

Title: Determinants of Oxygen Uptake (VO_2) Among Patients with CF-LVADs.

Purpose: Characterize individual components of VO_2 (cardiac output [Qc] and $(\text{A-V})\text{O}_2$ difference) at rest and during submaximal and peak exercise among CF-LVAD patients.

Methods: Thirteen CF-LVAD participants (56 ± 12 yrs, 12 male) and 9 healthy controls (42 ± 12 yrs, 7 male) completed invasive cardiopulmonary exercise testing on a stationary upright cycle ergometer. Hemodynamic data and gas-exchange parameters were collected at rest, two submaximal levels of exercise below the ventilatory threshold, and peak workload. Swan-Ganz catheterization was performed to determine baseline hemodynamics. A conductance catheter was then used to calculate Qc at each stage of exercise. VO_2 was recorded on a breath-by-breath basis by indirect calorimetry. Blood pressure was continuously monitored by arterial line. Musculoskeletal performance was assessed by calculating the $(\text{A-V})\text{O}_2$ difference at each stage of exercise.

Results: Cohort characteristics and baseline demographics are demonstrated in **table 1**. Peak VO_2 among CF-LVAD participants was severely reduced compared to healthy controls. When CF-LVAD participants were matched to healthy controls by workload according to VO_2 quartiles, the CF-LVAD participants had a hypotensive response to exercise, as well as a blunted rise in Qc , with modest increases only from rest to submaximal exercise (**figure 1**). As a result, $(\text{A-V})\text{O}_2$ difference was higher for CF-LVAD participants than healthy controls at each VO_2 quartile.

Conclusion: Due to impairments in contractile reserve, CF-LVAD participants exhibit a greater $(\text{A-V})\text{O}_2$ difference than healthy individuals when exercising at similar workloads.

Table 1: Baseline Demographics and Hemodynamic Characteristics

	CF-LVAD (N=13)	Healthy Control (N=9)
Demographics		
Age, years	56±12	42±12
Male Sex, N (%)	12 (92)	7 (78)
Height, cm	178±9	176±10
Weight, kg	91±18	78±11
Body mass index, kg/m ²	28±5	25±2
Body surface area, m ²	2.1±0.3	1.95±0.19
Heart Failure Etiology		
Ischemic, N (%)	6 (46)	---
Nonischemic, N (%)	7 (54)	---
LVAD Characteristics		
Duration of support, months	20±22	---
Heartmate II, N (%)	3 (23)	---
Heartmate 3, N (%)	1 (8)	---
Heartware VAD, N (%)	9 (69)	---
Medications		
Beta-blocker, N (%)	5 (38)	---
Angiotensin-converting-enzyme inhibitor, N (%)	7 (53)	---
Angiotensin receptor blocker, N (%)	3 (23)	---
Mineralocorticoid receptor antagonist, N (%)	5 (38)	---
Baseline hemodynamics		
Heart rate, bpm	76±11	59±5
Systolic blood pressure, mmHg	108±23	128±10
Diastolic blood pressure, mmHg	81±9	72±12
Mean arterial pressure, mmHg	90±12	91±9
Right atrial pressure, mmHg	6±3	4±2
Systolic pulmonary arterial pressure, mmHg	29±7	24±2
Diastolic pulmonary arterial pressure, mmHg	13±5	9±3
Mean pulmonary arterial pressure, mmHg	19±5	13±3
Pulmonary capillary wedge pressure, mmHg	10±5	7±3
Pulmonary arterial saturation, (%)	65±6	73±3
Cardiac output (Fick), L/min	5.4±0.9	6.3±1.6
Cardiac index, L/min/m ²	2.8±0.8	3.2±0.8
Right Ventricular Afterload		
Pulmonary vascular resistance, Woods units	1.6±0.7	1.1±0.4
RV Systolic Function (contractility)		
Preload recruitable stroke work, mmHg	7 ± 5	10 ± 3
dpdt _{max} , mmHg/sec	235±72	230±21
RV Diastolic Function		
Tau, msec	58±21	40±12
dpdt _{min} , mmHg/sec	-195±66	-190±21

Figure 1: Hemodynamics Among CF-LVAD Participants and Healthy Controls at Similar Workloads According to Oxygen Uptake (VO₂)

