel dephasing often caused by fast or complex blood flow (4).

The purpose of this study is to determine the performance of Inhance 3D Inflow IR (GE) in the depiction of the renal arteries and in the detection of main renal artery diseases.
Methods and Materials

Unenhanced-MRA was performed in 24 patients (14 men; mean [±SD] age, 54 ± 17 years) with clinical suspicion of main renal artery disease.

Two radiologists independently evaluated the ability of U-MRA for depiction of the renal arteries and detection of the main renal artery disease by comparing the results with the gold standard tests: CE-MRA (14 patients) and Digital Subtraction Arteriography (DSA) (8 patients).

All examinations were performed with a 1.5 T GE Hdxt MR system. Unenhanced-MRA was perform using a respiratory-triggered 3D fat saturated fast imaging employing steady state acquisition (FIESTA) with inversion recovery pulses (Inhance 3D inflow IR [GE]). Inhance 3D inflow IR is an unenhanced-MRA sequence based on the inherent in-flow effects of blood. A selective inversion recovery RF pulse is applied to invert all the spins in the specific region. As soon as the longitudinal magnetization recovers to the null point, FIESTA is used for signal acquisition. The stationary background signal and the slow flow venous blood signal are suppressed by this inversion recovery (IR) RF pulse. The arteries generate a significantly bright signal due to the in-flow effects of the fresh blood (4,13).

An eight-channel phased-array body coil was used for signal reception. First, the patient underwent MRI feet first with the arms above the head. Respiratory trigger is used to reduce motion artifacts and SPECIAL (a chemical saturation technique) is implemented to obtain good fat saturation. Parallel imaging (array spatial sensitivity encoding technique [ASSET]) was used in the in-plane phase encode direction. The MR parameters are shown in Table 1.

The CE-MRA sequence was a 3D fast spoiled gradient echo (FSPGR). Automatic triggering (Smart prep) was used to start MR data acquisition when the contrast agent reached an optimal concentration in the renal arteries, detected by positioning a "tracker" in the aorta just superior to the renal arteries. The maximum monitoring period was 40 s. Suspension of respiration was required during MR data acquisition. Parallel imaging (ASSET) was used in the in-plane phase encode direction with an acceleration factor of 2. The MR imaging parameters are presented in Table 2. Gadobutrol 10 ml (GADOVIST 1.0, BAYER, Berkshire, UK) was injected at 2 ml/s, followed by 20 ml normal saline while Smart Prep monitored the change of signal that determines the time of arrival of contrast medium.

Intraarterial DSA was performed with a flat panel DSA system. Angiography was performed by an interventional radiologist through the right femoral arterial route with a
5F pigtail catheter and injection of 30 mL of iodinated contrast medium at a flow rate of 15mL/sec.

The MR image quality of the renal arteries was graded as follows (Fig. 1):

- **Excellent**: Homogenous vessel signal intensity without flow artifacts, sharp and complete delineation of vessel borders and less interference from venous system.
- **Good**: Homogeneous vessel signal intensity with slight flow artifacts, good delineation of vessel borders, including the main renal artery and segmental branches up to the renal parenchyma.
- **Poor**: Inhomogeneous vessel signal intensity and irregular delineation of vessel borders and unclear depiction of the main renal artery.
- **Not assessable**: Vessels not visible or diagnostic information cannot be obtained because of severe blurring artifacts.

The following segments were evaluated: main renal artery, first order segmental branches and secondary order arteries within the renal parenchyma (Fig. 2).

The presence of renal artery disease and the ability to depict main renal artery stenosis were recorded. The degree of stenosis was classified as hemodynamically non-significant (<50%), and stenosis hemodynamically significant (>50 %).

After the independent reviews, a consensus reading was performed to resolve discrepancies. These consensus data were used as the reference for the Unenhanced-MRA reading.
### INHANCE-3D INFLOW IR SEQUENCE PARAMETERS

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<thead>
<tr>
<th>Parameter</th>
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<td>ACQUISITION TIME</td>
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**Table 1**: Parameters used in Inhance 3D Inflow IR sequence.

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### CE-MRA PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tr>
<td>ACQUISITION TIME</td>
<td>16-20 seg</td>
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</table>

**Table 2**: Parameters used in CE MRA.
Fig. 1: Criteria for evaluating renal artery image quality: A: Example of excellent image quality; B: example of good image quality; C: example of indeterminate image quality.
**Fig. 2:** Renal artery segments. The renal artery was divided into 3 segments: main renal artery (a), first order segmental branches (b) and secondary arteries within the renal parenchyma (c).

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Results

Nineteen of the 24 patients underwent Unenhanced-MRA successfully. Blurring artifacts secondary to respiratory motion resulted in not assessable image quality in three patients (Fig. 3) and in one patient, the artifacts were caused by an aortic stent. Unenhanced-MRA failed to identify a renal transplant artery because the vessel was oriented perpendicularly to the acquisition plane. It was the only allograft studied.

A total of 38 main renal arteries were evaluated. Four main renal arteries could not be evaluated as a result of a stent implantation (two cases) (Fig. 4) and thrombosis (two cases) (Fig. 5).

Unenhanced MRA provided excellent image quality in 18 patients, good image quality in 12 patients and poor image quality in four patients.

The main renal artery was visible in 34 cases, first order segmental arteries in 25 cases, and second order segmental arteries in 19 cases.

Of the 34 arteries evaluated, 17 were normal (Fig. 6), 16 had stenosis (Figs. 7, 8 and 9) and one artery had an aneurysm (Fig. 10). Unenhanced-MRA agreed with the gold standard diagnosis in all of the 17 normal arteries, in the 16 with stenosis, and in the artery with aneurysm. Overall accuracy for both readers was 100%, with a sensitivity of 100% and a specificity of 100%, and 100% interobserver agreement in the grading of the severity of the stenosis. Unenhanced MRA failed to depict one stenosis and one aneurysm located in two segmental arteries.
Images for this section:

Fig. 3: Not assessable image quality was caused by respiratory movement with blurring artifacts.

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Fig. 4: Left main renal artery could not be assessed as a result of a stent implantation (arrow) (A). Digital subtraction angiography shows permeability of the artery (arrohead) (B).

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**Fig. 5:** Thrombosis of the left main renal artery (arrow).

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Fig. 6: Normal bilateral renal arteries demonstrated by corresponding MIP imágenes of U-MRA (A) and CE-MRA (B).

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Fig. 7: Fibromuscular dysplasia. In U-MRA (A, B) both renal arteries exhibited wall irregularities with alternating dilatations and minimal stenosis (below 50%) in both arteries. CE-MRA displayed permeability of both renal arteries with stenosis below 50% (C).

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**Fig. 8:** Renal artery stenosis in a 28 years old man. A) U-MRA reveals stenosis greater than 75% in the left main renal artery (arrow) which is also detectable with DSA (arrowhead) (B).

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Fig. 9: Left renal renal artery stenosis in a 53 years old man. A) U-MRA (arrow) reveals stenosis greater than 50% in the left main renal artery which is also depicted with DSA (arrowhead)(B).

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**Fig. 10:** U-MRA (A) shows an aneurysm located in lower segmentary of the right renal artery (arrow). DSA shows the same aneurysm (arrowhead) (B).

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Conclusion

Unenhanced-MRA is a reliable diagnostic method to depict normality and stenosis in the main renal arteries. The presence of arterial stent or thrombosis prevents unenhanced-MRA assessment. Segmental renal artery disease cannot be adequately depicted with unenhanced-MRA in all cases. Unenhanced-MRA can be used as an alternative to enhanced techniques in patients with renal insufficiency.
References