Coronary MR Angiography

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Background

A prospective, multicenter study shows that electrocardiography triggered, free-breathing, 3D volume targeted CMRA allows for accurate detection of coronary artery disease in the proximal and middle segments of coronary arteries (1). Whole-heart CMRA has been introduced as a method that can encompass the entire heart with a single 3D volume, rather than 3D volume targeted CMRA (2,3). Relatively low spatial resolution and long imaging time are the two major limitations of whole heart CMRA at 1.5T. The theoretical doubling of SNR from 1.5T to 3.0T can be traded for improved spatial resolution and/or reduced imaging time. Thus, 3.0T has emerged as a promising platform for high resolution CMRA (4). Despite the substantial progress in imaging hardware and techniques, to date the clinical utilization and the efficiency of whole-heart CMRA remains limited because of the relatively long scan times and operator dependency.

Technical challenges and practical solutions

Cardiac motion:

Coronary MRA uses prospective ECG gating to synchronize data acquisition to the rest period in each cardiac cycle. Because coronary artery motions in various vessel segments are different during the cardiac cycle, residual motion artifacts can occur, especially in patients with relatively high heart rates. A patient specific coronary rest period is recommended based on the free breathing cine images.

Respiratory motion:

A major challenge for CMRA remains to be respiration-induced motion artifacts. Adaptive navigator-gating and motion correction is an effective method for reducing respiratory motion artifacts. However, the effectiveness of the method is related to patient's breathing pattern. Patient training and practice before data acquisition for maintaining regular breathing should be useful to improve the gating efficiency and image quality of CMRA. A free-breathing approach using real-time gating and motion correction based on the diaphragmatic navigator echo allows improved resolution and larger coverage. Abdominal belt additionally may impact image quality.

Contrast of the Coronary Artery:

SSFP has been the sequence of choice for non-contrast whole heart CMRA at 1.5T. However, there are substantial technical challenges of using SSFP imaging for CMRA at 3.0T. Contrast-enhanced data acquisition overcomes many problems associated with SSFP and allows faster imaging because of its shorter TR and high contrast between blood and background tissue(5). For 3.0T CMRA, 0.2 mmol/kg body weight of Gadobenate dimeglumine (MultiHance; Bracco Imaging SpA, Milan, Italy) was slowly infused using a power injector at a rate of 0.3 ml/sec, immediately followed by 20 ml saline at the same rate. Sixty seconds after the initiation of contrast administration, whole-heart CMRA data acquisition was started.

Clinical Applications of whole heart CMRA

Non-contrast whole heart CMRA at 1.5T

Several single-center studies have evaluated the diagnostic accuracy of 1.5T SSFP whole heart coronary MRA for detecting significant coronary artery stenoses(6,7). These studies indicate that whole heart coronary MR angiography is useful in ruling out significant coronary artery disease in patients suspected of coronary artery disease.

Contrast enhanced whole heart CMRA at 3.0T

Our recent study has demonstrated that 3.0T contrast-enhanced whole-heart CMRA has high sensitivity and moderate specificity for the detection of stenoses in patients suspected of coronary artery disease(8). The results compare favorably with the performance of multicenter

64-slice MDCT and this CMRA approach now represents the current state of the art(9). Combined with dedicated 32-channel cardiac coils, along with parallel imaging, allows improvements in imaging speed, study success rate and reduced dose of contrast agent when compared with conventional 12-channel coils(10). The gaps between 64-slice MDCT and CMRA are quickly closing.

In conclusion, whole-heart MRCA at 3.0T with slow infusion of contrast agent allows for noninvasive detection of significant coronary artery stenoses with high accuracy. Improved SNR and CNR from high field strength and contrast-enhancement warrant further development of MRCA to allow for whole-heart coverage with higher spatial resolution and/or shorter imaging time.

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