Effect of cycle exercise on regional oxygen saturation in Failing-Fontan patients

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Introduction:
Failing-Fontan patients suffer from increased morbidity and mortality, while pathophysiologic changes leading to a failing still remain unknown. We investigated differences in regional oxygen saturation (rSO2) by near infrared spectroscopy (NIRS) in Failing-, Non-Failing Fontan and biventricular (TGA) patients during ramp incremental cycle exercise, following the hypothesis that rSO2 is lower in Failing-Fontan patients, which could contribute to the development of a failing.

Methods
38 patients underwent (n=7 Failing Fontan, n=22 Non-Failing Fontan and n=9 TGA patients) incremental ramp cycle exercise under continuous blood pressure, heart rate and ECG-surveillance. The average age was 16.5y (± 5.57). NIRS was measured with 4 electrodes (kidney, frontal cortex, quadriceps femoris and triceps brachii) during the exercise, a 5-minute recovery period and during one hour physiologic regeneration by a portable NIRS monitor. Absolute and relative (from baseline) were calculated.

Results
Failing-Fontan had significantly shorter duration of exercise than Non-Failing or TGA patients (p<0.01), less watts per kilogram (p<0.01), a higher resting heart rate (p=0.01), a lower maximum heart rate (p<0.01) and lower resting and maximum blood pressure (p<0.01). Failing and Non-Failing Fontan showed significantly lower baseline in cerebral oxygen saturation than biventricular patients (66.2 and 69.9 vs. 76.7 p=0.03/p=0.04) and Failing patients showed a trend of lower renal oxygen saturation than TGA patients (64.3 vs. 82.8; p=0.09). In musculature rSO2 was significantly lower in triceps brachii for Failing patients compared to TGA (61.2 vs. 72.1; p=0.02), in quadriceps femoris absolute values of rSO2 were lower in Failing (p=0.09) and Non-Failing but didn’t pass the significant threshold. Failing patients showed a significantly (p<0.01) faster decrease of rSO2 according to exercise time than Non-Failing or TGA patients. On the other side TGA patients showed a significantly faster regeneration regarding rSO2.

Conclusions
This is the first study demonstrating regional oxygen measurements in Failing-Fontan patients under cycle ergometry, showing that Failing-patients present with significant decreased rSO2 in rest and under exercise compared to Non-Failing and especially biventricular patients. Decreased rSO2 univentricular patients compared to biventricular controls demonstrates low output of the single ventricle. The effects of chronic desaturation in Failing-Fontan patients need to be discussed and further evaluated.