A normal database for the detection of abnormal myocardial contraction patterns

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INTRODUCTION: Ventricular dyssynchrony is a condition where the walls of the left ventricle (LV) do not contract simultaneously. Dyssynchrony has been observed in approximately 30% of all heart failure patients and can be treated with Cardiac Resynchronization Therapy (CRT). Recent studies have suggested that comparing myocardial velocity patterns in the LV wall is a method to assess dyssynchrony and select patients for CRT. In order to identify and assess ventricular dyssynchrony based on velocity patterns, the normal left ventricular myocardial velocity pattern must be quantified.

PURPOSE: 1) To construct a database of the myocardial velocity pattern from a group of normal volunteers and 2) To compare velocity patterns in patients scheduled for CRT to the normal database.

METHODS: Myocardial tissue velocity measurements were performed on a 1.5T Philips Medical Systems Intera CV MRI scanner using a cardiac coil. A segmented, navigator-echo and ECG-gated phase contrast sequence was used to acquire three-directional velocities in a basal slice of the left ventricle [1]. Presaturation slabs were used on each side of the slab were used to null the signal from in-flowing blood. VENC value was 30 cm/s, temporal resolution was 26 msec, and voxel size was 1.4 x 1.4 x 8mm. Velocity maps were acquired at three short axis myocardial slices (apical, mid, and basal) in 10 normal volunteers and 8 heart failure patients prior to CRT implantation.

Background phase errors were removed by fitting a plane to static tissue using a linear regression [2]. Velocities were converted into radial, circumferential, and longitudinal coordinate systems and averaged according to the AHA 16-segment model. For each normal volunteer, the values of peak systolic and diastolic velocities, and *time-to-peak* systolic and diastolic velocities were determined in each AHA segment. Mean and standard deviation values for each segment of the normal database were averaged across all ten normal volunteers. Patient values were compared to the normal database on an individual basis. Patient values were considered abnormal if they fell two or more standard deviations away from the normal mean.

RESULTS: Velocity maps were successfully acquired in all normal volunteers and dyssynchrony patients. Average values of the normal database are shown in Figure 1. Patient values were compared to the normal database:

Peak Velocities: Peak systolic velocity in all 8 patients was below two standard deviations of the normal mean in at least one myocardial segment. Peak systolic radial velocity was outside the normal range in all 8 patients, as was peak longitudinal velocity. Peak circumferential velocity fell outside two standard deviations of the normal mean in 7/8 patients.

Peak diastolic velocity below two standard deviations of the normal mean was observed in at least one myocardial segment in all 8 patients. In the radial and longitudinal directions, all patients had at least one segment outside of the normal range, and in the circumferential direction, in 7/8 patients at least one segment fell outside of normal range in the circumferential direction.

Time-to-peak velocities: All 8 of the dyssynchrony patients had at least one myocardial segment in which time-to-peak systolic velocity occurred later than the normal mean+2 standard deviations (i.e. peak velocity in that segment was delayed). In 6/8 patients, this delay was observed in the radial direction, in 7/8 patients the delay was observed in the circumferential velocity direction, and in 5/8 patients the delay was observed in the longitudinal direction.

2 of the 8 patients showed a delay in time-to-peak diastolic velocity. 1 patient had a delayed segment in the radial direction, and two patients showed delayed segments in the circumferential and longitudinal directions.

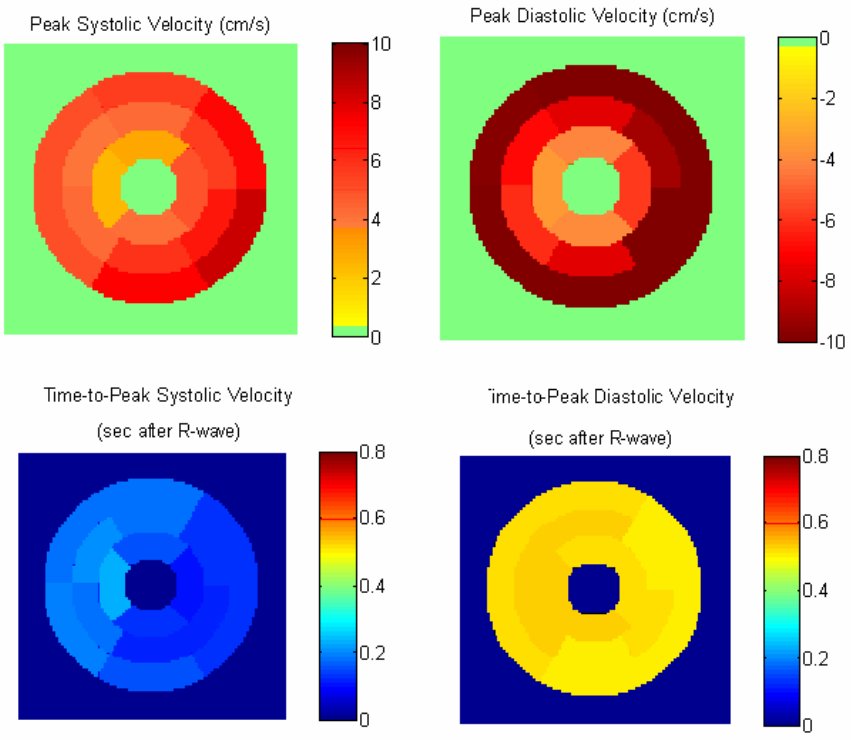

***Figure 1**: Average values in the normal database in the longitudinal direction. Velocity values are in cm/s and time-to-peak values are in seconds from the detection of the R-wave. Notice that time-to-peak velocity is uniform throughout the entire myocardium and that that peak longitudinal velocity values are greatest in the basal slice and decrease toward the apex as expected. This is seen in both systole and diastole.*

DISCUSSION: The finding that heart failure patients exhibit lower peak velocities during both systole and diastole is not unexpected. The delay in time-to-peak velocity observed during systole, but not diastole, is also not surprising, as the patient group we studied were scheduled for CRT based on the presence systolic dysfunction and a prolonged QRS interval.

CONCLUSIONS: A database describing the normal myocardial velocity pattern was constructed. Comparing patient velocity scans to the database may be useful in identifying areas of abnormal myocardial velocity or areas of abnormal time-to-peak velocity. With the use of this database, abnormal areas can be identified on a regional basis based on the AHA 16-segment model.

[1] Delfino, JG, et al., *J Magn Reson Imaging*, (2006) 304-11. [2] Walker, PG, et al., *J Magn Reson Imaging*, (1993) 521-30.