Single breath-hold 3D cine imaging of the heart: a non-angulated isotropic acquisition using SENSE on a 32 channel system

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Introduction

Two dimensional (2D) cine cardiovascular magnetic resonance (CMR) imaging has been shown to be an accurate method of assessing cardiac anatomy and function. However, it requires complex scan planning and multiple breath-holds. Isotropic three dimensional (3D) CMR requires minimal planning, and can be reformatted in any plane without loss of resolution. Unfortunately, it lacks the temporal information needed to assess cardiac function. The optimum solution is isotropic single breath-hold 3D cine imaging. Such imaging requires minimal planning and 3D cine data can be reformatted to allow qualitative and quantitative analysis of function. 3D cine imaging in a single breath-hold requires significant acceleration of imaging. In this study we utilized 2D sensitivity encoding (SENSE) on a 32 channel scanner.

Purpose

The aim of this study was to demonstrate the feasibility of using 3D cine imaging as a method cardiovascular assessment.

Methods

Images were acquired in 8 volunteers on a 1.5T MR scanner using a prototype 32 channel receive coil (Philips Medical Systems, Best, The Netherlands). Single slice 2D cine images were acquired in the long axis (LA) and 4 chamber (4CH) orientations. Multi-slice 2D cine images were acquired in the short axis (SA) orientation for quantification of ventricular function. 3D cine data were acquired in the transverse orientation using a prospectively cardiac gated bSSFP sequence (SENSE factor 2 in the FH and AP direction). Each data set was acquired in a 30-35 second breath hold. The acquired voxel size was 3×3×3 mm and 10 cardiac phases were acquired. 3D cine data was planar reformatted into the 4CH, LA and SA orientations to produce reformatted 2D cine data. MR volumetry was performed on the multi-slice SA and reformatted SA data and Wilcoxon rank sum tests were used to compare the 2 methods.

Results

Reformatted 2D cine images and conventionally acquired 2D cine images are shown in Figures 1 and 2. Note the comparable image quality of the reformatted and conventionally acquired 2D cine images. Mean LVEDV was slightly smaller when measured using the reformatted SA data (145.8±22.7 ml vs. 152.9±25.3 ml, p=0.64), while mean LVESV was slightly larger when measured using the reformatted SA data (46.7±10.8 ml vs. 44.7±12.4 ml, p=0.87). Consequently, mean LVSV (99.2±15.3 ml vs. 108.2±14.5 ml, p=0.28) and LVEF (68.1±3.9% vs. 71.2±4.0%, p=0.38) were slightly lower when measured using the reformatted data. However, differences did not reach statistical significance.

Conclusions

We have demonstrated the feasibility of acquiring isotropic 3D cine data in a single breath hold. 3D cine data was acquired in the axial orientation and required minimal planning during acquisition. This is a major benefit of this technique, as scanning can be performed by less skilled operators. During post processing arbitrary planar reformatting can be performed allowing qualitative and quantitative assessment of cardiac function. We have demonstrated that 3D cine imaging provides good image quality. In addition, there was reasonable agreement between volume data measured using the 2 methods. Prospective gating and inadequate temporal resolution accounted for the small differences seen. The use of higher SENSE factors will allow improved temporal resolution, shorter breath-holds and the use retrospective gating. This will improve the accuracy of 3D cine imaging. We believe that once optimized this technique will allow the more widespread use of CMR as it will improve ease of use, user independence and patient throughput.

Figure 1: Reformatted (top row) and conventionally acquired (bottom row) 2D cine images in the 4CH orientation.

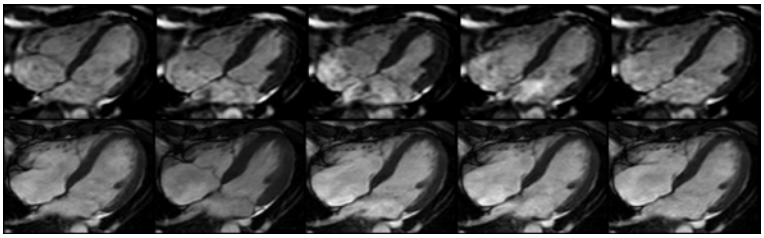

Figure 2: Reformatted (top row) and conventionally acquired (bottom row) 2D cine images in the SA orientation.