One-Breath-Hold Acquisition of the Whole Abdomen in One Minute Using Continuously Moving Table MRI

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Introduction

In recent years fast MR imaging techniques with a continuously moving table that cover large volumes of interest in a very time efficient manner have been successfully applied to numerous clinical fields like angiography [1] and whole body tumor screening [2], [3]. However, the image quality provided by these techniques in body regions like the upper abdomen that are subject to strong motion could so far not compete with stationary multiple-breath-hold approaches. To improve this situation, a dedicated sequence setup for fast imaging of the whole abdomen is developed which combines 2D continuously moving table imaging [4] with parallel acquisition techniques [5], [6] to a one-minute scan with only one breath-hold required. A FOV-saving data acquisition technique [7] is applied to increase data homogeneity along the scanners axis.

Method

A package of thirteen 5 mm thick slices was acquired repeatedly during continuous table motion using a contrast enhanced T1 weighted gradient echo sequence with fat saturation. With this a FOV_z of 55 cm from the lower lung to the pelvis (Fig. 1) was covered in a total measurement time of 1:10 min at a constant table velocity of 9 mm/s. The sequence parameters were: TR = 95 ms, TE = 2.5 ms, flip angle = 70°, matrix size = 320 x 208, in-plane resolution = 1.25 mm. GRAPPA [5] with an acceleration factor of two was used to speed up the acquisition. A sliding multi slice acquisition technique [7] was applied in order to minimize the required FOV along the axis of the scanner (8.5 cm) to increase data homogeneity. The method was tested on phantoms, normal volunteers and as additional examination on several patients who underwent standard abdominal MRI for different reasons. After the first five seconds of the examination the subjects were pleased to hold their breath for the next 20 seconds (corresponding to a FOV_z of 18 cm) to enable an artifact free acquisition of the liver region during this period. Afterwards the measurement proceeded down to the pelvis during free breathing. All measurements were performed on a 1.5 T whole body system (Magnetom Avanto, Siemens Medical Solutions, Erlangen, Germany) featuring an automatically moving patient table and a multi channel array of local surface coils (Tim system, Siemens medical solutions, Erlangen, Germany). The single array elements (four ventral and eight dorsal) were dynamically switched on and off as required during the examination.

Results

In Fig. 1 five exemplary transverse slices are shown. The slices a and b were acquired within the breath-hold phase, whereas slices c-e were recorded during free breathing. While the image quality provided in the liver during the breath-hold phase is fully comparable to standard stationary approaches, the upper ventral parts of the bowel which were acquired during the first breath of the subject after the breath-hold phase show motion related artifacts. The end of the breath-hold acquisition is indicated by the dashed line in the sagittal overview in Fig. 2b; the slice shown in Fig. 1c represents the area where the breathing artefacts are most visible. The artefacts diminish towards the lower abdomen and the pelvis (Fig. 1d) which appears free from artefacts. The dorsal parts of the body including the vertebral column and the retroperitoneal space are well delineated in all images. The reformatted coronal and sagittal images in Fig. 2 demonstrate the high homogeneity of the data concerning both signal intensity and contrast. This holds particularly for the fat saturation which benefits from the sliding multi slice acquisition.

Discussion

The presented fast imaging sequence with continuous table motion allows for performing examinations of the whole abdomen with only one breath-hold required. Apart from slight restrictions in the upper ventral parts of the bowel the image quality of the presented whole abdomen dataset obtained in only 1:10 min is comparable to standard stationary MRI approaches which usually require multiple breath-holds. In cases where artifact free delineation of the entire bowel is required, the breath-hold area can be shifted in order to coincide with the desired region. Due to the minimized required FOV of only 8.5 cm along the z-direction the technique provides highly homogeneous data along the z-direction and is particularly suitable for being used on short bore magnets.

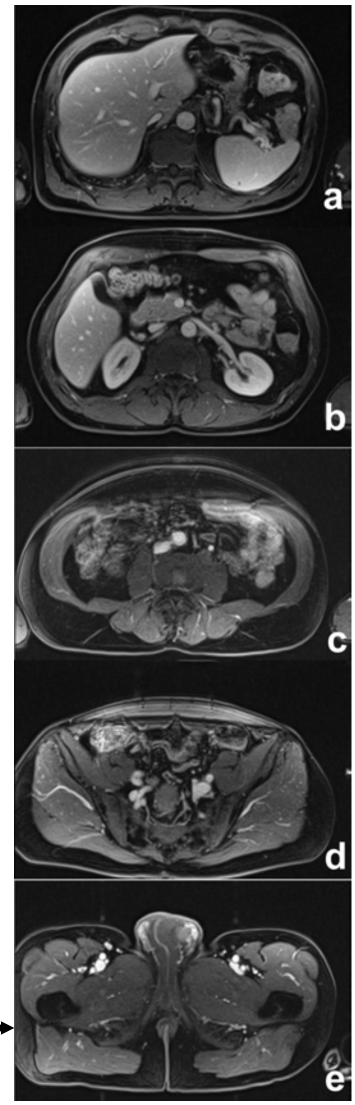

Fig. 1: Original axial slices from five different positions along z.

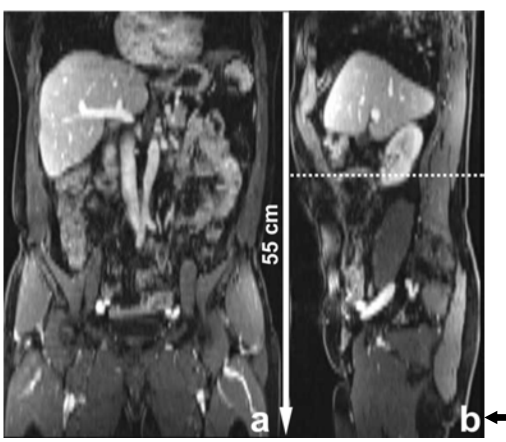

Fig. 2: Reformatted coronal (a) and sagittal (b) whole FOV_z overview. The arrow indicates the direction of data acquisition.

References

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