Left Ventricular Longitudinal Stress and Strain Relationship is Altered in Marfan Syndrome, but Ventricular-Arterial Coupling is Preserved

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Background

Marfan syndrome is a heritable vascular disorder caused by a deficiency in fibrillin, an important component of the vessel wall. A potentially devastating complication of Marfan syndrome is aortic aneurysm formation and subsequent dissection or rupture. However, early surgical root replacement has greatly reduced morbidity and mortality associated with this complication. Currently, the only clinical measurement associated with risk of aortic catastrophe is aortic size. Current practice recommendations dictate that patients with Marfan syndrome undergo prophylactic aortic root replacement when the aortic size reaches more than 50mm. Nevertheless, aortic dissections can occur at aortic size less than 50mm. We hypothesize that the inherent aortic structural abnormalities in Marfan patients result in altered interaction between the heart and systemic vasculature and that ventricular-arterial coupling (VAC) relations are different in this group compared to control subjects. We further postulate that VAC might be a more sensitive marker to predict aortic dissection/rupture.

Objective

Determining a way to predict future adverse events in Marfan syndrome, other than aortic size, would save patient lives. Ventricular arterial coupling (VAC), a measure of the interaction between the ventricles of the heart and their respective artery outputs could provide a more accurate way to predict adverse events. We sought to understand VAC in Marfan subjects.

Patients and Methods

We recruited patients from general cardiology, internal medicine, and a specialized aortic clinic at the University of Kentucky. We included male and female subjects, age>18 yrs, and without previous cardiac or aortic surgery. Exclusion criteria included known PAD, h/o coronary intervention or MI, h/o congestive heart failure, surgery involving the heart or aorta, and CKD II-V. After obtaining informed consent, we performed a detailed analysis of existing complete two-dimensional echocardiograms using standard echocardiographic measurements according to the American Society of Echocardiography guidelines. Hemodynamic parameters including LV elastance, longitudinal stress, global longitudinal strain, stroke work, cardiac index, arterial compliance, and VAC ratios expressed as the ratio of arterial elastance to LV elastance (Ea/EesLV) were calculated. Non-invasively measured blood pressure at the time of echocardiography was used to calculate arterial elastance.

Table 1. Patient Demographics

Column1	Marfan	Non-Marfan	Control
Age	34(21,60)	51 (28,87)	44 (27,69)
SBP	118±14	134±15	128±14
DBP	69±12	81±7	79±12
MAP	85±12	98±9	95±11
HR	69±10	65±11	73±11
BMI	23±4	30±5	29±7
Height	74±4	70±5	66±3
LVMI	96±22	94±24	69±26
AoSV	5±1	4±1	3±0.4
AoSTJ	3±1	3±1	3±0.3
LVEF	0.54±0.1	0.60±0.05	0.62±0.06
LVEDVI	61±14	56±5	46±9
LAVI	36±11	29±6	23±6

Table 1. A total of 35 subjects were recruited including 8 with Marfan syndrome, 13 with a non-Marfan aortopathy, and 14 controls without aortic disease. Subjects with Marfan syndrome were of younger age, taller stature, lower BMI and lower BP compared with non-Marfan and control subjects.

Results

Table 2. Echocardiographic Findings

	Marfan	Non-Marfan	Control	ANOVA
LVEF	0.54±0.1	0.60±0.05	0.62±0.06	0.005
E_a	1.26±0.15	1.56±0.11	1.692±0.09	0.013
E_{es}	1.98±0.65	2.30±0.63	2.80±0.59	0.466
E_a/E_{es}	0.67±0.29	0.67±0.56	0.61±0.36	0.212

Table 2. LV and arterial elastance, VAC ratios, as well as the relation of arterial elastance to LV stroke work, LVEF to VAC, and LV elastance to arterial compliance were not significantly different between the groups. Subjects with Marfan syndrome had a slightly lower LVEF compared to the other two groups: 54% vs 60% vs 62%, respectively.

Figure 1. LVEF

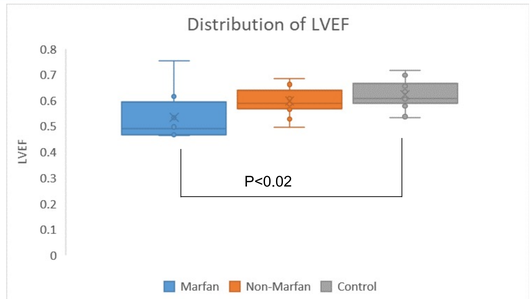

Figure 1. Left ventricular ejection fraction (LVEF) is a measurement of the amount of blood being pumped out of the left ventricle, and it is a way to measure left ventricular systolic function. Subjects with Marfan syndrome had slightly lower LVEF compared to the two other groups (0.54±0.1, p-value <0.005).

Figure 2. Elastance and Ventricular-Arterial Coupling

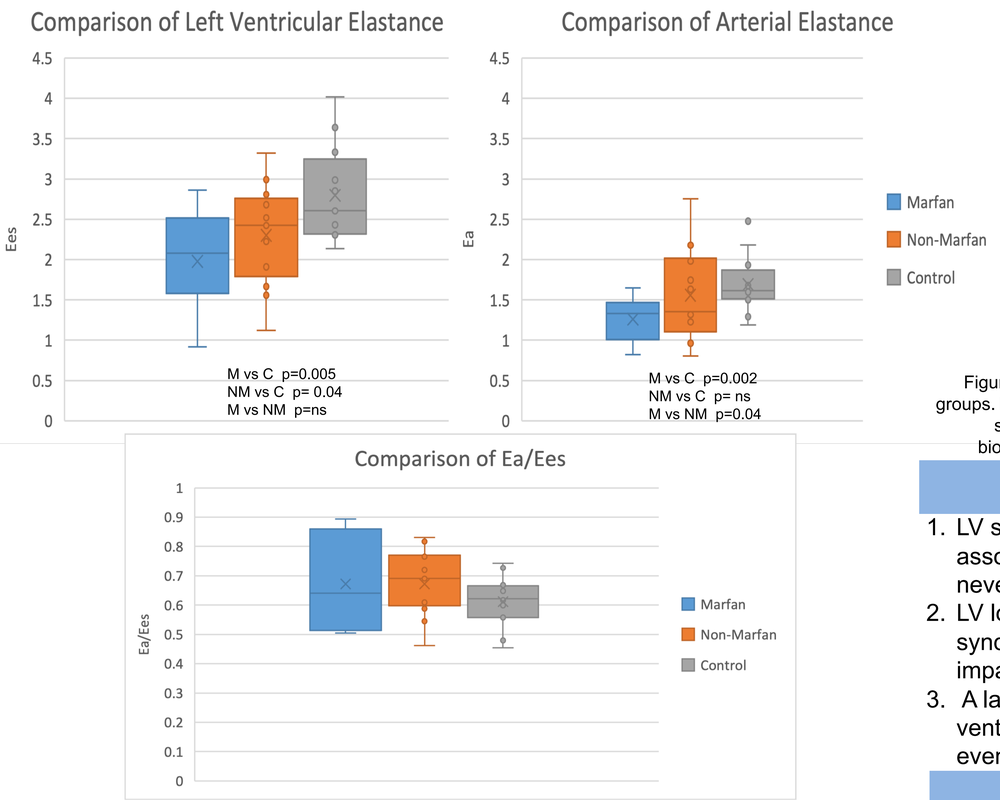

Figure 2. Ventricular-arterial coupling is used to assess the interactions between the left ventricle and the aorta, and it is a way to estimate cardiac function. Subjects with Marfan syndrome had lower LV and arterial elastance than control subjects. However, the VAC ratios were not different between any of the groups.

Figure 3. Relation of LV longitudinal Stress vs LV Global Longitudinal Strain

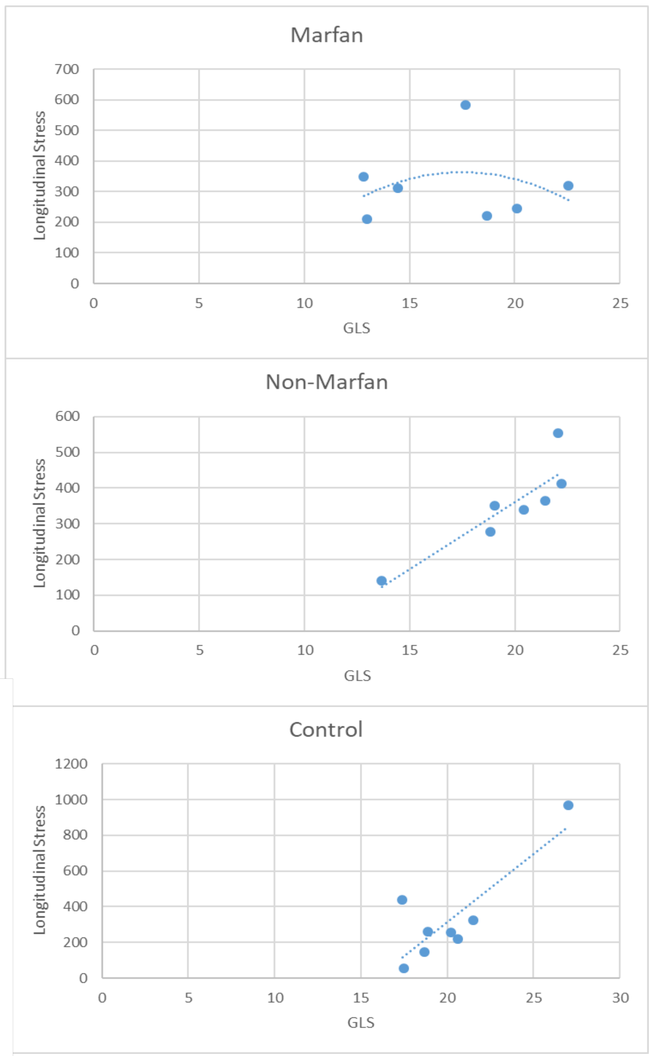

Figure 3. There was no difference in the distribution of longitudinal stress values between the groups. However, an altered relation between LV longitudinal stress and strain exists in the Marfan's syndrome subjects, leading us to conclude that mutations in the fibrillin gene alter the biomechanical properties of the heart, not just the aorta, in people with Marfan syndrome.

Conclusions

1. LV systolic function is reduced in subjects with Marfan's syndrome and is associated with lower LV elastance, but ventricular-arterial coupling is nevertheless preserved in this cohort.
2. LV longitudinal stress and strain relationship is altered in Marfan's syndrome, possibly reflecting differences in LV biomechanical properties imparted by mutations in the fibrillin gene.
3. A larger sample size may enhance the interactions between left ventricular function and systemic vasculature to predict future adverse events in Marfan syndrome.

Disclosures

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