MR Coronary Vessel Wall Imaging using radial k-Space Sampling and Steady-State Free-Precession

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Abstract

We investigated the impact of radial k-space sampling and steady-state free-precession (SSFP) technique on image quality in 3D MRI of the coronary vessel wall. In eleven volunteers the right coronary artery vessel wall was studied using three different navigator-gated free-breathing black-blood sequences (Cartesian and radial gradient-echo (GRE) sequences, and radial SSFP). SNR and vessel sharpness as well as the subjective motion artifact level were analyzed. Motion artifacts were significantly reduced using radial k-space sampling. Superior SNR was found for SSFP-imaging. No difference was seen for vessel border definition among the three sequences.

Introduction

Previous studies demonstrated the potential of high-resolution MRI for non-invasive visualization of the coronary vessel wall[1,2,3]. However, for routine clinical use image quality still remains to be improved. The major impediment to coronary MR vessel wall imaging includes cardiac and respiratory motion, and small vessel wall thickness. The purpose of our study was to investigate the impact of radial k-space sampling, which is known to be less sensitive to motion artifacts, and SSFP imaging, which bears intrinsically high signal.

Materials and Methods

Right coronary artery vessel wall of eleven healthy volunteers (21 to 38 years) was investigated on a 1.5 Tesla MR system (Intera, Philips, Netherlands) using three navigator-gated free-breathing black-blood sequences (Cartesian and radial k-space sampling as well as radial k-space sampling combined with SSFP-imaging) with identical spatial resolution (0.9x0.9x2.4mm^3, reconstructed to 0.35x0.35x1.2mm^3). Sequence parameter for Cartesian GRE imaging included TR/TE 7.5/2.3 ms, flip angle 30°, for radial GRE TR/TE 7.1/1.96 ms, flip angle 30° and for radial SSFP imaging TR/TE 5.3/2.7 ms, flip angle 55°. Additionally, for SSFP imaging five startup cycles and a $\alpha/2$ approach were applied to rapidly achieve steady-state conditions. Blackblood properties for inplane vessel wall imaging maintaining high signal intensity from the vessel wall were obtained by the use of a non-slice-selective inversion pulse combined with a 2D selective local reinversion pulse, which was placed along the main axis of the right coronary artery[3]. The appropriate inversion time was adjusted according to the method of Fleckenstein[4]. For data analysis, two investigators blinded to sequence parameters subjectively compared image quality regarding motion artifact level on a three-point scale. Furthermore, SNR and vessel wall definition were objectively analyzed using a recently described vessel edge detection tool[5].

Results

Both sequences with radial k-space sampling (GRE and SSFP) demonstrated fewer motion artifacts compared to Cartesian GRE imaging (Fig. 1). The mean SNR of the coronary vessel wall using Cartesian-, radial- and radial k-space sampling combined with SSFP-imaging was 1.6±0.4, 2.0±0.6, and 2.8±0.5, respectively ($p<0.05$ for all comparison). Comparable vessel border definition was found for all three sequences (0.22±0.09, 0.24±0.09, and 0.23±0.10).

Conclusion

Radial k-space sampling yields fewer motion artifacts in GRE and SSFP coronary vessel wall imaging. Although radial SSFP-imaging showed superior SNR, vessel wall border definition was similar. Based on these data, radial GRE seems to be preferential for navigator-gated free breathing vessel wall imaging.

Fig. 1a Fig. 1b Fig. 1c

Figure 1: In-plane vessel wall images using Cartesian GRE (1a) and radial GRE (1b), and radial k-space sampling combined with SSFP (1c). Note the enhanced motion artifacts in phase encoding direction using Cartesian data acquisition (arrows in Fig. 1a).

References:

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