Renal MR Angiography with Steady-State Free-Precession (SSFP) and Slice-Selective Spin Inversion during Free Breathing

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Abstract

The aim of our study was to investigate a 3D steady-state-free-precession (SSFP) sequence for free-breathing renal MR angiography (MRA) without contrast medium and to examine the advantage of an additional inversion prepulse for improved contrast. A navigator-gated cardiac-triggered 3D SSFP sequence was performed either without magnetization preparation or with a non-slice-selective inversion pulse or a slice-selective inversion pulse in eight volunteers and eight patients. Images were analyzed concerning SNR and CNR. SSFP imaging combined with a slice-selective inversion pulse allows for selective and high-contrast visualization of the renal arteries without the need for contrast media application.

Introduction

Contrast-enhanced MRA is the standard magnetic resonance angiography technique for non-invasive visualization of the renal arteries. This technique yields a relatively low spatial resolution due to the short acquisition time of one breath-hold. Furthermore, cardiac triggering for reduction of potential motion errors cannot be performed. Thus, the purpose of our study was to implement a reasonably fast high-resolution free breathing and cardiac-triggered renal MR angiography technique, which allows for selective visualization of the proximal and distal renal arteries without the use of contrast media.

Materials and Methods

Eight healthy volunteers (mean age 29 years) and eight patients (mean age 53 years) were investigated on a 1.5 Tesla MR system (ACS-NT, Philips, Best, Netherlands). Renal MRA was performed using three different navigator-gated cardiac-triggered 3D SSFP sequences (TR/TE 3.8/1.9ms, flip-angle 85°, TI 325ms, spatial resolution 1.1x1.1x2.0mm^3, acquisition time approximately 2min): the sequence was performed without magnetization preparation, with a non-slice-selective inversion pulse and a slice-selective inversion pulse. Slice-selective spin inversion may allow for suppression of stationary tissue while contrast of the artery may be supported by inflowing blood. SNR and CNR as well as maximal visible vessel length were compared.

Results

3D SSFP imaging combined with a slice-selective inversion pulse allowed for selective and high contrast visualization of the renal arteries including the distal subsegmental branches (Fig. 1a, 2, 3). Standard SSFP imaging without magnetization prepulse demonstrated overlay by veins and renal parenchyma (Fig. 1b). A non-slice-selective prepulse yielded insufficient vessel visualization (Fig. 1c). $CNR_{ra\text{-}rv}$ (Fig. 2) in SSFP with slice-selective inversion was 43.6 vs. 10.6 (SSFP only) and 0.4 (SSFP with non-slice-selective inversion), ($p<0.05$).

Conclusion

Navigator-gated cardiac-triggered 3D SSFP-imaging combined with a slice-selective inversion prepulse is a novel, fast renal MR-angiography technique without the need for contrast media.

Fig. 1a

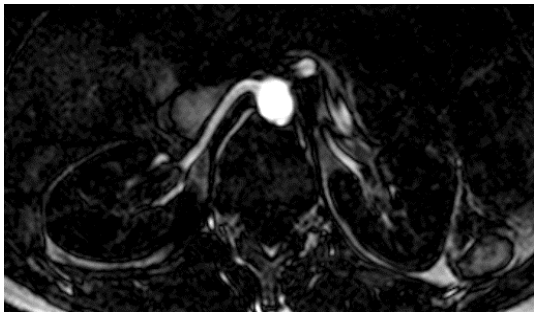


Fig. 1b

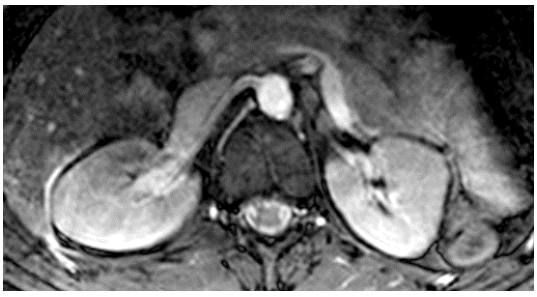


Fig. 1c

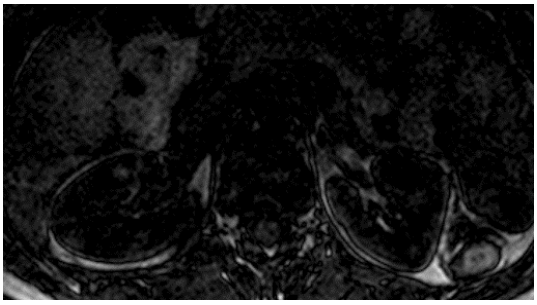
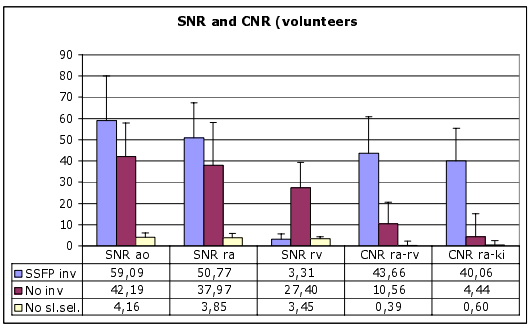


Figure 1: Single slice images demonstrating the effect of a slice-selective inversion pulse (1a), no inversion pulse (1b) and a non-slice-selective inversion pulse (1c).

Figure 2: SNR and CNR calculated from the aorta (ao), renal artery and vein (ra, rv), and parenchyma of the kidney (ki).

Figure 3: Maximum intensity projection of a 3D SSFP sequence combined with a slice-selective inversion pulse. Respiratory and cardiac motion is almost completely suppressed due to navigator-gating and cardiac-triggering resulting in sharp delineation of the vessel lumen.

Fig. 2



	SNR ao	SNR ra	SNR rv	CNR ra-rv	CNR ra-ki
SSFP inv	59,09	50,77	3,31	43,66	40,06
No inv	42,19	37,97	27,40	10,56	4,44
No sl.sel.	4,16	3,85	3,45	0,39	0,60

Fig. 3