Breath-hold Quantitative Perfusion Imaging of the Kidneys at 3 T by FAIR True-FISP

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Synopsis

In arterial spin labelling (ASL) techniques for perfusion imaging respiratory motion reduces image quality and might influence quantitative results in abdominal studies. The sensitivity of the ASL methods is expected to improve for higher field strength. Breath-hold measurements of the kidneys of healthy volunteers were performed on a 3 T scanner using a novel FAIR True-FISP technique. Perfusion images of good quality were obtained in several seconds of measuring time. The calculated perfusion rates are in good agreement with previous ASL studies.

Introduction

The combination of ASL techniques with imaging sequences insensitive to susceptibility effects has been shown to provide useful applications on internal organs and on the musculoskeletal system (1-6). Usually averaging of a large number of scans is necessary to achieve a sufficiently high signal-to-noise ratio (SNR) in perfusion images. Doing so, respiratory motion can influence the quality of FAIR images. At higher field strength the sensitivity of the ASL methods is expected to improve. The recently developed FAIR True-FISP technique (5,6) is suitable for perfusion-weighted imaging of the kidneys at 3 T (7). The relative increase of the perfusion related signal yield by FAIR True-FISP studies allows high quality perfusion-weighted images even in breathold studies. The goal of this study was to present a possible strategy for quantitative perfusion measurements on the kidneys at 3 T in breath-hold technique.

Methods

Examinations of the kidneys of healthy volunteers were performed on a 3 T whole body MR scanner (Siemens Medical Solutions, Erlangen, Germany). For a homogeneous RF transmission the body coil was used, for signal detection the phased-array torso coil. The FAIR True-FISP sequences with α = 60°-80º, TR = 3.6 ms, TE = 1.8 ms, BW = 890 Hz/pixel were implemented for perfusion studies with a 128×128 matrix size and a FoV of 360×360 mm^2. A centric reordered phase encoding scheme was used to be sensitive to the prepared magnetization. A 10.24 ms FOCI adiabatic inversion RF pulse with μ=5, β=935 was applied to obtain steep slopes for slice-selective inversion (8). The inversion time TI was set to 1200 ms and the waiting period between two inversion pulses to 3200 ms. The recorded slice thickness was 8 mm, the inversion slab thickness was 20 mm. Additional 2 pre-scans were performed prior to the first recorded scan in order to avoid the rest signal arising from static tissue with long T1. Two or three pairs of labeled and non-labeled images were acquired and averaged during single breath-hold studies. For a quantitative analysis, an additional density-weighted image was acquired (without preparation) in a second breath-hold . The T1 values in the renal cortex at 3.0 T, necessary for the calculation of perfusion maps, was estimated based on T1 relaxation measurements at 1.5 T (9) and on the relatioship $T1 \sim B_0^{0.33}$ (10).

Results

FAIR True-FISP images of the kidneys of healthy volunteers showed a sufficient image quality with respect to resolution and SNR. The image in Fig. 1a shows an density weighted image of the kidneys acquired by True-FISP sequence without preparation. The corresponding perfusion-weighted subtraction image shows the kidney cortex well perfused (Fig 1b). Apart from the kidneys, the spleen can be clearly identified. The resulting perfusion map is depicted in Fig. 2. From this quantitative image an averaged perfusion rate of 270±50 ml/(100 g min) in the renal cortex could be obtained. In the spleen the averaged perfusion rate was 160±40 ml/(100 g min).

Discussion

The presented work shows the FAIR True-FISP imaging technique to be suitable for quantitative perfusion imaging on the kidneys at 3 T. The short TR and TE of this SSFP sequence avoid undesired signal dephasing and therefore signal losses in the kidney tissue. The increase of SNR at 3 T allowed to obtain good quantitative results in breath-hold studies.

References

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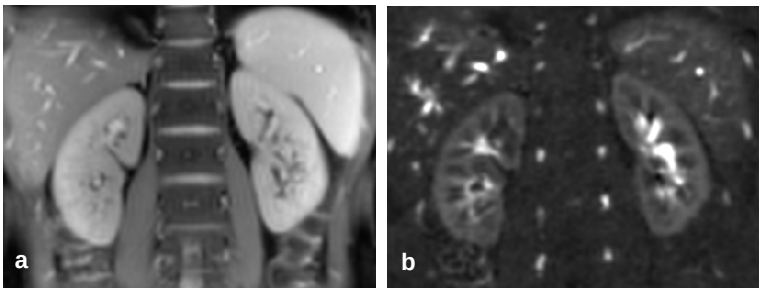

Fig 1. *Images of the kidneys of a healthy volunteer recorded in breaht-hold: a) A density weighted image was recorded by the True-FISP sequence without preparation; b) FAIR True-FISP perfusion-weighted image obtained within 19 s (two pairs of images were recorded).*

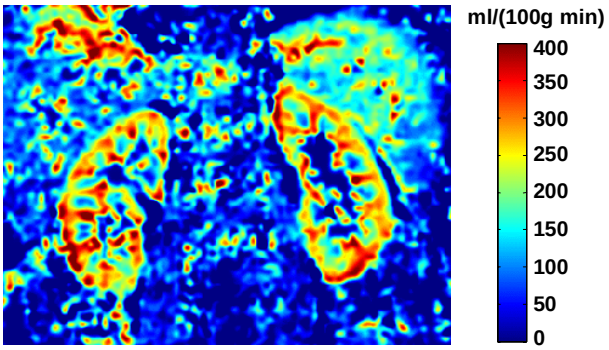

Fig 2. *Quantitative color encoded FAIR True-FISP perfusion image of a healthy volunteer shown in Fig. 1. The averaged perfusion rates in the renal cortex is 270±50 ml/(100g·min) and in the spleen is 160±40 ml/(100g·min). Note: All pixels with extremely high flow rates (> 600 ml/(100g min) corresponding to blood vessels) were set to zero.*