Quantification of Left Ventricular Twist in Patients with Becker and Duchenne Muscular Dystrophy

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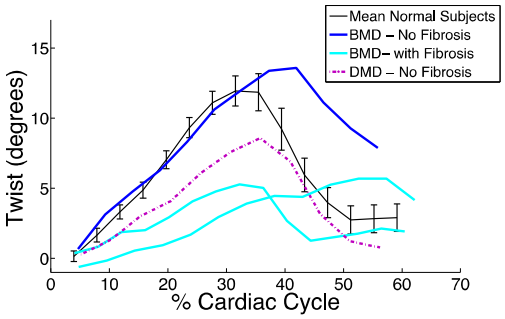
INTRODUCTION – Becker and Duchenne Muscular Dystrophy (B/DMD) are common inherited neuromuscular disorders that often develop into cardiomyopathy with posterobasal myocardial involvement(1) and subepicardial fibrosis(2), resulting in cardiac dysfunction during childhood or early adulthood(1). Left Ventricular (LV) twist, defined as the difference in rotation between the apex and base of the heart, has been suggested as an imaging biomarker of ventricular dysfunction. In mice with DMD cardiomyopathy, peak twist is reduced and the duration of LV twisting and untwisting are both decreased, when compared with controls (3). However, a recent study of twist in DMD patients demonstrated no significant change in twist compared with age matched controls (4). Further study of LV twist in B/DMD patients is needed to clarify these findings. The ***objective*** of this study was to evaluate changes in LV rotational mechanics in patients with B/DMD.

METHODS – Four male pediatric subjects diagnosed with B/DMD were studied (3 BMD and 1 DMD) using tagged cardiac MRI (14.8±4.0 years, 48.6±17.3 kg, 72.7±7.3 bpm). N=10 non-aged-matched (29±4.3 years) controls were also studied. Cine horizontal and vertical line tagged images were acquired on a 1.5T scanner (Siemens, Avanto) at the apex and base of the heart, with the following imaging parameters: TE/TR= 3.0/6.1ms, 1.7×1.7×6 mm^3 spatial resolution, 250 Hz/px bandwidth, 6 views-per-segment, 36.6ms temporal resolution, and 8mm tag spacing. Measurements of end-diastolic and end-systolic volume were made from short-axis bSSFP cine images. Tagged images were analyzed with Fourier Analysis of STimulated Echoes (FAST), a recently validated method for the rapid quantification of LV twist(6). Systolic twist-per-volume slope was calculated as peak twist divided by the difference between end-systolic and end-diastolic blood volumes. Torsion was calculated twist divided by the distance between the slices. CL-shear angle was calculated as the apical and basal difference of the product of rotation and epicardial radius normalized by the distance between the apical and basal slices. Measured values were reported as mean±SD (minimum, maximum). The presence and absence of myocardial fibrosis was determined using late gadolinium enhancement from long axis and short axis LV T1-weighted images(5).

RESULTS – Fibrosis was observed in two BMD patients only. Figure 1 shows that LV twist is generally reduced in B/DMD patients, but may depend upon the presence of fibrosis and the kind of muscular dystrophy, compared to normal subjects. Mean peak LV twist was 8.3±3.8°, (5.3 to 13.6° deg). Mean peak LV twist was 12.9±2.8° in normal subjects. Mean peak LV torsion was 1.9±0.6°/cm (1.3 to 2.4°/cm) in patients and 2.5±0.5°/cm in normal subjects. Mean peak LV CL-shear angle was 4.6±1.0° (3.5 to 5.6°) in patients and 6.5±1.3° in normal subjects. Mean LV systolic twist-per-volume slope was -0.2±0.1°/mL (-0.09 to -0.34°/mL) in patients. In patients, LV end diastolic volume was 85.2±32.1mL, LV end systolic volume was 43.7±13.6mL, LV end-diastolic mass was 93.4±20.2g, and mean ejection fraction was 51.0±6.4%.

	BMD	BMD	DMD	Mean B/DMD	Normal Subjects
Age [years]	17	16.5	9	14.8±4.0	29±4.3
Fibrosis	**No**	**Yes**	**No**	**Yes/No**	**No**
Peak Twist [deg]	13.6	5.5±0.3	8.6	8.3±3.8	12.9±2.8
Peak Torsion [deg/cm]	2.3	1.4±0.1	2.4	1.9±0.6	2.5±0.5
Peak CL-Shear Angle [deg]	5.3	3.8±0.5	5.6	4.6±1.0	6.5±1.3



DISCUSSION – Mean LV peak twist, LV torsion, and LV CL-Shear angle were all decreased in B/DMD patients compared to non-age matched normal subjects. Mean peak LV twist reported herein, however, is similar to the age matched normal subject literature value measured with echo in 13 to 18 year old (8.8±2.6deg) (7). Our results may be skewed by a small population with heterogeneous results and varying degrees of fibrosis. DMD appears to be associated with a decrease in LV twist even prior to appearance of fibrosis. Li *et al.* also observed a trends of decreasing LV twist with respect to increasing myocardial fibrosis in DMD mice, which is consistent with the observations of this study(3). More patients are needed to further confirm these initial findings. Furthermore, follow-up studies for the B/DMD patients in this study will provide insight to patient-specific longitudinal changes in LV rotational mechanics.

CONCLUSION – FAST processing of LV tagged images is a quick and robust way(6) to evaluate LV rotational mechanics in pediatric subjects with B/DMD. A decrease in LV twist within the B/DMD patients appears to correspond to an increase in myocardial fibrosis. Apparent decreases in LV twist, LV torsion, LV CL-shear, and LV twist-per-volume rate indicate an impairment of the rotational mechanics in these subjects relative to non-age-matched controls.

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