Accuracy of multidimensional steady-state free precession MR Angiography of the renal arteries in intra-individual comparison to three-dimensional contrast-enhanced MR Angiography

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Synopsis:

Aim of the study was to individually compare multidimensional steady state free precession (SSFP) MR images of the renal arteries with contrast-enhanced three-dimensional MR Angiography (CE-MRA) in patients suspected of renal artery stenosis. After sequence and protocol optimization in five healthy volunteers, 19 patients underwent MR imaging of the renal arteries. Random consensus readout was performed by two radiologists. SSFP images precisely displayed the first two-thirds of the renal arteries, but frequently overestimated the degree of stenosis. Despite this, SSFP appears attractive as a fast MRA technique, but it cannot be considered to supplant CE-MRA of the renal arteries.

Introduction:

Three-dimensional contrast-enhanced magnetic resonance angiography (CE-MRA) has been established as a safe, robust, and reliable technique for detection and grading of renal artery pathologies (1). The technique is based on the bright display of gadolinium in the renal arteries on fast gradient echo sequences aquired during a single breath-hold. Recently, fast steady state free precession (SSFP) MR techniques have become available (2). Inherent to SSFP is bright blood signal and sharp vessel delineation. Thus, optimized SSFP sequences might obviate the need for CE-MRA of the renal arteries. In this study, we aimed to evaluate multiplanar two-dimensional (2D) and three-dimensional (3D) SSFP for the display of the renal arteries and the detection of significant stenosis.

Methods:

Five healthy volunteers (male/female, 4/1; age, 28 ± 1.1 yrs) underwent non-contrast-enhanced MRI examinations for optimization of 2D and 3D SSFP images (TrueFISP; TR, 4.3 ms; TE, 2.3 ms; FA, 25°; slice thickness, 2 mm, Matrix, 386 x 512, TA, 19 sec). Subsequently, 19 patients (male/female, 12/7; age, 67.6 ± 7.3 yrs) with clinically suspected secondary arterial hypertension due to renal artery stenosis or fibromuscular dysplasia (FMD) were enrolled in the study. All examinations were performed on a 1.5T clinical scanner (Magnetom Sonata, Siemens Medical Solutions, Erlangen, Germany) using dedicated multi-channel phased array coils. All SSFP imaging preceded CE-MRA (0.2 mmol/kg bodyweight gadodiamide, Omniscan™, GE Healthcare, Princeton, NJ) in the patient group. Two radiologists performed a consensus readout of the exams in random order. Visualization (vis.) of the renal arteries was scored on a 4-point scale (score 1 = no vis., 2 = poor vis., first 1/3 of vessel, 3 = good vis., first 2/3 of vessel, 4 = excellent vis., 3/3 of vessel). Only data sets with a score 2-4 were included for comparison with CE-MRA as gold standard.

Results:

Overall SSFP yielded high contrast visualization of the renal arteries with a score of 3.1 ± 0.4. 3D SSFP displayed the renal arteries superior to 2D data sets, but without amounting to a statistical significance (2.9 ± 0.2 vs. 3.2 ± 0.2; $p > 0.1$). A total of 39/41 renal arteries in 19 patients was correctly detected with SSFP imaging. Two patients were found to have relevant stenosis (>70%) both of which were correctly identified by SSFP. In five cases where the readers merely found stenoses less than 50% based on CE-MRA image analysis, read-out of SSFP data sets led to false-positive overgrading of vascular disease (>70%) in all of these. One case with FMD was falsely judged as single-sided high grade stenosis on the SSFP images.

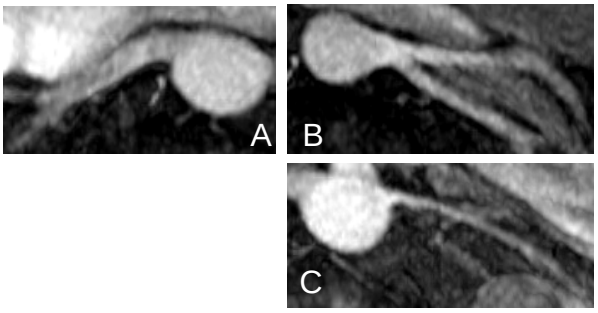

Figure 1: 28 yo male volunteer. Maximum Intensity Projections (MIP) of 3D SSFP images clearly show right renal artery (A) and left renal artery (B) with an early bifurcation. In addition, a small accessory left renal artery was detected (C).

Discussion:

CE-MRA of the renal arteries is not without its limitations (3). Hence, the search for non-invasive objective imaging alternatives or technical refinements is necessary. Against this background SSFP without the need for intravenous contrast media is highly attractive. However, in patients with suspected renal artery disease, SSFP might be a beneficial supplementary sequence in cases when CE-MRA is hampered by venous overlay or motion artifacts. However, reflecting the current results, SSFP is not very likely to displace CE-MRA. Further analysis of SSFP MR imaging of the renal arteries will include comparison to catheter angiography as well as sequence modification to more precisely define the role of this promising technique.

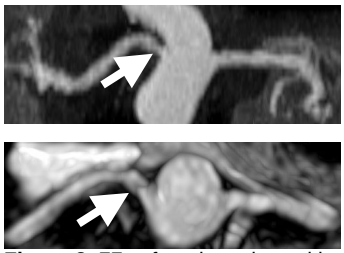

Figure 2: 77yo female patient with arterial hypertension and suspected renal artery stenosis. Vessel wall irregularities are nicely displayed on oblique MIP of CE-MRA (A) and are also detected on the paratransverse MIP of SSFP data set (B). In addition, a <50% stenosis at the origin of the left renal artery (arrows) with discrete poststenotic dilatation was correctly identified on the SSFP images.

References:

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