Free-breathing Delayed Contrast-enhanced Three-dimensional Viability MR Imaging of the Myocardium at 3T: A Feasibility Study

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Introduction

Delayed contrast-enhanced viability magnetic resonance (MR) imaging of the myocardium is a valuable tool for the detection of myocardial infarction (MI) and various cardiomyopathies. A standard delayed contrast-enhanced viability MR imaging technique is a breath-hold two-dimensional (2D) inversion-recovery gradient-echo imaging. However, there are some disadvantages related to the breath-hold 2D imaging sequences: a number of repeated breath-holds required to cover a whole heart, slice misregistration and no feasibility for postprocessing techniques. A single-breath-hold three-dimensional (3D) viability MR imaging has disadvantages, including lower spatial resolution, longer temporal resolution and imaging blurring.

Another possible approach of 3D viability MR imaging is a free-breathing data acquisition with navigator gating. The possible decrease in image quality due to increases in spatial resolution and receiver bandwidth (RBW) associated with the free-breathing 3D viability imaging can be partly compensated by high-field MR imagers, such as 3T, because of inherently large magnetization. The purpose of this study was to evaluate the technical feasibility of free-breathing delayed contrast-enhanced 3D viability MR imaging at 3T.

Methods

Twenty-one consecutive patients with some forms of heart diseases, including MI and hypertrophic cardiomyopathy, were included in this study. MR imaging was performed using a 3T unit (Achieva 3T, Philips Medical Systems). A six-element phased-array coil was used for signal reception and VCG for retrospective cardiac gating. Breath-hold 2D inversion-recovery gradient-echo viability MR imaging was performed in the short- and long-axes views. Free-breathing 3D inversion-recovery gradient-echo viability MR imaging was acquired with the following imaging parameters: TR 3.4 ms; TE 1.8 ms; flip angle 15; turbo factor 35; RBW 869 Hz/pixel; spatial resolution 1.5 x 1.25 mm; slice thickness 2.5 mm; and one signal excitation. In this free-breathing 3D viability imaging, a k-space weighted navigator-gating technique in combination with a real-time adaptive correction of the imaged 3D volume was used for the suppression of respiratory artifacts. The presence, CNRs and transmural extension of the hyperenhancing myocardium were compared between the two viability MR images at 3T.

RESULTS

Breath-hold delayed contrast-enhanced 2D viability imaging was completed in all 21 patients, while free-breathing 3D viability imaging was successfully performed in all but three patients, because of low navigator efficiency (< 10%). Another patient was excluded from the image analysis because of serious respiratory artifacts. Ten of the 17 patients had 37 hyperenhancing myocardial segments in the standard breath-hold 2D viability imaging. The 31 of the 37 hyperenhancing myocardial segments (83.8 %) were detected using free-breathing 3D viability images: the sensitivity and specificity and accuracy of this imaging technique were 0.976, 1.00, and 0.979, respectively. The agreement of the transmural extension of damaged myocardial, which were depicted by both breath-hold 2D and free-breathing 3D viability imaging, was almost perfect between the two viability imaging techniques ($k = 0.875$). CNR between hyperenhancing and normal myocardia was significantly lower ($P < 0.0001$) and that between the hyperenhancing myocardium and LV blood was significantly higher ($P = 0.04$) in the free-breathing 3D viability images. The free-breathing 3D viability MR imaging provided the reconstructed short and long axes view images with good image quality.

Discussion

This study demonstrated the feasibility of free-breathing delayed contrast-enhanced 3D viability MR imaging at 3T for the visualization and assessment of transmural extension of the hyperenhancing myocardium in some forms of cardiac diseases. Although saturation of tissue magnetization due to the volumetric excitation, shorter TR and higher RBW might reduce the image quality, the inherently large magnetization at 3T can compensate for the disadvantage to some extent. Compared with breath-hold 2D viability images, the in-plane and slice spatial resolution was improved by 9% and 300%, respectively, in the free-breathing 3D viability images. This contributed to the good imaging quality of source and multiplanar reconstruction images generated from the free-breathing 3D viability imaging.

In conclusion, free-breathing delayed contrast-enhanced 3D viability MR imaging visualized hyperenhancing damaged myocardium, comparable to breath-hold 2D viability imaging. This imaging technique provided source and multiplanar images of the heart with high spatial resolution.

References 1. Simonetti OP, et al. Radiology 2001; 218: 215-223. 2. Peters DC, et al. Radiology 2007; 243: 690-695.