Measuring pulmonary transit time by 2D magnetic resonance dynamic imaging in heart failure patients

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Background: Pulmonary transit time (PTT) can be measured using 3D MR acquisition. We developed a 2D dynamic acquisition to measure PTT in normals and heart failure patients (HF) and investigated the impact of temporal resolution on PTT measurement.

Methods: Prospectively enrolled subjects underwent cardiac MRI on a 1.5T Avanto scanner (Siemens, Malvern PA). During inspiratory breath-holds, ECG triggered first-pass dynamic imaging was performed in the sagittal plane covering the main pulmonary artery and left atrium using a saturation recovery SSFP sequence. Gadopentetate (Gd), 0.01 mmol/kg , was injected at a rate of 5 ml/sec. Imaging was performed with FOV 500 mm, slice thickness 15 mm, TE 0.92 ms, TR 160 ms, phase angle 50^0, matrix size 192 x 88 and voxel size 4.3 x 2.6 x 15 mm^3 over 50 cardiac cycles. Perfusion was analyzed using MASS software (Medis, Netherland). Small circular regions of interest were placed in the main pulmonary artery and left atrium (Figure A) and propagated through serial images to determine signal amplitude and time plot constructed (Figure B). PTT was measured as the time interval between peak signal amplitude in the main pulmonary artery and in the left atrium. To determine the effect of temporal resolution on manifest PTT, dynamic imaging was acquired without ECG gating with TR 113 msec in 2 subjects (one normal and one HF). Images were analyzed at temporal resolutions of 113 ms, 226 ms, 452 ms, 678 ms, 791 ms and 904 ms. Cardiac function was assessed using SSFP cine imaging and quantitated using MASS software.

Results: PTT was successfully measured in all 40 subjects, 29 with HF. There was significant PTT prolongation in the HF group 8.4±2.3 sec vs 5.9±0.8 sec in the control group ($p < 0.001$). Figure A and B illustrated a HF patient with prolonged PTT at 10.5 sec. Prolonged PTT was associated with reduced left and right ventricular ejection fractions, stroke volumes and cardiac index. Using the highest temporal resolution of 113 ms as a reference value there were 0.9%, 1.1%, -1.9%, -3.1% and -15.5% differences in PTT measurements at temporal resolutions of 226 ms, 452 ms, 678 ms, 791 ms and 904 ms, respectively.

Conclusions: PTT can be measured using a 2D saturation recovery SSFP dynamic sequence in normal and in HF subjects with small Gd doses. The effect of temporal resolution on the peak-to-peak PTT measurement is small (1-3%) with sampling at intervals less than 800 ms.

Figure A

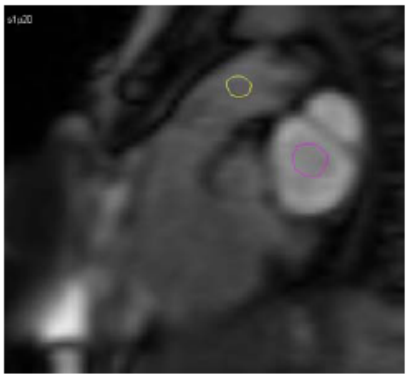

Figure B