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Effect of Exercise on Pulmonary Arterial Capacitance in Heart Failure

Authors: Kirsten E. Coffman, Bryan J. Taylor, Courtney M. Wheatley, Alex R. Carlson, Caitlin C. Fermoyle, Briana L. Ziegler, Bruce D. Johnson

Purpose: Heart failure is often associated with abnormal pulmonary hemodynamics. Pulmonary arterial capacitance (PAC) is a measure of the distensibility of the pulmonary vasculature and is a determinant of right ventricular afterload. Previously it has been shown that, at rest, PAC demonstrates a hyperbolic relationship with pulmonary vascular resistance (PVR) in heart failure (HF) patients and is an independent predictor of mortality. Our aim was to determine how exercise affects PAC and its relationship with exercise capacity and indices of respiratory gas exchange.

Methods: 39 HF patients undergoing right heart catheterization performed incremental exercise to exhaustion. Pulmonary arterial systolic pressure (PAPs), pulmonary arterial diastolic pressure (PAPd), mean pulmonary artery pressure (PAPm), and mean pulmonary wedge pressure (PWPm) were measured invasively at rest and at peak exercise. Ventilation (V_E), oxygen consumption (VO_2), carbon dioxide production (VCO_2), and heart rate (HR) were continuously collected at rest and during exercise. Arterial and mixed venous blood samples were collected for determination of cardiac output (Q) via direct Fick. The following variables were then calculated: stroke volume (SV)=Q/HR; PAC=SV/(PAPs-PAPd); PVR=(PAPm-PWPm)/Q.

Results: PAC significantly decreased from rest to peak exercise (2.6 vs. 1.6 ml/mmHg, $p<0.01$). At peak exercise, PAC was correlated with VO_2max (PAC=0.29*VO_2max-0.87, R=0.74). PAC was negatively correlated to PVR at rest (R=0.85) and during exercise (R=0.82) according to a hyperbolic fit. PAC was negatively correlated to V_E/VCO_2 at rest (R=0.53) and during exercise (R=0.52) according to a hyperbolic fit.

Conclusions: In patients with classic systolic HF, PAC is reduced and falls further with exercise. In addition, subjects with the greatest capacitance to accept increases in pulmonary blood volume have a better exercise capacity. This increased pulmonary vascular distensibility during exercise yields lower resistance to forward flow. The gas exchange measure ventilatory efficiency, a marker of disease severity and prognosis in HF patients, is also related to reduced PAC. Supported by NIH grant HL71478.