Renal MR Angiography with Steady-State Free-Precession (SSFP) and Slice-Selective Spin Inversion combined with Radial k-Space Sampling and Water-Selection Excitation

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Abstract

We investigated the impact of radial k-space sampling and water-selective excitation on a novel navigator-gated cardiac-triggered 3D steady-state free-precession (SSFP) renal MR angiography technique, which uses a slice-selective inversion prepulse for high contrast visualization of the renal arteries. In four volunteers and four patients this approach was investigated using Cartesian and radial SSFP, and radial SSFP with water-selective excitation. SNR and CNR as well as vessel border definition were analyzed. All sequences allowed for high-contrast and selective visualization of the renal arteries. However, superior SNR, CNR, and vessel sharpness was found for standard Cartesian SSFP imaging.

Introduction

In a prior study we implemented selective imaging of the renal arteries without contrast medium using a navigator-gated cardiac-triggered 3D SSFP sequence combined with a slice-selective inversion prepulse. Signal from the renal parenchyma and veins was completely suppressed by the inversion prepulse while high-contrast visualization of the renal arteries including the distal subsegmental branches is enabled. In this study we investigated the effect of radial k-space sampling and water-selective excitation concerning vessel border definition and improved SNR.

Materials and Methods

Four healthy volunteers (mean age 28.0 years) and four patients (mean age 42.5 years) were investigated on a 1.5 Tesla MR system (Intera, Philips, Best, NL). Renal MR angiography (MRA) was performed using three different approaches of the navigator-gated cardiac-triggered 3D SSFP sequence with the slice-selective spin inversion prepulse: Cartesian (TR/TE: 5.7/2.8 ms, FA: 85°) and radial (TR/TE: 5.5/2.7 ms, FA: 85°) SSFP imaging as well as radial SSFP combined with water-selective excitation (TR/TE: 9.9/4.9 ms, FA: 85°) with identical spatial resolution (FOV: 390, Matrix 384x384, 1.1x1.1x1.8mm^3). SNR and CNR and vessel sharpness was analyzed using a previously described edge detection tool. Statistical analysis was performed using a Wilcoxon-Test and the p-value was set to 0.05.

Results

All sequences allowed for selective visualization of the renal arteries without venous overlay (Fig. 1a, 1b and 1c). In Cartesian SSFP, SNR of the renal arteries was 113 compared to 61 and 39 in radial SSFP and radial SSFP with water-selective excitation, respectively ($p<0.05$). The resulting CNR between the renal arteries and parenchyma were 110, 60 and 39 ($p<0.05$). Concerning vessel border definition superior value was found for Cartesian SSFP, too (5982 vs. 5104 and 4085, $p<0.05$). In the patient study even high-grade stenosis could be clearly visualized (Fig. 2a and 2c).

Conclusion

The navigator-gated cardiac-triggered Cartesian 3D SSFP sequence combined with a slice-selective inversion prepulse yields high-resolution MR angiograms without the use of contrast medium, which can correctly characterize low-grade as well as high-grade stenoses of renal arteries. Neither the application of radial k-space sampling nor water-selective excitation resulted in further improvement on image quality in our study.

Fig. 1a

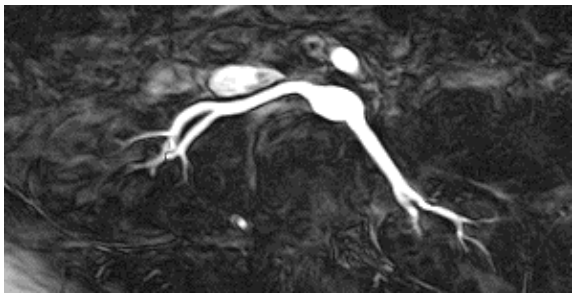

Figure 1: Maximum intensity projection images after Cartesian SSFP (1a), radial SSFP (1b), and radial SSFP with water-selective excitation (1c).

Figure 2: Conventional x-ray angiography demonstrating a stenosis of the left renal artery close to the ostium with mild poststenotic dilatation (2a). The corresponding MR angiogram clearly illustrates the high-grade stenosis (2b).

Fig. 1b

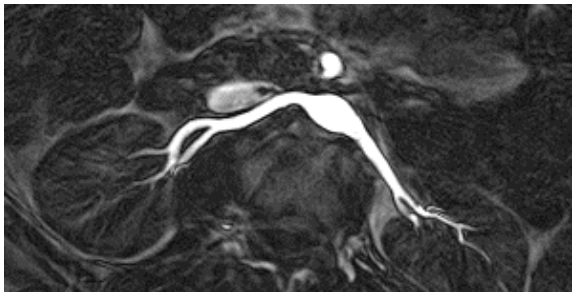

Fig. 2a

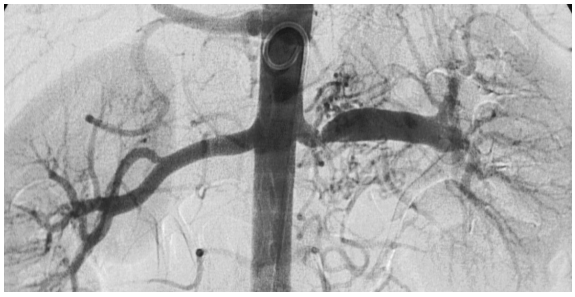

Fig. 1c

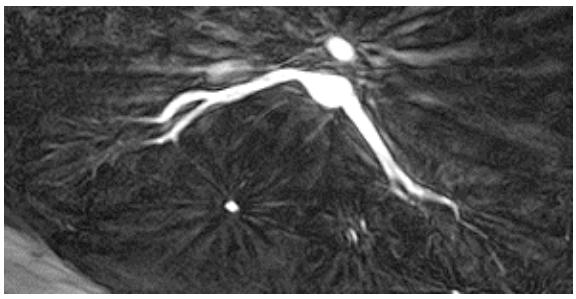

Fig. 2b