Navigator-gated Non-contrast Renal MR Angiography: Qualitative and Quantitative Comparison of 3T and 1.5T Images

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**Purpose**: The aim of this study was to compare non-contrast 3T renal MRA with that of 1.5T unit.

**Methods and Materials**: We performed renal MRA in twelve volunteers using a 1.5T and 3T unit. For renal MRA, 3D SSFP sequence was used. For quantitative evaluation, ROI was set on the aorta, main stems of bilateral renal arteries, and IVC, measuring flow signal at each point. Signal intensity ratio (SIR) of renal artery relative to the parenchyma and IVC were calculated. For subjective analysis, two readers evaluated visual quality. **Results**: SIR of the both renal artery on 3T MRA were significantly higher than those on 1.5T (p<0.01). On subjective analysis, the mean visualization score of renal main stem showed no statistically significant difference. However, the scores of the peripheral branches on 3T was significantly higher than those of 1.5T bilaterally (p<0.05). IVC showed significantly lower signal ratio on 3T relative to that on 1.5T. **Conclusion**: 3T MRA showed superior demonstration of renal arteries compared with 1.5T MRA. The intraparenchymal peripheral branches are especially well demonstrated on 3T MRA. Decreased venous signal on 3T system contributed to the selective arterial demonstration. (Kitakanto Med J 2011; 61: 483~487)

**Key words**: non-contrast MR angiography, 3T vs 1.5T, 3D SSFP

**Purpose**

MR angiography (MRA) without using contrast agents has become increasingly common in the clinical setting. In higher field system, increased blood flow signal and decreased background signal enable better quality non-contrast MRA images, such as Time-of-flight of the head.1

While the theoretical increase of signal intensity in 3T units might improve quality of MR images, prolonged relaxation time, increased susceptibility effects and effects of food intake may limit this improvement.

Recently, the usefulness of non-contrast renal MRA performed on a 3 Tesla unit has been published.2 The report suggests improvement of image resolution in higher field units is due to an increase of blood signals and a decrease of retroperitoneal tissue signals.

The motion artifacts from peristalsis of the intestinal tract and susceptibility effects from intestinal gas change affect image quality. These factors can change even during a single MR imaging session. Since food intake increases mesenteric arterial flow, renal flow is also affected by food intake and other factors.3 Therefore, to compare 3 tesla and 1.5 tesla MRA images, both studies should be done during a short period of time, preferably sequentially, to minimize these changes. Evaluation of signal changes around vessels in terms of selective visualization of arteries is also necessary.

The aim of this study was to compare navigator-gated non-contrast renal MRA on 3T with that of 1.5T system under strictly regulated conditions.

**Material and Methods**

This study was approved by our institutional review boards, and informed consent was obtained from all subjects.

We performed renal MRA on twelve volunteers (age range, 24~49 years; mean age 30.6 years) using a 1.5T and a 3T MRI unit in Gunma University Hospital from June 2010 to August 2010. The MRI units were Magnetom Symphony 1.5T and Trio 3T, Siemens,

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Address : TAKEHIRO SHIMADA Department of Diagnostic Interventional Radiology and Nuclear Medicine, Gunma University Graduate School of Medicine, 3-39-22 Showa-machi, Maebashi, Gunma 371-8511, Japan
Germany. On both MRI units, an eight-channel phased array coil was used with a spinal matrix coil. Each set of two examinations were done one after the other. Six subjects were examined on the 1.5T unit first, and on the 3T unit immediately after. The other 6 were imaged with the order reversed. All subjects were imaged after at least 8 hours of fasting.

For renal MRA, a three dimensional steady-state free precession (SSFP) sequence (True FISP, Siemens) was used with diaphragmatic navigator gating. All MRA studies used axial data acquisition. First, we applied the axial selective inversion pulse over the acquisition slab. This helps to optimize contrast between the inflow and the background static tissue, which recovers after the previously described 180-degree pulse. To suppress fat tissue signal, an additional frequency selective fat saturation pulse was applied just before data acquisition. The resulting time interval between the first inversion pulse and effective echo time was set at 1200 msec both on 1.5 and 3T studies. Transversal selective saturation pulse of 10 cm thickness was applied just caudal to the data collection slab to suppress venous signal entering from the caudal side of the FOV. Detailed imaging parameters are shown on Table 1.

<table>
<thead>
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<th>TR/TE/FA</th>
<th>3T</th>
<th>1.5T</th>
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<tbody>
<tr>
<td>TI</td>
<td>1.2sec</td>
<td>1.2sec</td>
</tr>
<tr>
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<tr>
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<td>0.9×1.15×1.27</td>
</tr>
<tr>
<td>parallel imaging factor</td>
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</table>

SSFP = steady-state free perception

We calculated the signal intensity ratio (SIR) of the abdominal aorta and the bilateral renal arteries relative to the background renal parenchyma, cortex and medulla. To calculate the tentative contrast noise ratio (CNR) of abdominal aorta and renal artery relative to renal parenchyma, standard deviation of noise was measured in the quadrates lumbarum muscle near the renal artery to avoid the influence of parallel imaging acquisition. To assess the effect of venous signal, the signal intensity ratio of IVC flow was measured at the height of the bifurcation of the largest renal artery, and the signal intensity ratio of the IVC relative to renal artery was calculated.

For subjective analysis, two radiologists independently evaluated the visual quality of the maximum intensity images (MIP), with a manually targeted area limited to the kidney and the aorta. The visualization quality was scored on a three-point-scale: 3, excellent (renal arteries are sharply defined and strictures, if any, can be evaluated); 2, good (confidence level of the evaluation decreases due to partially irregular depiction of arteries); 1, poor (arteries are not visible and difficult to evaluate). When the result was discordant between the readers, the final score was determined by consensus. The quantitative results, SIR and CNR, were evaluated with the Wilcoxon rank test, and the qualitative results were evaluated with the Mann-Whitney test. A P-value of less than 0.05 was considered statistically significant.

**Results**

Flow in the right and left renal arteries showed higher signal intensity in all subjects on 3T than on 1.5T, and the difference was significant (p<0.01). Similarly, CNR also demonstrated significantly higher value on the 3T unit (p<0.01). SIR and CNR of abdominal aorta were not statistically significant (Fig. 1).

Based on these higher flow signals and contrast, 3T MRA provided excellent visualization of the main stem of the renal arteries and its branches, compared to that of 1.5T. Demonstration of peripheral branches was significantly superior at 3T (Fig. 2).

Signal intensity of IVC was also effectively suppressed on 3T images. Ten of twelve subjects showed lower IVC signal, while the remaining two showed almost equal signal levels (Fig. 3, 4).

**Discussion**

Recent developments of non-contrast MRA techniques are remarkable. In addition to the conventional time-of-flight and phase contrast technique, the use of ECG-gated partial-Fourier fast spin echo technique for evaluating the upper and lower extremity arteries has become clinically widespread. The more recently developed SSFP data collection with flow-tagging technique has enabled selective arteriography in the chest and abdomen without using contrast media. Various combinations of pulse tagging and data collection are possible depending on the purpose, and their optimization is under investigation.

Among these studies, non-contrast renal MRA has been intensively investigated, and SSFP technique with pulse tagging appears clinically promising.

High field non-contrast MRA in the head and neck region has been shown to be useful, based on higher flow signal and excellent background suppression. Similar results are anticipated in the body, and the usefulness of 3T renal MRA has been recently reported. While the authors pointed out the higher flow
signal of the technique compared with 1.5T MRA, detailed observation of the background static tissue or adjacent venous structures was not fully described. Additionally, they scanned the subjects within a period of two weeks, without regard to food intake or other potentially influential conditions, possibly altering circumstances between the studies being compared which affected the various signal intensities.

We performed our examinations under stricter conditions and evaluated the signal pattern of the surrounding static tissue more intensely. Venous flow signal in the IVC showed lower signal on 3T in ten of the twelve subjects, and the signal difference was statistically significant. Although a selective saturation pulse is applied in the lower level, considerable IVC flow signal was observed in some cases on 1.5T, probably due to fast stream inflowing from outside the saturation pulse. The decreased venous blood signal

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**Fig. 1** Signal intensity ratio (SIR, A) and Contrast noise ratio (CNR, B)

The mean signal intensity ratio of each vessel (right and left renal arteries and the aorta) to the renal cortex, and the contrast noise ratio of each vessel were assessed. Differences between 3T and 1.5T were statistically significant, except for those of the aorta.

**Fig. 2** Signal intensity ratio of aorta to IVC on 3T and 1.5T MRI units

The mean signal ratio of the aorta to the IVC on 3T MRA was $2.83 + / - 0.82$. On 1.5T MRA, it was $1.83 + / - 0.5$, showing a statistically significant difference ($p < 0.05$).
due to short T2 relaxation was pronounced on 3T and contributed to excellent contrast between the arterial and venous flow. This finding is important in evaluation of the right renal artery, on which IVC signal may be superimposed. Two cases showed higher IVC signal on the 3T unit. This finding is probably due to relatively lower oxygen concentration of venous blood, which was sometimes observed in MRA of superficial veins of lower extremities using 3D SSFP technique.13

Because this non-contrast technique is applicable regardless of renal function, its greatest potential is probably in the screening of renal arterial disease such as atherosclerosis.13 However, as the peripheral segments are also more readily observable on 3T MRA, this technique may be also suitable for evaluation of diseases such as fibromuscular dysplasia, which involve more distal portions of the renal arteries.

**Conclusion**

3T non-contrast MRA using SSFP and navigator
technique can provide excellent demonstration of not only main stem but also segmental branches of the renal arteries. Increased arterial signal as well as suppressed venous and background static tissue signal make 3T MRA a more feasible and reliable technique compared to 1.5T MRA.

References