Direct Measurement of Intra Ventricular and Atrial Pressures Concurrent with MR Image Acquisiton

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Background: Cardiac magnetic resonance imaging (CMRI) in combination with high field small animal MR systems (micro MRI) allows precise and reproducible quantitative assessments of both cardiac structure and function in rats and transgenic mouse models of human cardiac disease. Dynamic cardiac volume measurements in the small rodents can be readily obtained using Pseudo CINE imaging techniques synchronized to the directly measured ECG signals obtained from the subject animal. In this study we now employ fiber optic microsensors placed directly into the left ventricle and right atrium to obtain real time (ms) measurements of the intra-ventricular and intra-atrial pressures together with the ECG waveform while simulataneously performing CINE MR imaging. The correlation of the ventricular volume measurements taken from the MR Images to the concurrent measurements of the interior cardiac chamber pressures allows precise characterization of cardiac function.

Methods: The protocol was performed with full adherence to the APS/NIH Guidelines. We studied both rats and mice in order to develop a technique for simultaneous measurement of pressure and volume of the left ventricle and right atrium. The animals were anesthetized and body temperature maintained at 37 ^{o}C. ECG, respiration and body temperature monitoring was accomplished using MRI compatible optical monitors (SA Instruments, Inc. Stony Brook, NY). Two optical micro-sensors (<.6 mm diameter) attached to optical fiber catheters were inserted directly into left ventricle and right atria via the right carotid artery and right jugular vein, respectively. The optical sensors and associated instrumentation (SAMBA Instruments, Inc.) were interfaced to the SA Instruments monitoring system for continuous pressure recording during the entire MR imaging procedure. All MR Images were acquired on a 9.4 T 20 cm bore horizontal magnet with AVANCE console (Bruker, Billerica, MA) using 7 cm birdcage resonator. Contiguous bright blood cine images were acquired using a 2-D FLASH technique.

Results: Real time measurements of LV and RA pressures were successfully acquired during MR Image acquisition. No artifacts were observed in theMR image and the ECG, LVP and RAP waveforms were unaffected by the operation of the MR imaging system. (See figures 1 and 2)

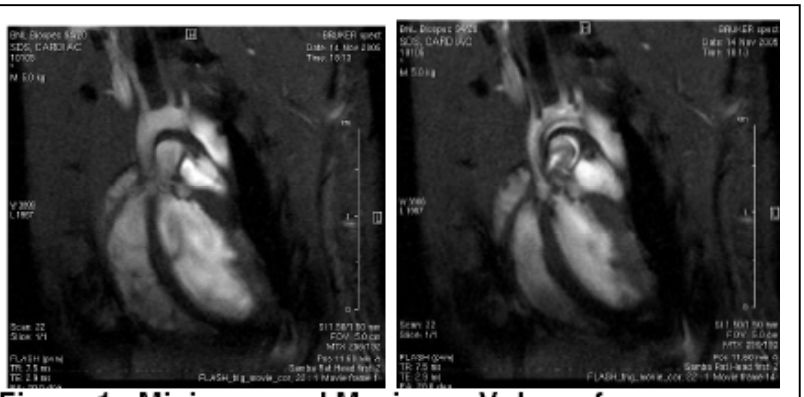

Figure 1: Minimum and Maximum Volume frames of a CINE MR Image of live Rodent.

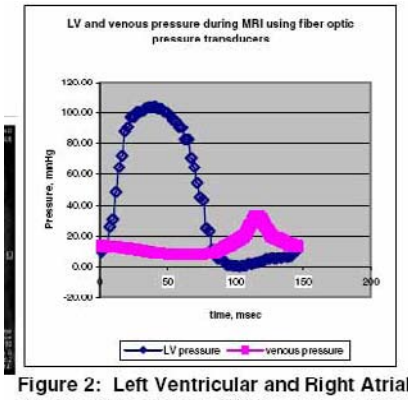

Figure 2: Left Ventricular and Right Atrial Pressure data acquired during MR Image acquisition.

Conclusion: Based on CMRI imaging we have developed a technique for reliable cardiac phenotyping of rodents. Quantifying specific functional changes associated with the genetic variability and pathological progression will allow clearer characterization of cardio vascular disease.

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