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Introduction

Velocity encoded cine (VEC) MR imaging provides quantitative assessment of blood flow in the cardiovascular system. With use of segmented k-space fast VEC MR imaging, noninvasive assessment of blood flow and vasodilator flow reserve in the coronary artery and coronary arterial bypass graft can be obtained within a single breath-hold time. However, it has been pointed out that blood flow measurement with breath-hold MR imaging may be altered in comparison to the physiological blood flow during regular breathing, since breath holding can change intrathoracic pressure which affects venous return to the heart. Paulev P et al [1] reported that cardiac output was 20-40 percent lower than the control values if subjects held their breath with relatively high intrapulmonic pressure using Valsalva maneuver. The purpose of the current study was to determine if breath-hold MR measurement of blood flow in the aorta and pulmonary artery can be significantly altered in comparison to that measured during regular breathing.

Materials and Methods

MR images were acquired with a 1.5 Tesla imager (Signa Horizon Echo-speed, GE Medical System). Seven healthy volunteers were studied. The subjects were situated in a supine position with four channel cardiac multi-coil arrays around the chest. A fast VEC MR sequence with k-space segmentation was used to measure blood flow in the aorta and pulmonary artery. The data was acquired on imaging planes which were perpendicular to the aorta or pulmonary artery with a slice thickness of 5 mm, a field-of-view of 28x21 cm, TR/TE of 14/4.5msec. Velocity encoding gradients were applied with velocity window of ±200cm/s. Fast VEC MR images were acquired for 24 heart beats. The subjects held their breath under shallow inspiration in order to avoid increased intrathoracic pressure and Valsalva effect. In addition, respiratory triggered VEC MR images were obtained during regular breathing to compare breath-hold and non-breath-hold MR flow measurements. Magnitude and phase-difference cine MR images with 11 to 15 temporal phases were obtained by using view sharing reconstruction. MR images were transferred to LINUX PC and blood flow in the aorta and pulmonary artery were quantified using Xphase software (Maier SE, Brigham and Women's Hospital, Boston, MA).

Results

Figure 1 demonstrates a MR blood flow curve in the ascending aorta measured under suspended shallow inspiration, breath-hold MR measurement of the cardiac output (6.29±1.43 l/min in the aorta and 6.56±2.19 l/min in the pulmonary artery) was not significantly altered in comparison with that measured by respiratory triggered VEC MR imaging (6.06±1.58 l/min and 6.72±2.30 l/min, respectively, Figure 2). The correlation between breath-hold and non-breath-hold MR blood flow measurements was high (r = 0.97 in the aorta and r=0.98 in the pulmonary artery, p<0.01).

Conclusion

MR measurement of the cardiac output can be substantially altered (~30%) when the images were acquired during breath-holding with Valsalva maneuver. However, if the subjects were instructed to hold their breath at shallow inspiration in order to prevent increased intrathoracic pressure, no significant difference was observed between breath-hold and non-breath-hold MR flow measurements.

Reference