Free-breathing Non-contrast-enhanced Three-dimensional Steady-state Free Precession MR Angiography for the Detection of Thoracic Aortic Disease and Simultaneous Visualization of Coronary and Internal Thoracic Arteries

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Introduction

Surgery of the thoracic aorta is still challenging not only in the emergency, but also in the chronic stage because of aging population with these diseases. Older patients with thoracic aortic aneurysm and aortic dissection tend to have concomitant coronary arterial diseases, and aortic dissection involves coronary arteries occasionally. Conventional X-ray angiography is a gold standard for the evaluation of diseases of the thoracic aorta and coronary arteries, but it is invasive, needs an amount of iodine contrast agents, and can lead to some critical complications such as thrombosis and dissection of the aorta and its branches. Contrast-enhanced three-dimensional (3D) magnetic resonance (MR) angiography, commonly combined with breath-holding technique, is useful for the detection of thoracic aortic diseases, but the possible disadvantages of this imaging technique are repeated breath-hold for patients with respiratory insufficiency, and adverse effects of gadolinium for those with bronchial asthma, serious hepatic dysfunction and serious renal impairment, including nephrogenic systemic fibrosis.

The purpose of this study was to assess the usefulness of free-breathing non-contrast-enhanced steady-state free precession (SSFP) MR angiography for the diagnosis of the thoracic aortic diseases and simultaneous visualization of the coronary and internal thoracic arteries.

Materials and Methods

Twenty-two patients with diseases of the thoracic aorta, such as aortic dissection, were enrolled.

MR examinations were performed using a 1.5-T unit (Achieva Novadual, Philips Medical Systems). Free-breathing non-contrast-enhanced 3D MR angiography was obtained using cardiac and navigator-gated, T2-prepared and fat-suppressed 3D steady-state free precession (SSFP) imaging sequence. The imaging parameters of free-breathing non-contrast-enhanced 3D MR angiography were as follows: TR 4.2 ms; TE 2.1 ms; flip angle 90; in-plane resolution of 1.47 x 1.47 mm^2, and parasagittal 3D volume included 35-45 3-mm-thick sections that were interpolated to 70-90 contiguous slices. A k-space weighted navigator-gating technique in combination with a prospective respiratory gating was used in the craniocaudal direction. Thereafter, coronal breath-hold contrast-enhanced 3D T1-weighted gradient-echo MR angiography was performed using a randomly segmented centric k-space sampling in combination with fluoroscopic triggering.

The signal-to-noise ratios (SNRs) of the ascending and descending aorta and aortic arch and their diameters were compared between the two imaging techniques. Visualization of right and left anterior descending coronary arteries and internal thoracic artery were defined as these arteries were observed at 5 cm or longer. The abilities to visualize these arteries were compared between the two 3D MR angiography techniques. In addition, the diagnoses based on the non-contrast-enhanced free-breathing 3D MR angiography were compared with the clinical diagnoses.

Results

Free-breathing non-contrast-enhanced 3D MR angiography examinations were achieved successfully in all but two patients, because navigator gating failed. Contrast-enhanced 3D MR angiography was not achieved in one patient because of no venous accesses. The scan efficiency of free-breathing non-contrast-enhanced 3D SSFP MR angiography using cardiac and navigator gating ranged from 28% to 80%. The SNR of aortic arch was significantly higher in free-breathing non-contrast-enhanced 3D MR angiography than in breath-hold contrast-enhanced 3D MR angiography ($P = 0.01$), The free-breathing non-contrast-enhanced 3D MR angiography visualized internal thoracic and right coronary arteries better than breath-hold contrast-enhanced 3D MR angiography ($P < 0.012$). Diagnoses of diseases of the thoracic aortic were made accurately using the non-contrast-enhanced 3D MR angiography in 16 of the 19 patients.

Discussion

The simultaneous visualization of thoracic aortic diseases and internal thoracic and coronary arteries by the free-breathing non-contrast-enhanced 3D MR angiography should be its important advantage over breath-hold contrast-enhanced 3D MR angiography in the patients with aortic dissection and thoracic aortic aneurysm. The diameters of thoracic aorta were accurately estimated with high vascular signals using the free-breathing non-contrast-enhanced 3D MR angiography. No needs of breath holding, venous injection and gadolinium-based contrast agents are other merits of this imaging technique.

In conclusion, a free-breathing non-contrast-enhanced 3D MR angiography of the thoracic aorta using cardiac and navigator-gated, T2-prepared and fat-suppressed 3D SSFP imaging was technically feasible and had some advantage, including its better visualization of internal thoracic and coronary arteries.

References 1. Sorensen TS, et al. Circulation 2004; 110: 163-169. 2. Hui BK, et. Al JMRI 2005; 21: 831-835