Quantify LV rotational mechanics in Duchenne and Becker Muscular Dystrophy using MR tagging

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INTRODUCTION – Duchenne and Becker Muscular Dystrophy (DMD/BMD) are recessive x-linked inherited neuromuscular disorders that frequently result in myocardial fibrosis and ventricular dysfunction [(1)]. The functional consequences of ventricular fibrosis in these patients are incompletely understood. Cardiac MRI tagging can be used as a noninvasive imaging biomarker for quantifying ventricular dysfunction in DMD/BMD cardiomyopathy. In particular, estimates of ventricular rotational mechanics (e.g. twist or torsion) may provide insight to early ventricular dysfunction that is not apparent in measures of ejection fraction. Furthermore, myocardial fibrosis in DMD and BMD patients is frequently reported and could significantly impact LV rotational mechanics. The **objective** of this study was to quantify both the LV rotational mechanics using cardiac MRI tagging and the presence or absence of ventricular fibrosis in pediatric patients with DMD or BMD.

METHOD – Fourteen (N=14) male pediatric subjects (13.7±4.5 years old) genetically diagnosed with DMD/BMD were consented to participate in an IRB approved study. Each patient underwent a cardiac MRI exam at 3T (Trio, Siemens, Erlangen, Germany) that included evaluation of functional status with cine balanced steady-state-free precession (bSSFP), cardiac tagging, and ventricular scar evaluation with late-gadolinium enhancement (LGE). Ten (M=10) non-aged-matched (29±4.3 years old) healthy volunteers were also evaluated to provide context for interpreting the pediatric data. Measurements of LV mass (LVM), LV end-diastolic volume (LVEDV), LV end-systolic volume (LVESV), and ejection fraction (EF) were obtained from short-axis bSSFP cine images. Cine horizontal and vertical line tagged images were acquired at the apex and base of the heart using the Fourier Analysis of Stimulated (FAST) cardiac MRI tagging acquisition and analysis tools [(2)]. FAST tagged images were acquired with the following imaging parameters: TE/TR= 3.0/6.1ms, 1.7mm×1.7mm×6mm spatial resolution, 250 Hz/px bandwidth, 6 views-per-segment, 36.6ms temporal resolution, and 8mm tag spacing. LV twist was calculated as the rotational difference between the apical and the basal tagged images. Measured values were reported as mean ± standard deviation. The presence and absence of myocardial fibrosis was determined on LGE short and long-axis images by consensus agreement amongst two cardiologists and one radiologist with extensive experience in cardiac MRI. Based upon the consensus agreement the patients were divided into four groups: BMD, BMD with fibrosis (BMD+f), DMD, and DMD with fibrosis (DMD+f).

RESULT – Patient data can be found in the Table. Our results demonstrate a decrease in the magnitude of peak LV twist amongst DMD+f and BMD+f patients compared to DMD and BMD patients. The magnitudes of systolic LV twist rates and diastolic untwist rates, however, are preserved amongst DMD, BMD, and DMD+f, but decreased for BMD+f. Note that EF is preserved for DMD, BMD, and DMD+f despite abnormality in rotational mechanics. Comparisons for DMD, BMD, DMD+f, and BMD+f patients demonstrate decreases in the magnitudes of the rotational mechanics parameters when compared to the non-aged matched controls. BMD+f appear to be the most effected.

Category	Age [year]	LVM [g]	LVEDV [mL]	LVESV [mL]	LVEF	Peak LV Twist [deg]	LV Twist Rate [deg/s]	LV Untwist rate [deg/s]
DMD (N=7)	13.7±5.4	88±22	79±22	29±6	63%±6%	9.2±0.4	49.3±9.2	-97.7±28.3
BMD (N=2)	9.0±2.8	49±15	53±4	22±5	58%±12%	11.0±1.9	54.8±11.3	-102.2±30.3
DMD+f (N=2)	14.0±2.8	71±5	91±5	35±0.2	61%±2%	7.1±0.6	50.8±6.5	-93.0±17.5
BMD+f (N=3)	16.7±1.5	103±4	104±16	50±5	51%±8%	6.5±2.1	35.9±7.5	-60.2±16.3
Normal (N=10)	29±4.3	---	---	---	---	12.8±2.6	73.0±14.4	-106.5±22.5

DISCUSSION – Our results indicate that DMD/BMD directly reduces the magnitude of all measures of ventricular rotational mechanics and that the presence of ventricular fibrosis in DMD+f and BMD+f is associated with further reductions in their magnitude. Note also, that EF was preserved in DMD, BMD, and DMD+f despite abnormality in LV rotational mechanics. Hence, quantitative measures of global rotational mechanics may be early indicators of ventricular dysfunction in these patients. FAST acquisition and analysis methods are a robust and quick way to estimate global ventricular rotational mechanics that has demonstrated clinical utility in pediatric patients. Due to limited patient data our current result may, however, be affected by the variable expression of the disease. More patient data and age-matched control data are needed for a more comprehensive analysis.

REFERENCES: [1] Frankel. *et al.* Hum Pathol 1976; 7:375-386. [2] Reyhan M. *et al.* JMRI 2012; 35:587-593.

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