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Atrial strain predicts exercise capacity in patients with the fontan circulation

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Introduction: Atrial function has recently emerged as a valuable parameter, particularly for evaluation of ventricular diastolic dysfunction and heart failure. There is a strong need for reliable echocardiographic predictors of exercise capacity in univentricular hearts, but their particular anatomy makes it challenging. In this work we aimed to characterize the relationship between atrial strain and exercise parameters in the Fontan population.

Methods: Fontan patients followed in our outpatient clinic were prospectively evaluated with cardiopulmonary exercise test and transthoracic echocardiogram. The dominant atrium, i.e. the atrium connected to the dominant atrioventricular valve, was assessed with speckle-tracking echocardiography for active (εact), conduit (εcon), and reservoir (εres) strain; and εact/εres ratio. A single cardiac loop from the 4 chamber view was selected for this analysis and the 'zero' strain reference for atrial deformation analysis was set at the onset of the electrocardiogram P wave. Exercise capacity defined as the percentage of peak oxygen uptake (VO2), comparing with predicted values, was chosen as the dependent variable. Independent variables were selected among clinical and echocardiographic data. Statistical analysis was performed using SPSS version 23. T-student test was used for binomial and continuous variable correlation; single and multivariable linear regression was used for continuous variable correlation. Statistical significance was defined as p-value < 0.05.

Results: Fifty-two Fontan patients were assessed. Nineteen (37%) were excluded due to inadequate deformation tracking of the atrial wall. Mean age was 18.0 years (SD 6.9, min. 10.0 - max. 36.0), mean age at Fontan surgery was 7.0 years (SD 2.9, min. 3.0 – max. 18.0). Peak VO2 as a percentage of the predicted value was 66.5% (SD 18.8, min. 36.4 – max. 118.6). εact was -11.1% (SD 3.7, min. -21.1 – max. -4.8), εcon was 10.6% (SD 6.5, min. -0.5 – max. 6.5), εres was 21.7% (SD 5.2, min. 13.2 – max. 34.4) and εact/εres ratio was 0.54 (SD 0.23, min. 0.22 – max. 1.04). On univariate analysis, all atrial strain variables correlated with peak VO2. After adjusting for collinearity, multivariable regression defined age (estimate -1.6, 95% CI: -2.5 to -0.9, p-value < 0.001) and εact strain (estimate 1.8, 95% CI: 0.5 to 3.2, p-value = 0.011) as the strongest predictors of peak VO2 (r2= 0.479).

Conclusion: Peak VO2 defines exercise capacity and is a strong marker of prognosis in Fontan patients. There are very few echocardiographic variables capable of predicting it, in part due to a variable cardiac anatomy. We showed that atrial strain rate is a novel echocardiographic parameter that predicts peak VO2. In the Fontan circulation, a higher reliance on active atrial contraction for ventricular filling predicts lower exercise capacity. Therefore, atrial strain rate, whenever measurable, may provide a new method of risk stratification in this population.

Abstract 1167 Figure. Example of atrial strain curve.