A NOVEL APPROACH TO COMPREHENSIVE ATRIO-VENTRICULAR FUNCTIONAL ANALYSIS

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TARGET AUDIENCE: Cardiologists, cardiovascular physiologists, scientists and engineers with research interests in cardiovascular MRI.

PURPOSE: Cardiac MRI provides important structural and functional information. However routine quantitative analysis of cine MRI is often restricted to left and right ventricular ejection fraction measurements. Functional assessment of left and right atria is frequently not performed. One of the major reasons for this is the significant operator input and time required for comprehensive time resolved analysis of all four cardiac chambers. Furthermore, despite development of automated and semi-automated algorithms for cardiac functional assessment, there is often uncertainty in the results regardless of operator input. This is due to lack of accurate delineation of the basal segments of the left and right ventricle because of partial volume effects and through plane motion. Furthermore, the unique shape of the right ventricle leads to additional challenge at the right ventricular outflow tract. In this abstract, we present a framework for comprehensive evaluation of all cardiac chambers simultaneously, which leverages limited human input to optimize quantitative functional output. The proposed approach can be modified and implemented to develop algorithms for bi-atrioventricular function assessment simultaneously.

Table 1. MRI Ventriclular Function Parameters

	LV	RV
EDV,ml	130.98±5.42	135.86±6.07
ESV,ml	57.04±0.40	62.18±3.87
SV,ml	73.94±2.28	73.68±2.36
EF,%	57.84±0.81	56.16±0.89
LVSV-RVSV, ml		0.25±0.49

L, left; R, right; SV, stroke volume; mean±SE

Table 2. MRI Atrial Function Parameters

	LA	RA
Max V	48.7±1.70	54.09±1.86
Min V	19.08±0.84	21.04±1.13
Ejection V	33.4±1.48	35.8±1.33
Conduit V	40.52±1.33	37.88±1.69
Passive EF,%	48.54±0.94	42.99±1.2
Active EF,%	36.84±1.6	32.32±1.0

V, volume; EF, emptying fraction. LA, left atrium; RA, right atrium. mean±SE

METHODS: *Population/Imaging:* MRI images were acquired from 8 normal volunteers between the ages of 19 and 24, 3 males and 5 females, using a Siemens 3 Tesla (T) scanner (Siemens Healthcare, Germany). Standard cardiac cine slices were taken in 360° long axis and short-axis (SA) orientation with a triggered-gated breath-hold balanced SSFP sequence. SA slices covered the whole heart that includes both atria and ventricles. Additional images in right ventricle outflow track (RVOT) and right 2 chamber (R2CH) orientation were also performed. The parameters were set as follows: FOV: 360-400mm, 8mm slice thickness, zero spacing, 40° flip angle, 256x128 matrix, TR/TE of 5.4/1.4ms.

Analysis: Intersections of the mitral valve (MV), tricuspid valve (TV) leaflets with the LV and RV wall were manually placed in 2 and 4 chamber views in 360 group and R2CH. Pulmonary valve (PV) intersections were marked in RVOT view, and aortic valve (AV) intersections were marked in two LVOT views in 360 group. All intersections and lines were marked at end-diastole (ED) and end-systole (ES) and propagated to the remaining time frames using automated algorithm.[1] Endocardial contours were drawn continuously from the LA apex to LV apex, and RA apex to RV apex in short-axis views without regard to atrioventricular or arterial boundaries at ED and ES and propagated to remaining time frames using automated algorithm. All contours were registered using contours from all long axis views. Planes were fit to the landmarks of each valve and used to split the volume defined by each contour into atrium, ventricle, or artery.

RESULTS: As shown in Fig. 1, volume time curves for all four cardiac chambers were obtained simultaneously with limited additional operator input. There is no significant difference between the RV an LV stroke volume (Table 1) suggesting accurate chamber segmentation using our technique. As expected, there is atrioventricular, biatrial and biventricular synchronicity as depicted in Fig 1.

CONCLUSION: A simple approach for comprehensive time resolved cardiac analysis is demonstrated. This approach allows for evaluating bi-atrial and biventricular interactions simultaneously that may be important in various disease states.

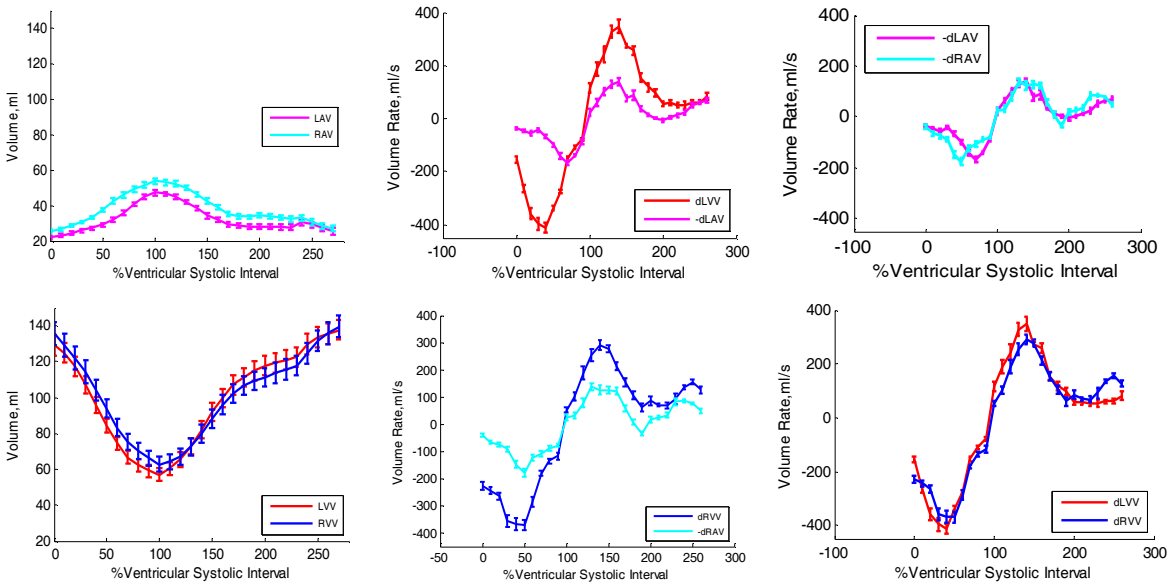

Fig. 1 Mean volume (left) and volume rate (center and right) vs. time curves. Bars represent one standard error. Note that LA and RA rate curves are negated (-dLA/dt and –dRA/dt)

REFERENCES: 1. Feng W, et al. JCMR 2009; 2. June C, et al. AM J Physiol Heart Circ Physiol 2010; 3. Zhang X, et al. JCMR 2014; 4. Ahtarovski KA, et al. AM J Physiol Heart Circ Physiol 2012.