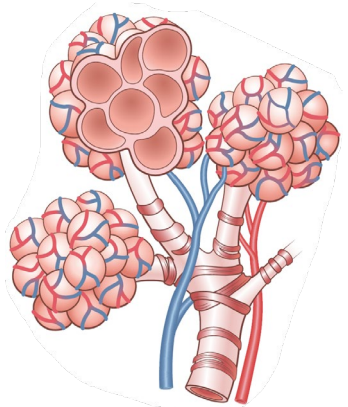
Cardio-pulmonary Physiology and Exercise in Healthy Aging and Heart Failure

Stephen Wright, PhD

Assistant Professor, Department of Physical Therapy
Investigator, Centre for Heart Lung Innovation
Associate Member, Division of Cardiology



THE UNIVERSITY OF BRITISH COLUMBIA
Department of Physical Therapy
Faculty of Medicine

Centre for
Heart Lung Innovation
UBC and St. Paul's Hospital

Providence HEALTH CARE
How you want to be treated.

Outline

- **Background and Overview**
- Core Research Line
- Additional Research Areas

Background in Exercise and Medical Science

MSc: UofT/Mount Sinai Stress Echocardiography Lab

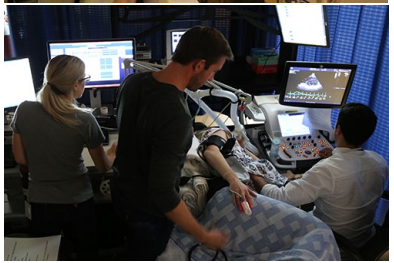
- Left atrial adaptations to short-term interval training & chronic endurance exercise participation

PhD: UofT/Mount Sinai Cardiac Catheterization Research Lab

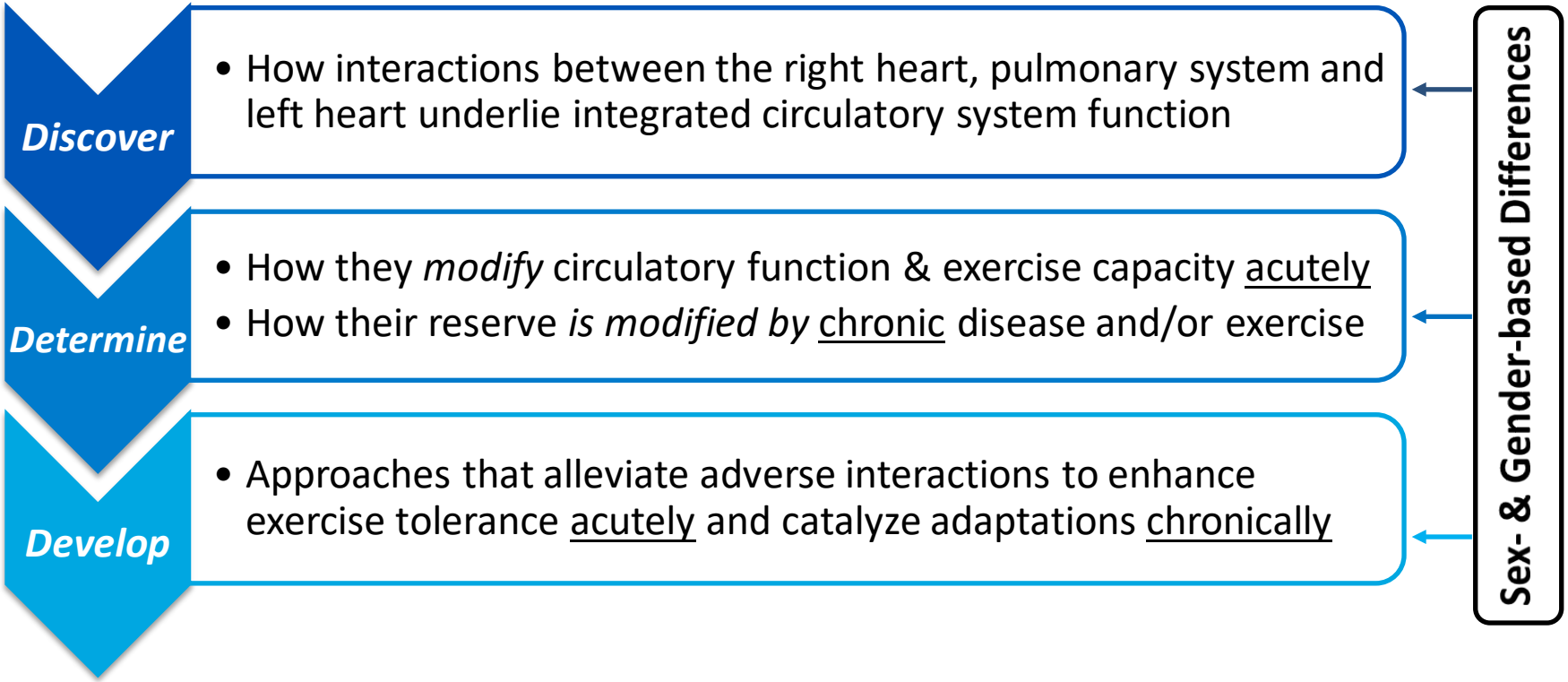
- Right ventricular-pulmonary vascular hemodynamics during exercise in health, heart failure & pulmonary hypertension

PDF: UBC Okanagan Clinical Cardiopulmonary Physiology Lab

- Influence of sex on heart-lung interactions during exercise in healthy aging



Circulatory Exercise Physiology Themes and Aims



Circulatory Exercise Physiology Approaches

Normal Aging

Chronic Disease

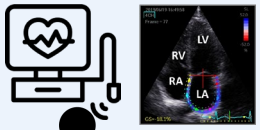
NSERC

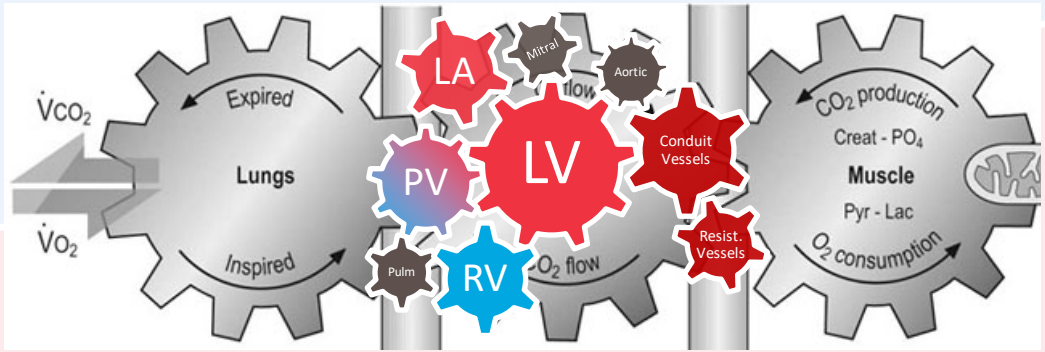
CIHR

Experimental Physiology

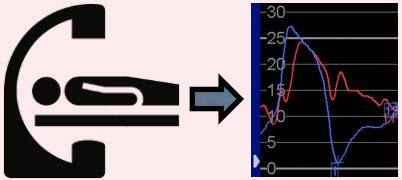
Age, Sex, & Health Spectrum

Rest *vs.* Stress



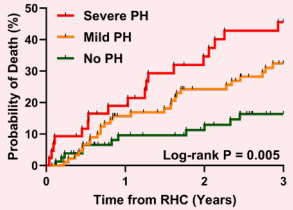


Observational Cohorts



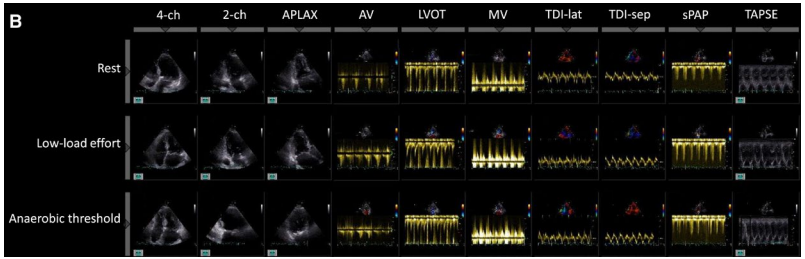
Hemodynamic Analysis & Classification

- Severe PH
- Mild PH
- No PH

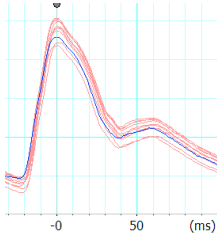


CFI: Comprehensive Circulatory Physiology Research Lab

- **Cardiac structure/function & reserve**



- **Vascular hemodynamics**



- **Total blood volume**

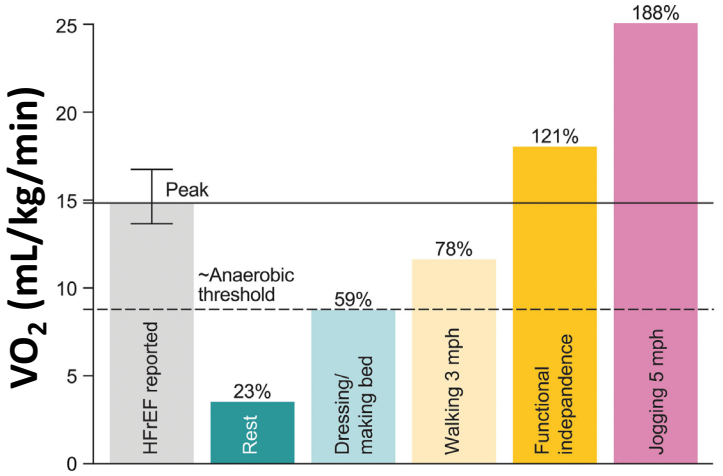
Outline

- Background and Overview
- **Core Research Line**
  - **Mechanisms of Normal vs. Abnormal Circulatory Reserve in Aging**
- Additional Research Areas

The Circulatory System, Reserve, and Limitation

- Left/right atria, ventricles, vascular networks function as units
- Cardiac output ↑ >5x in health
- Decline in reserve over lifespan
- Accelerated by circulatory disease
- *Understand 'normal' to better recognize 'abnormal', develop therapies, and improve health*

Activities of Daily Living vs. Peak VO_2 in Heart Failure w/ Preserved Ejection Fraction (HFpEF)



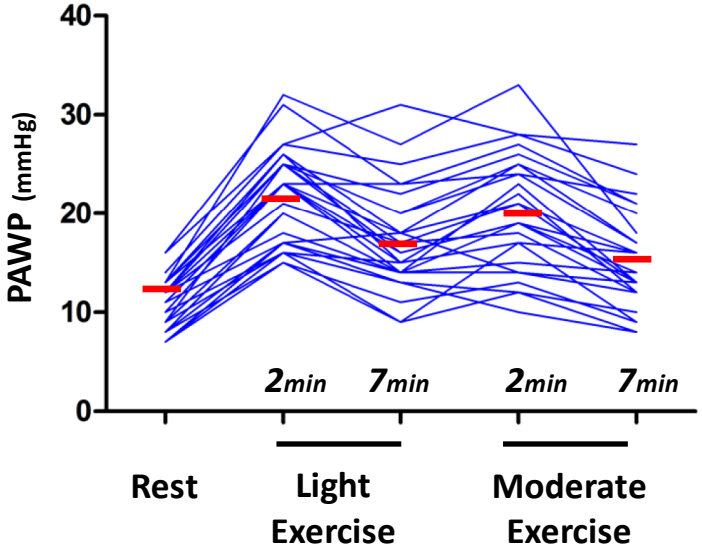
Lewis *et al.*, 2022, *Circ HF*:15

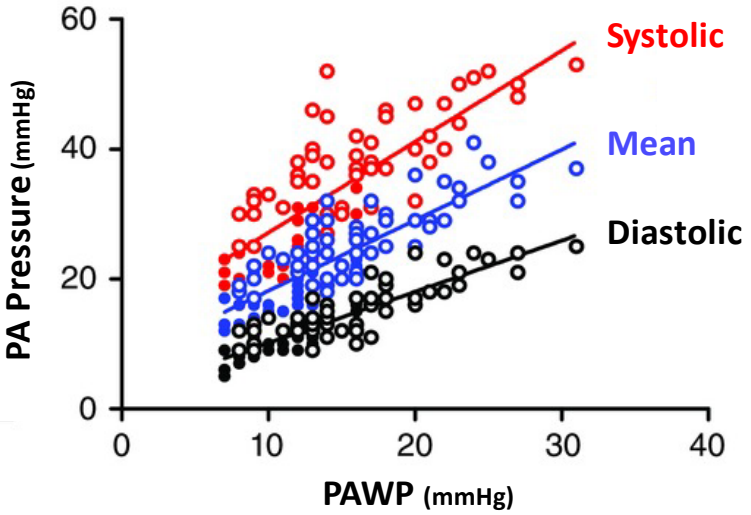
Exercise Hemodynamics in 2010: What is Normal?

- **Goal: Exercise testing to expose pulmonary hypertension early**
  - ***Gap: Normal pulmonary hemodynamics during exercise were unclear***

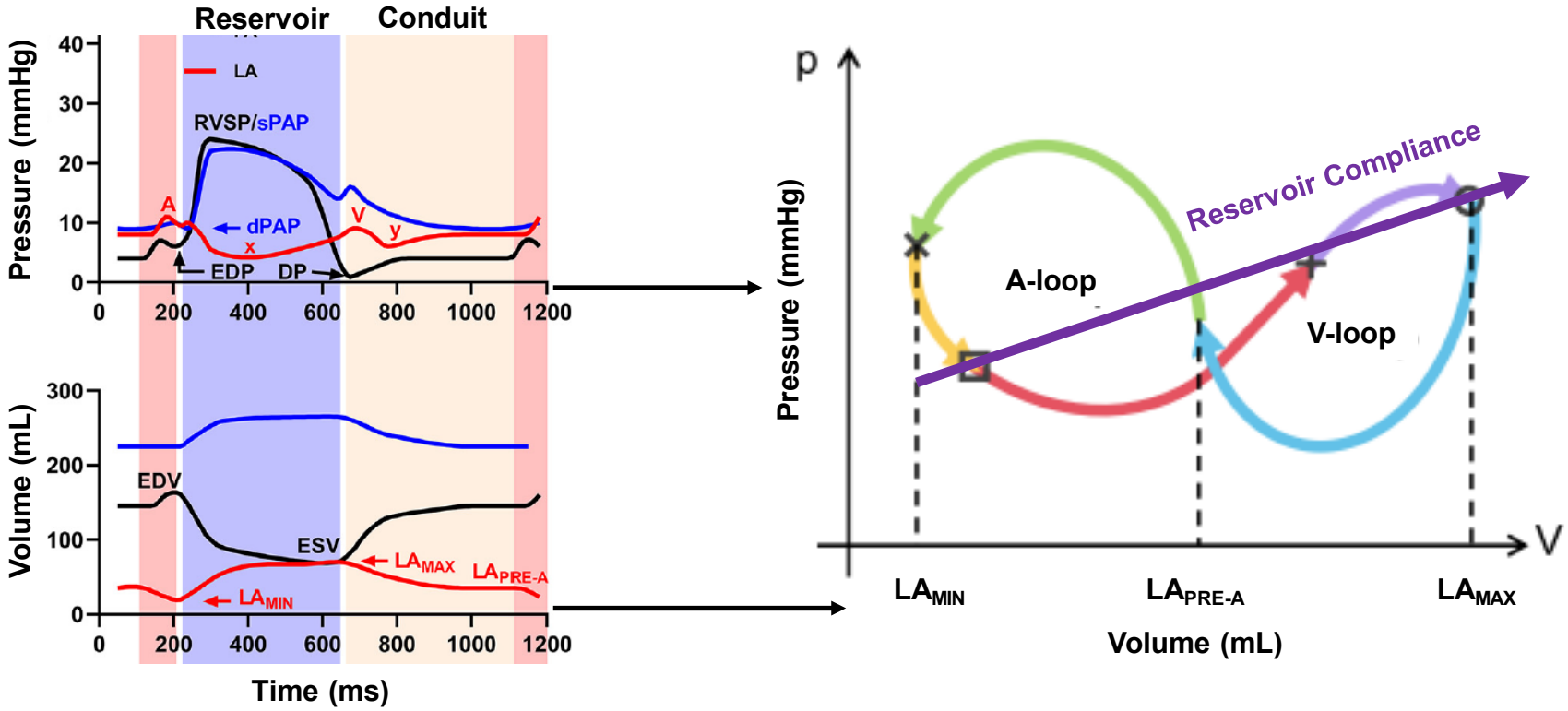
Left Atrial-Pulmonary Vascular Responses to Exercise

- Recruited 36 healthy adults 45-65 yrs (50% female)



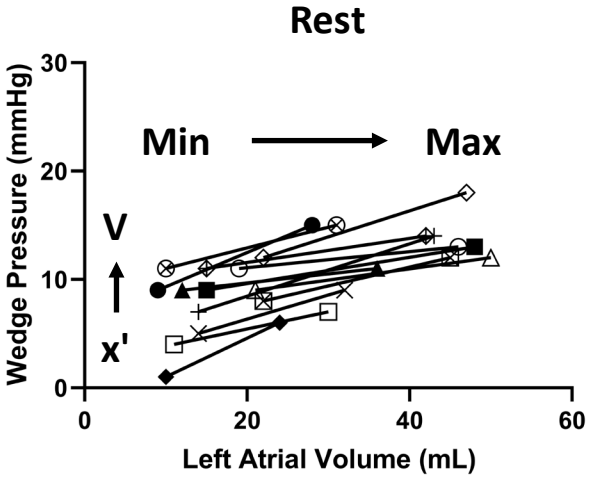


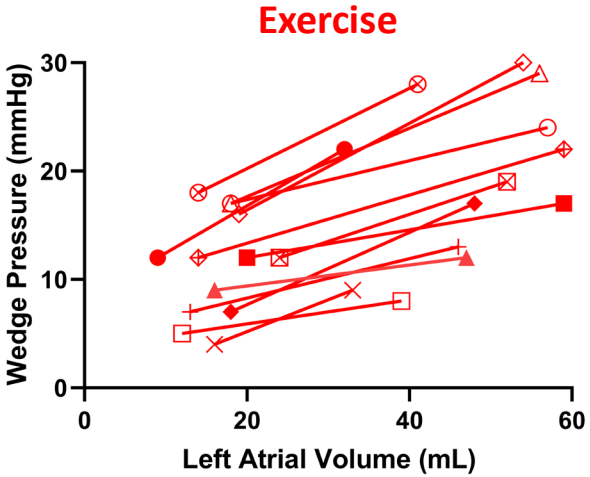
LA Function Described by Pressure-Volume Relations

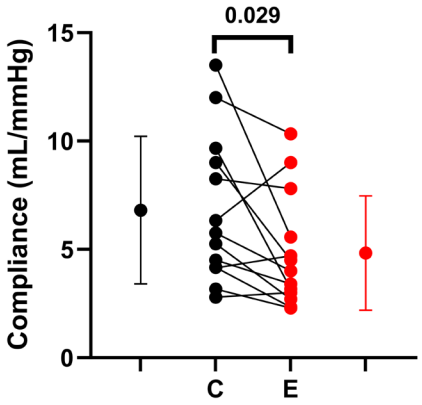


Exercise Augments LA Wall Stress, Reduces Compliance

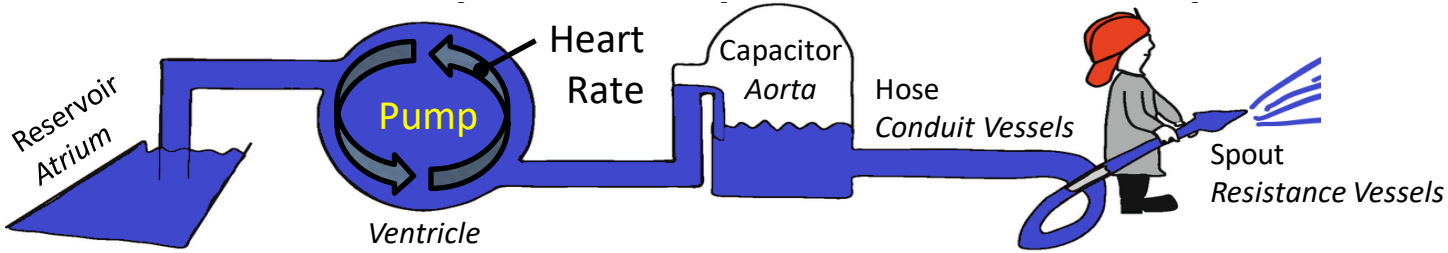
$$Wall\ Stress = \frac{Pressure \times Volume}{2 \times Wall\ Thickness} = \frac{Peak\ V\ wave \times Max\ LA\ Volume}{2 \times Wall\ Thickness}$$

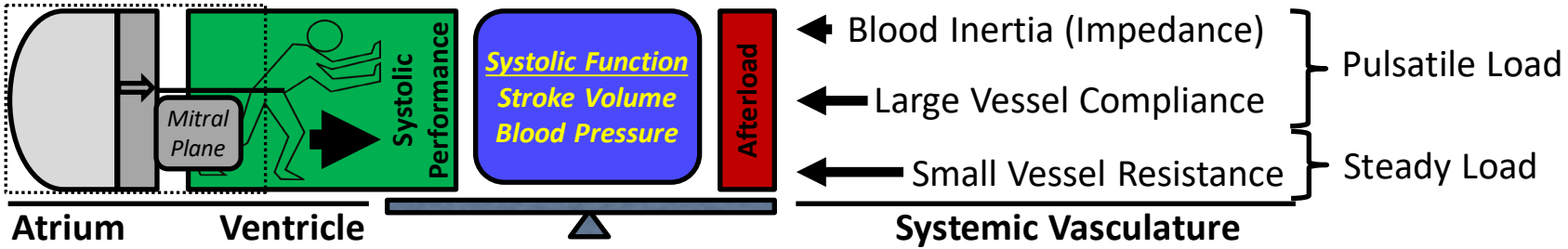






Characterizing Atrio-Ventricular-Vascular Interactions

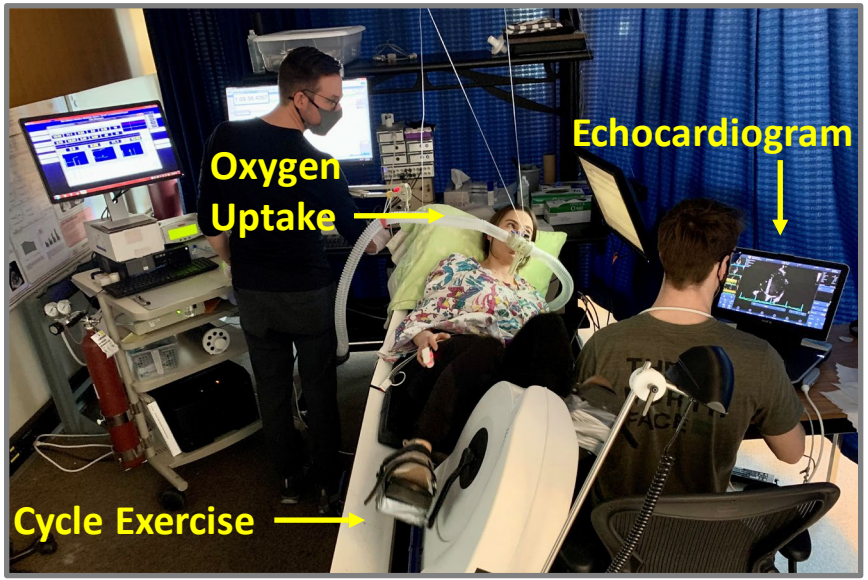




Atrio-Ventricular-Vascular Interactions: Aging & HFpEF

- **NSERC**: ***Sex-specific Left-heart Interactions Underlying Stroke Volume Generation Across the Lifespan***

- **Catalyst**: ***Sex-specific Impacts of Vascular Hemodynamics on Cardiac Function in Older Adults Living with HFpEF***



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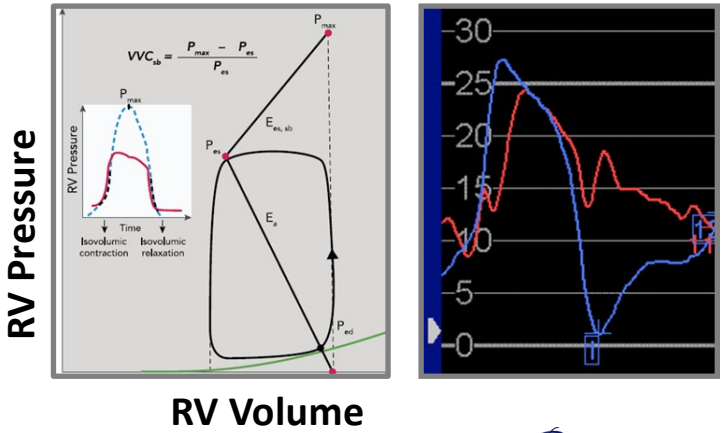
- **Additional Research Areas**
  - **Right Ventricular-Vascular Coupling in Advanced Heart Failure**

Can We Better Evaluate RV Function in Heart Failure?

- Pulmonary hypertension often due to LV dysfunction
- Predicting RV failure in advanced therapies is difficult[1]
- In adults w/ referred for catheterization in transplant work-up:
  - "Single-beat" method for RV elastance
  - Applied to hemodynamics in registry
  - Studied relationship with mortality

Dr. Leah Groves, PhD



1. Read, 2022, *JHLT*:41

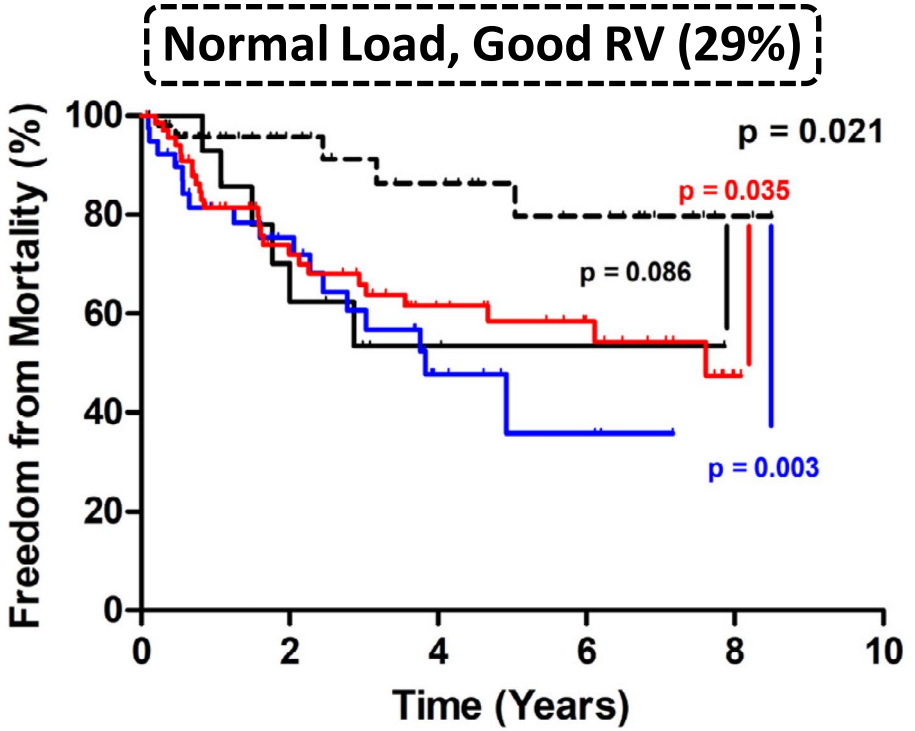
Altered RV-PA Coupling Associated with Worse Survival

N = 175

High Load, Good RV (n = 42, 24%)

High Load, Bad RV (n = 68, 39%)

Normal Load, Bad RV (n = 14, 8%)



Elizabeth Karvasarski

Michael Zarathus-Cook

Tayler Buchan

Wright, 2020, *JHLT*:39

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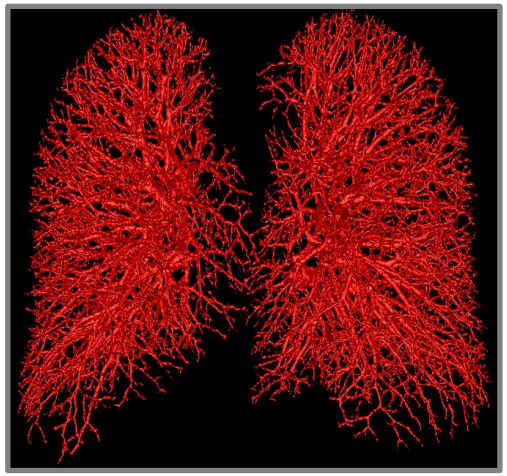
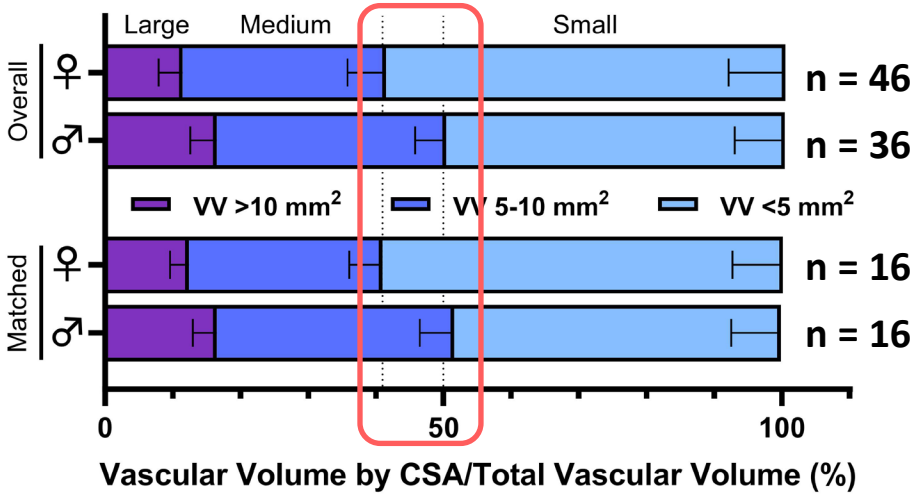
  - Right Ventricular-Vascular Coupling in Advanced Heart Failure
  - **Pulmonary Vascular Structure in Health, PAH, and PH-HFpEF**

Sex-based Differences in Pulmonary Vascular Structure

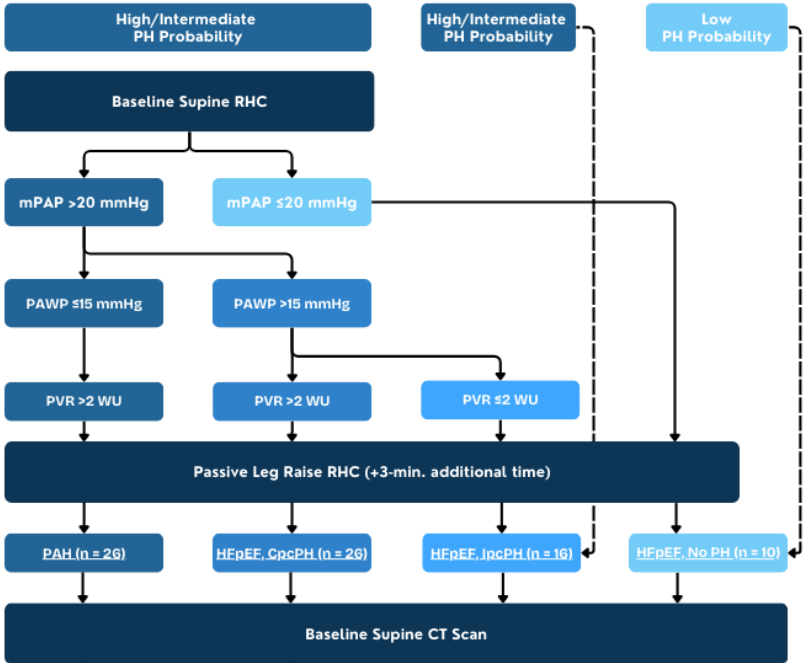
- Healthy females & males in CanCOLD with CT images
- Vessels classified by CSA in bins >10, 5-10, <5 mm²

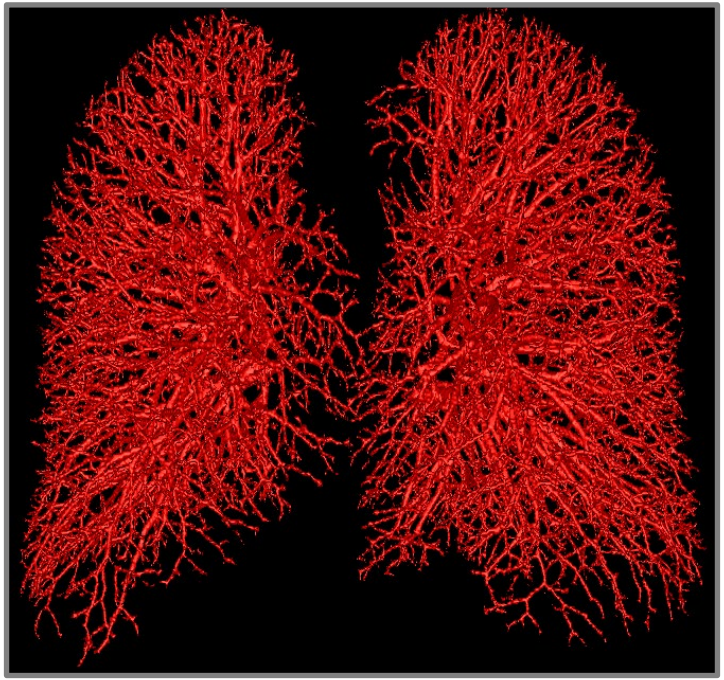
Dr. Miranda Kirby, PhD





Pulmonary Vascular Morphometry in PH-HFpEF & PAH





Rachel Eddy

Nathan Brunner

Nat Hawkins

Jennifer Monaghan

Outline

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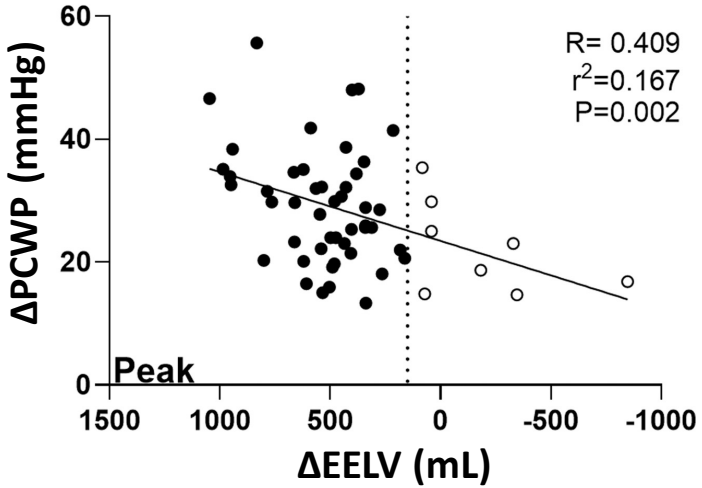
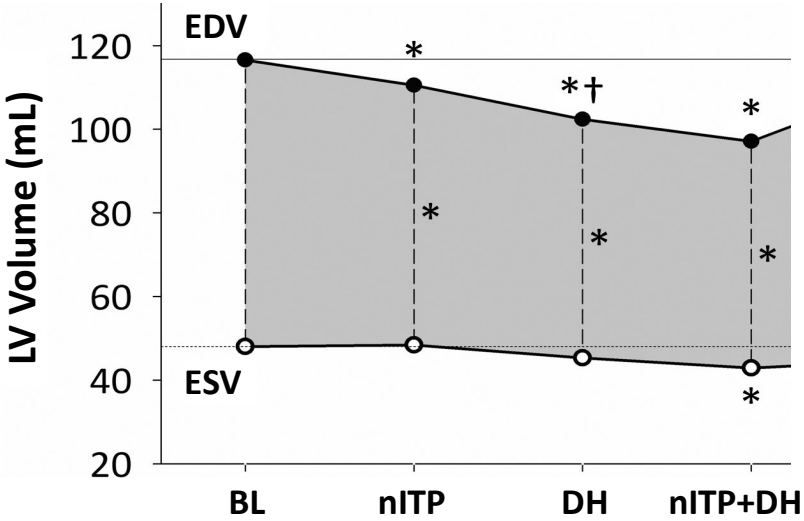
- Core Research Line
- Additional Research Areas
  - Right Ventricular-Vascular Coupling in Advanced Heart Failure
  - Pulmonary Vascular Structure in Health, PAH, and PH-HFpEF
  - **Interactive Cardio-pulmonary Dysfunction in HFpEF and COPD**

The Heart & Lungs are Interlinked (For Better or Worse)

- COPD w/ EF >50%, nearly half have diastolic dysfunction[1]
- HFpEF, 15-40% have COPD[2,3]; dynamic hyperinflation in 85%[2]

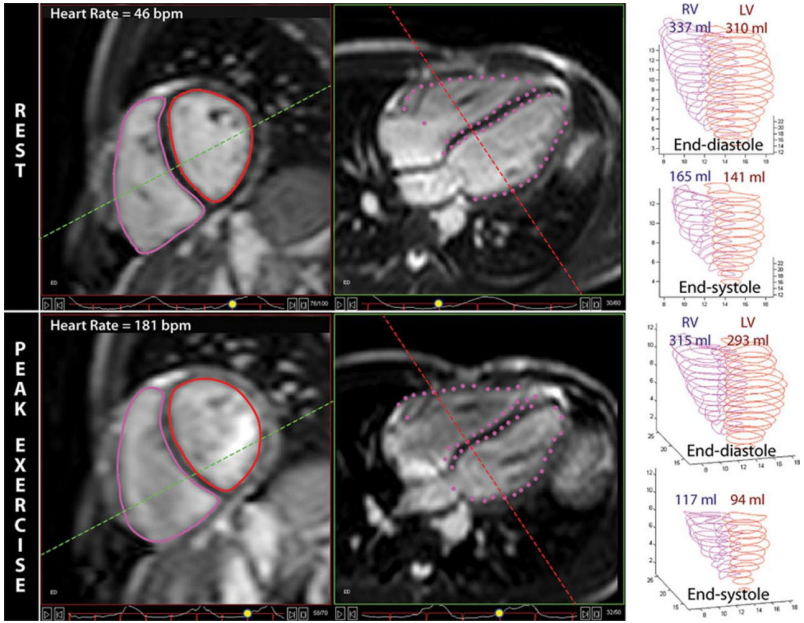




1. Segev, 2025, *In Press*
2. Leahy, 2025, *JACC-HF*
3. Ramalho, 2024, *Curr HF Rep*:2
4. Cheyne, 2016, *AJP Heart*:311

Exercise CMR Imaging to Investigate HFpEF/COPD

- **Approach to quantify heart and lung function during exercise**



Thank You

Steve Wright

Stephen.Wright@ubc.ca
@TheWrightHeart