# Emerging applications of stress echocardiography:

# Right heart haemodynamics

EuroEcho-Imaging 2014


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# DECLARATION OF INTEREST

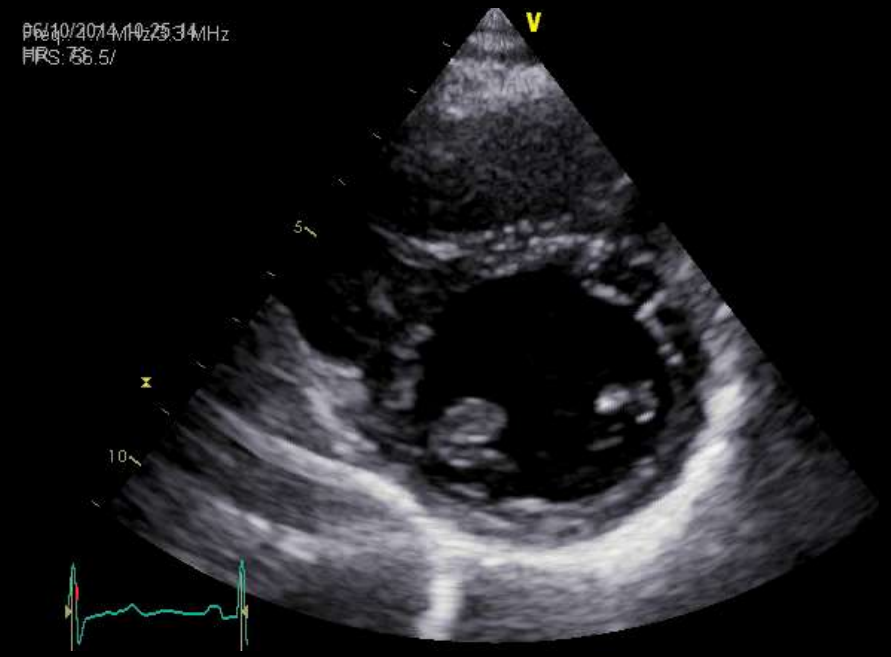
- I have nothing to declare

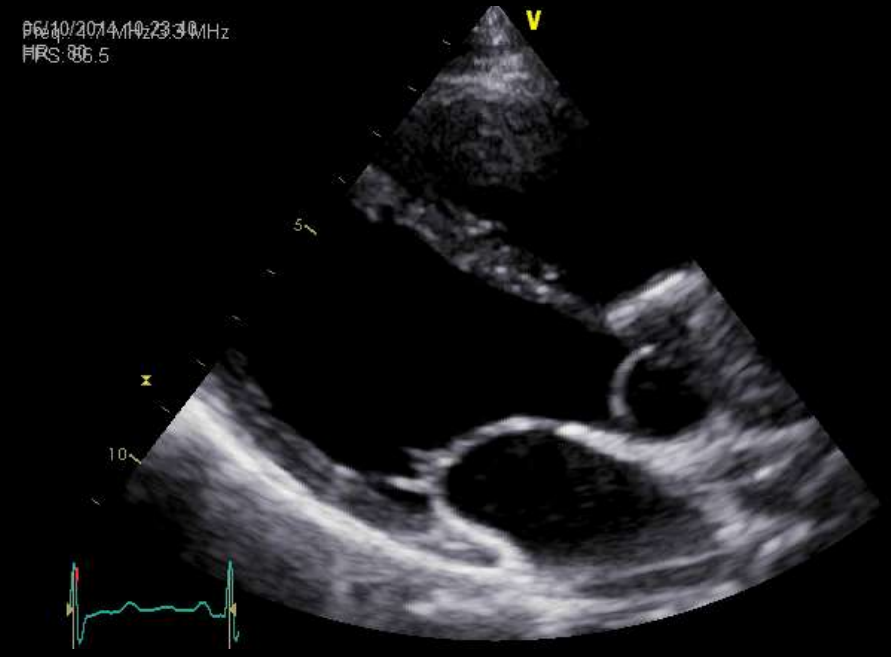
# Ms MF

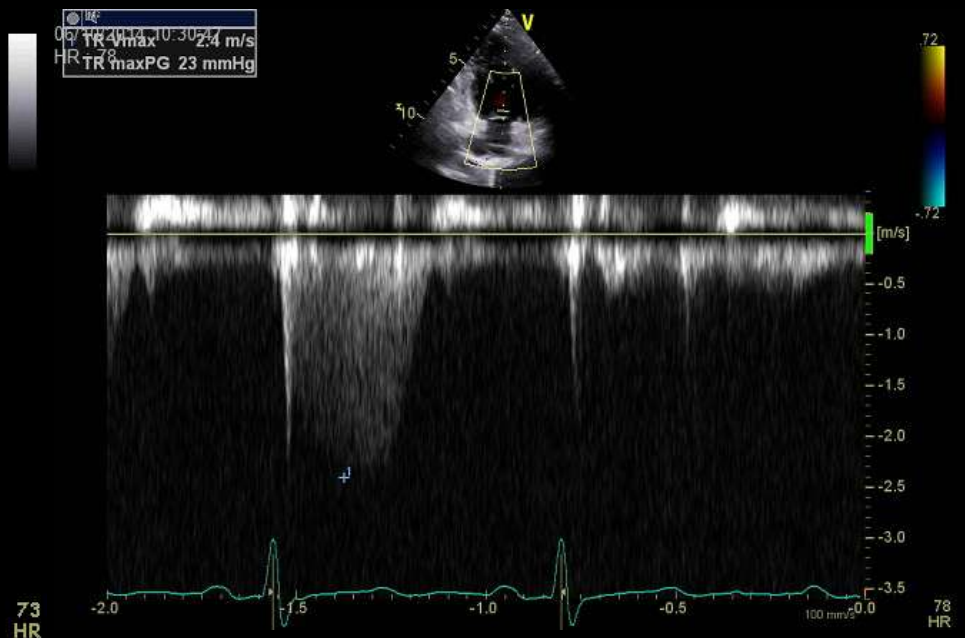
- 27 year old mother
- Hemodynamic collapse, now recovered
- Past history
  - Addison's disease
- Non-smoker
- Medications
  - Hydrocortisone
  - Oral contraceptive

# Ms MF

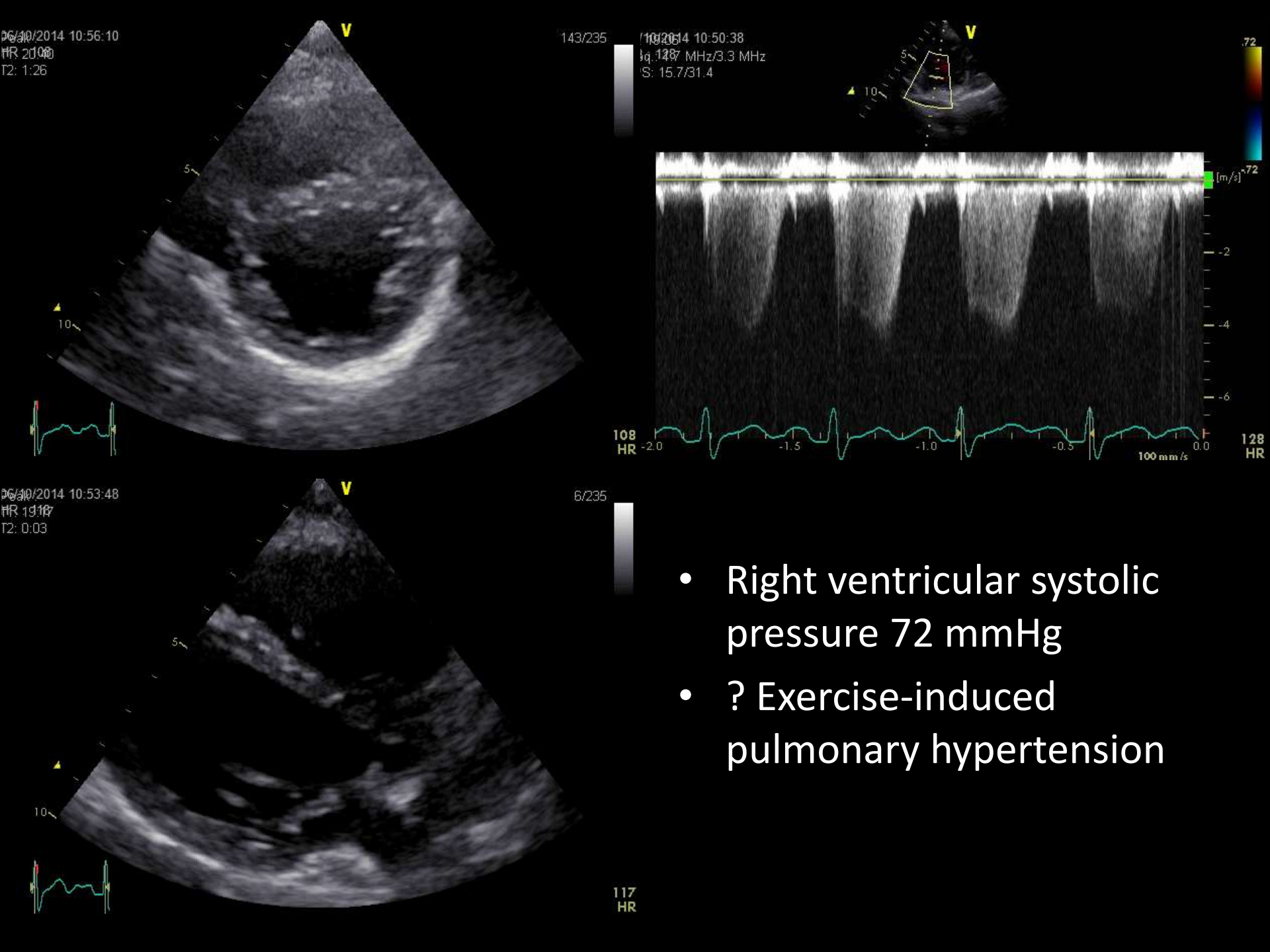
- Exercise stress echocardiogram
  - 9:19 minutes to Stage 4
  - Developed severe dyspnoea, fatigue and $O_2$ desaturation
  - Poor blood pressure response



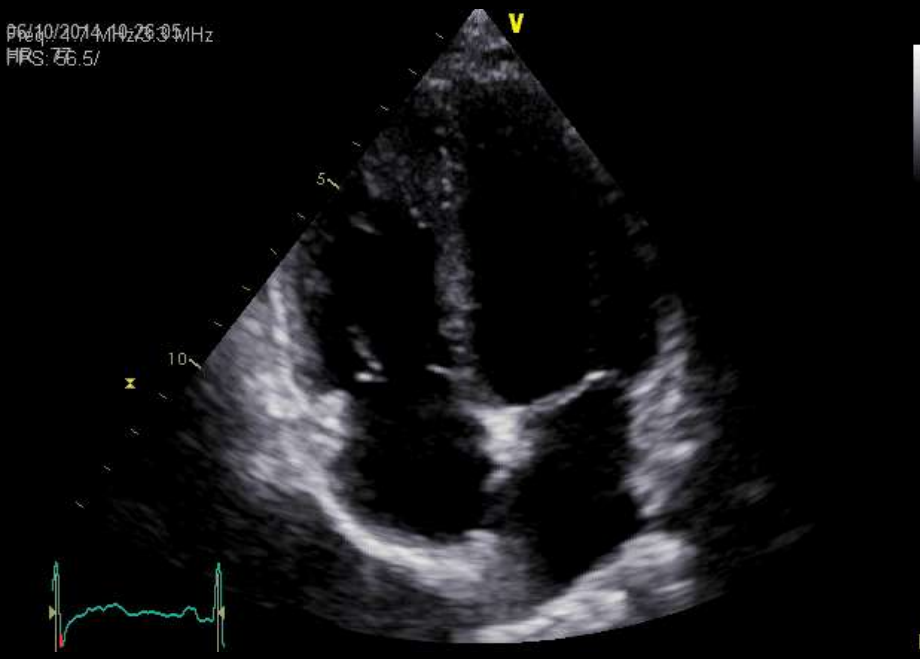




- Dilated right ventricle
- Normal LV
- Right ventricular systolic pressure 28 mmHg

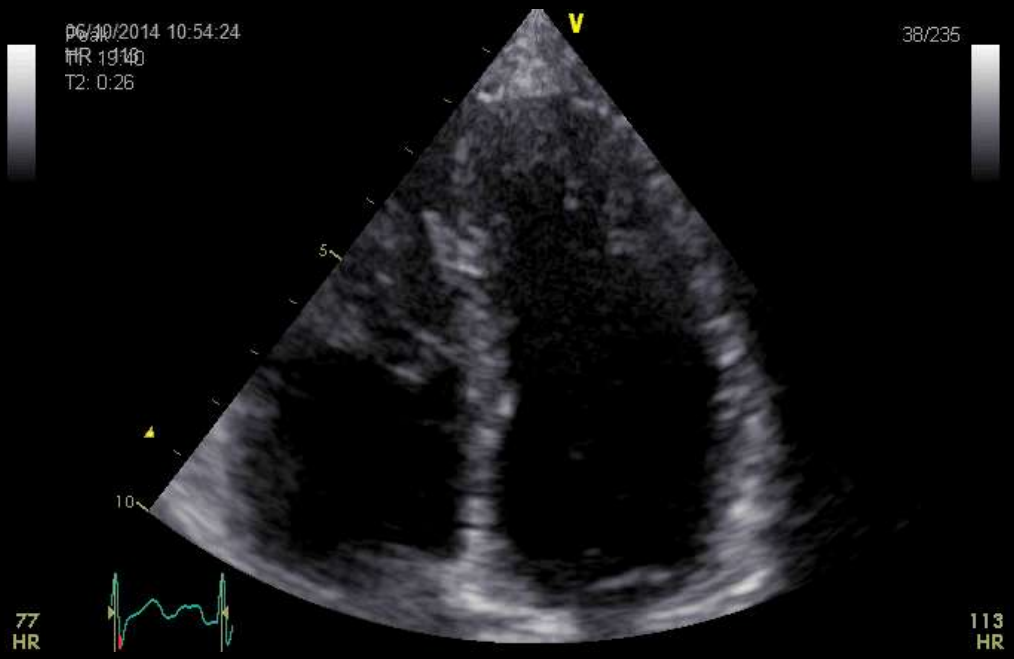



- Right ventricular systolic pressure 72 mmHg
- ? Exercise-induced pulmonary hypertension

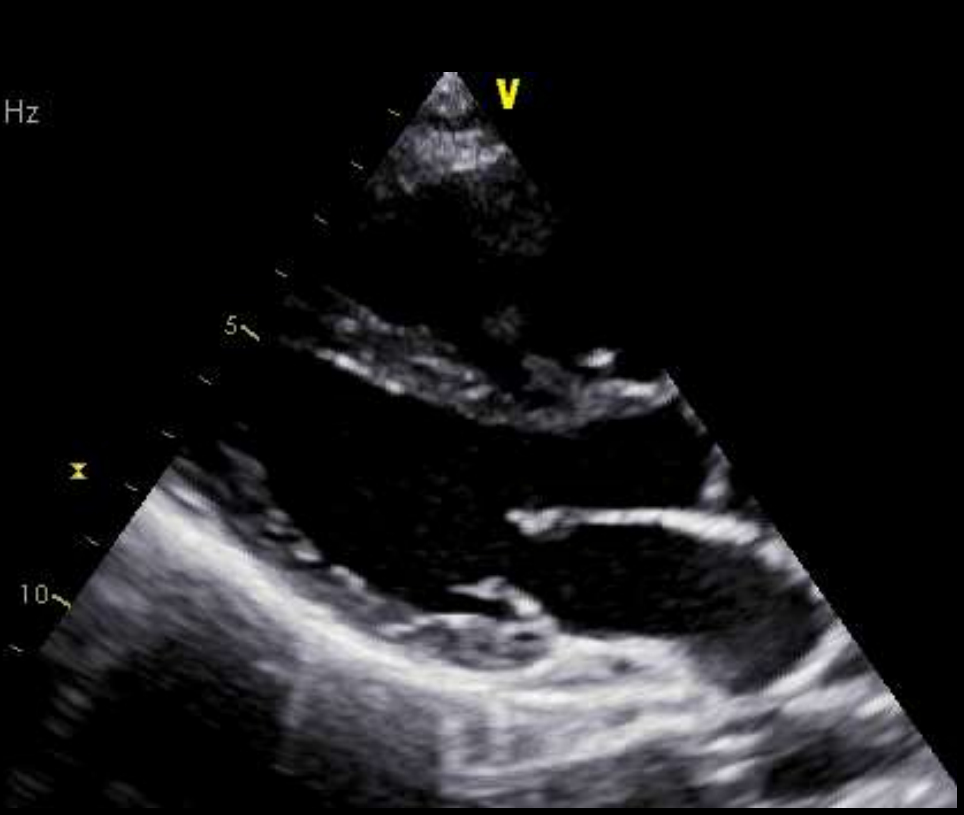
# Rest

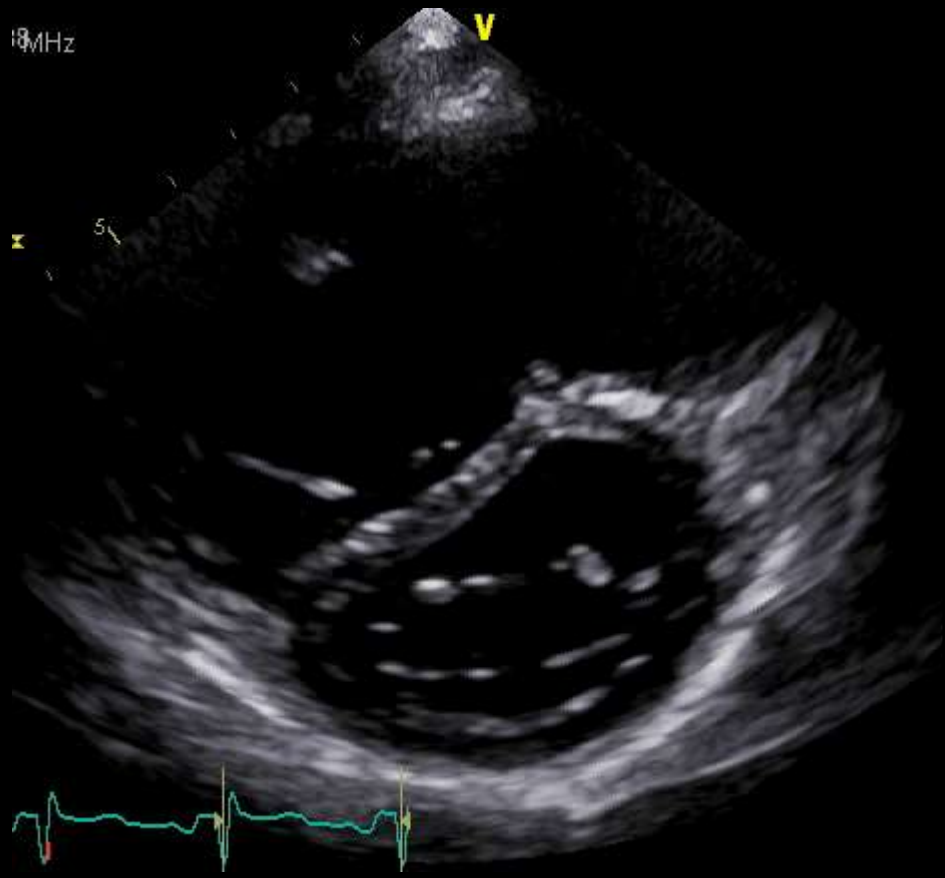


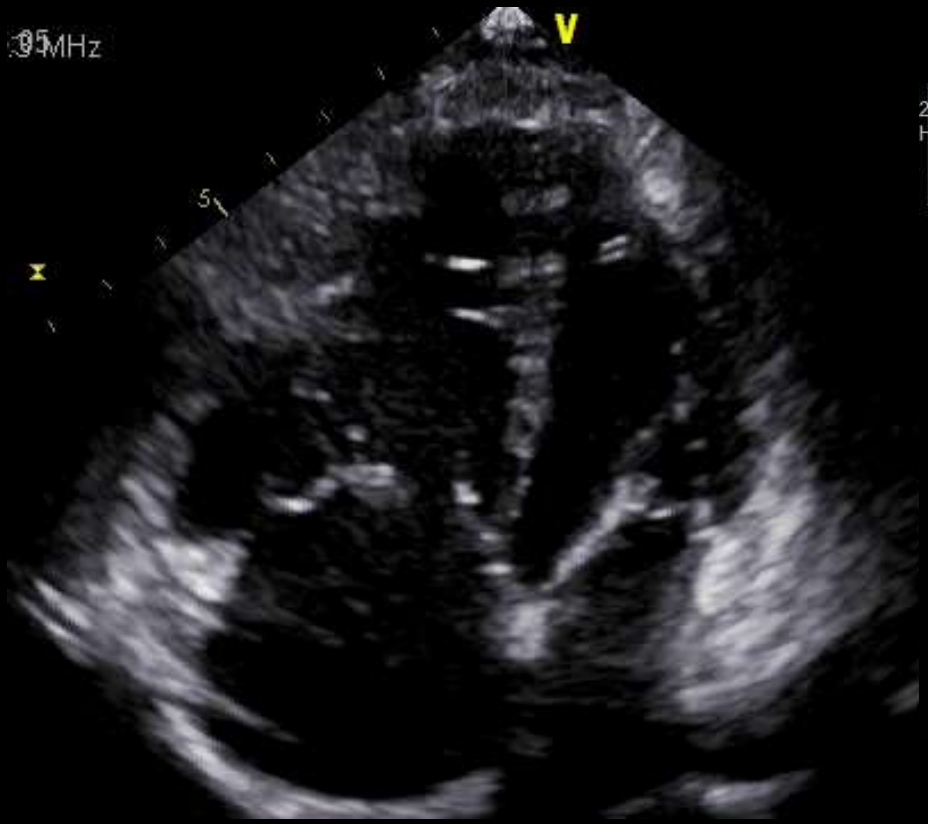

# Exercise



# 3 months later…






| | |
|---|---|
| TR Vmax | 3.2 m/s |
| TR maxPG | 42 mmHg |
| PAp-mn (from PAP-sys) | 10 mmHg |
| RVSP | 47 mmHg |

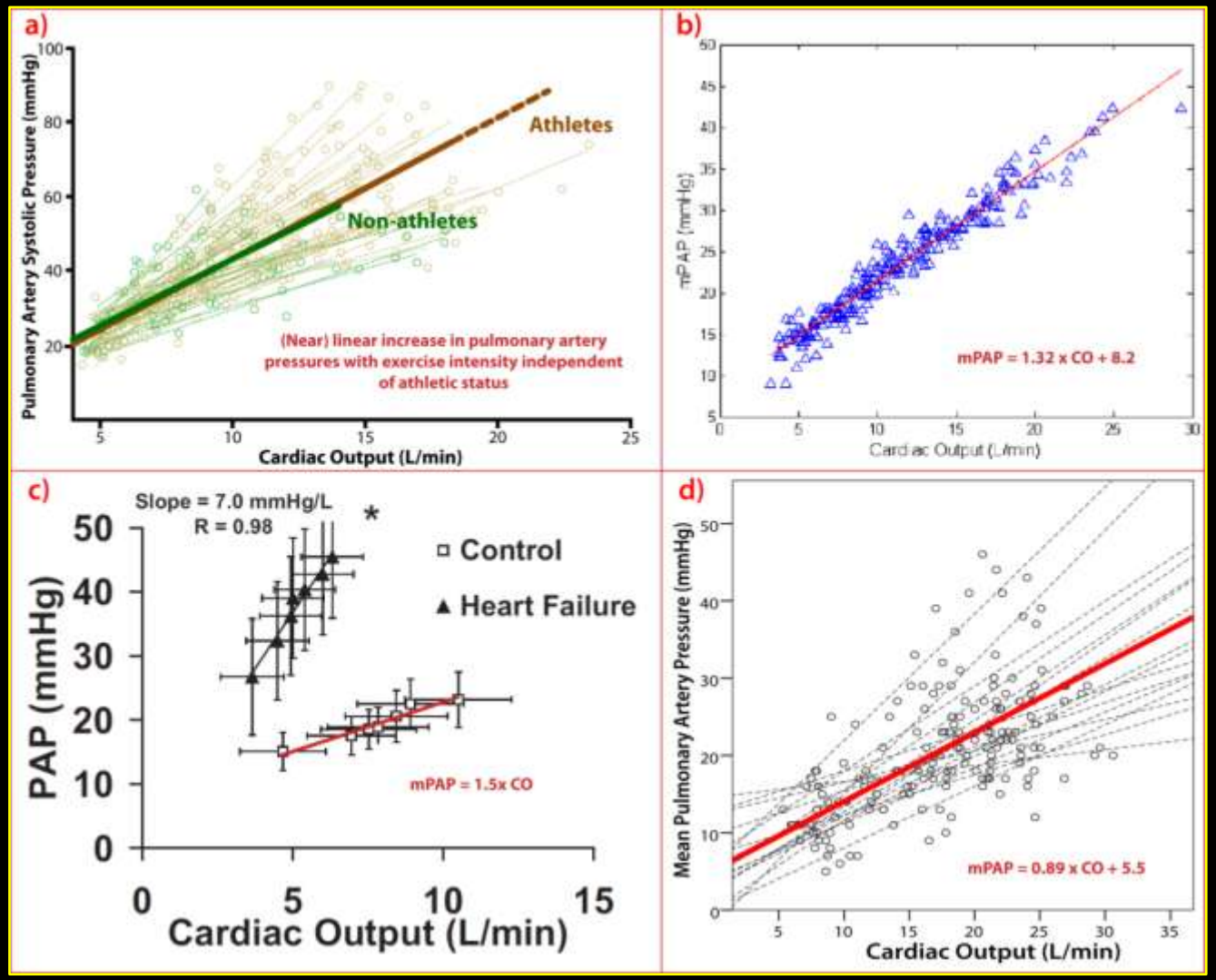
# Mrs MF

- Right heart catheter
  - Mean pulmonary artery pressure = 34mmHg
  - Cardiac output = 3.3 L/min
  - Pulmonary vascular resistance = 6 WU

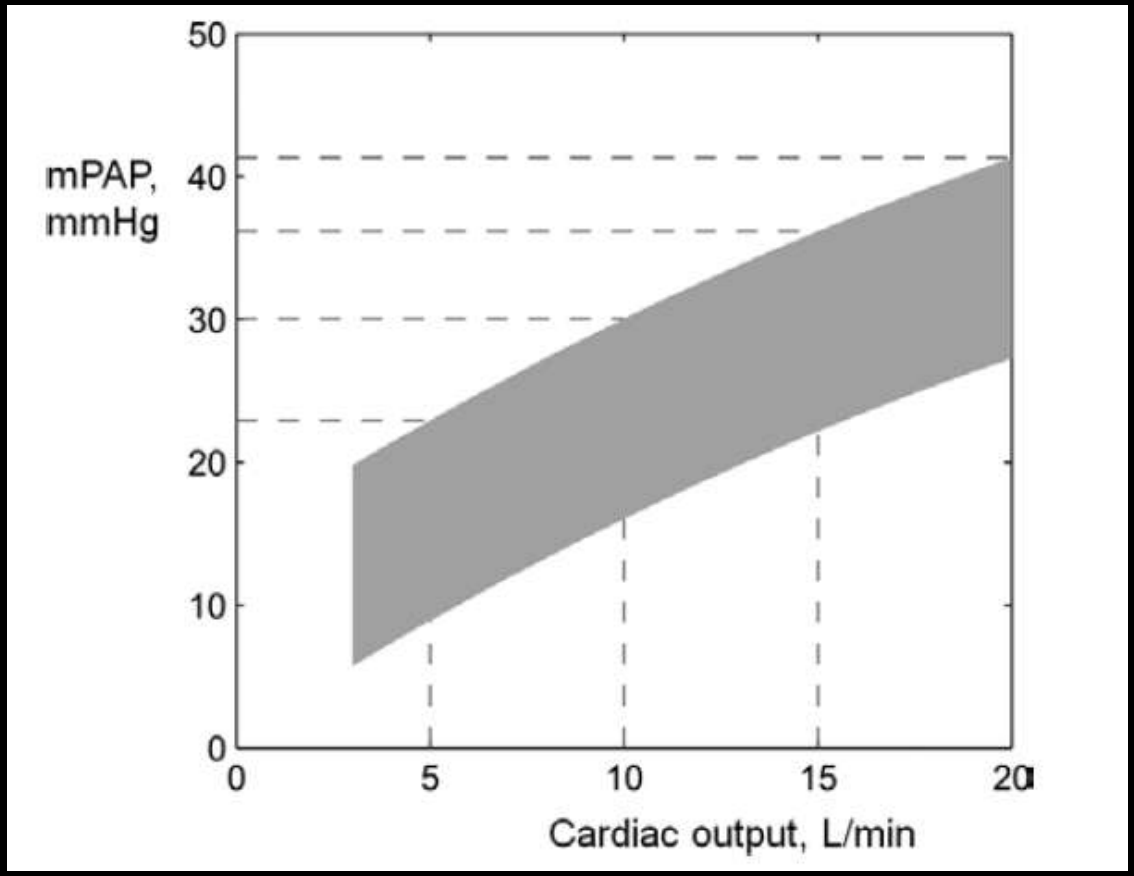
**Mean pulmonary artery pressure ≥ 25mmHg at rest**
**Pulmonary capillary wedge pressure ≤15mmHg**
**Pulmonary vascular resistance >3**

# What is EIPH?

## - normal pulmonary vascular response to exercise



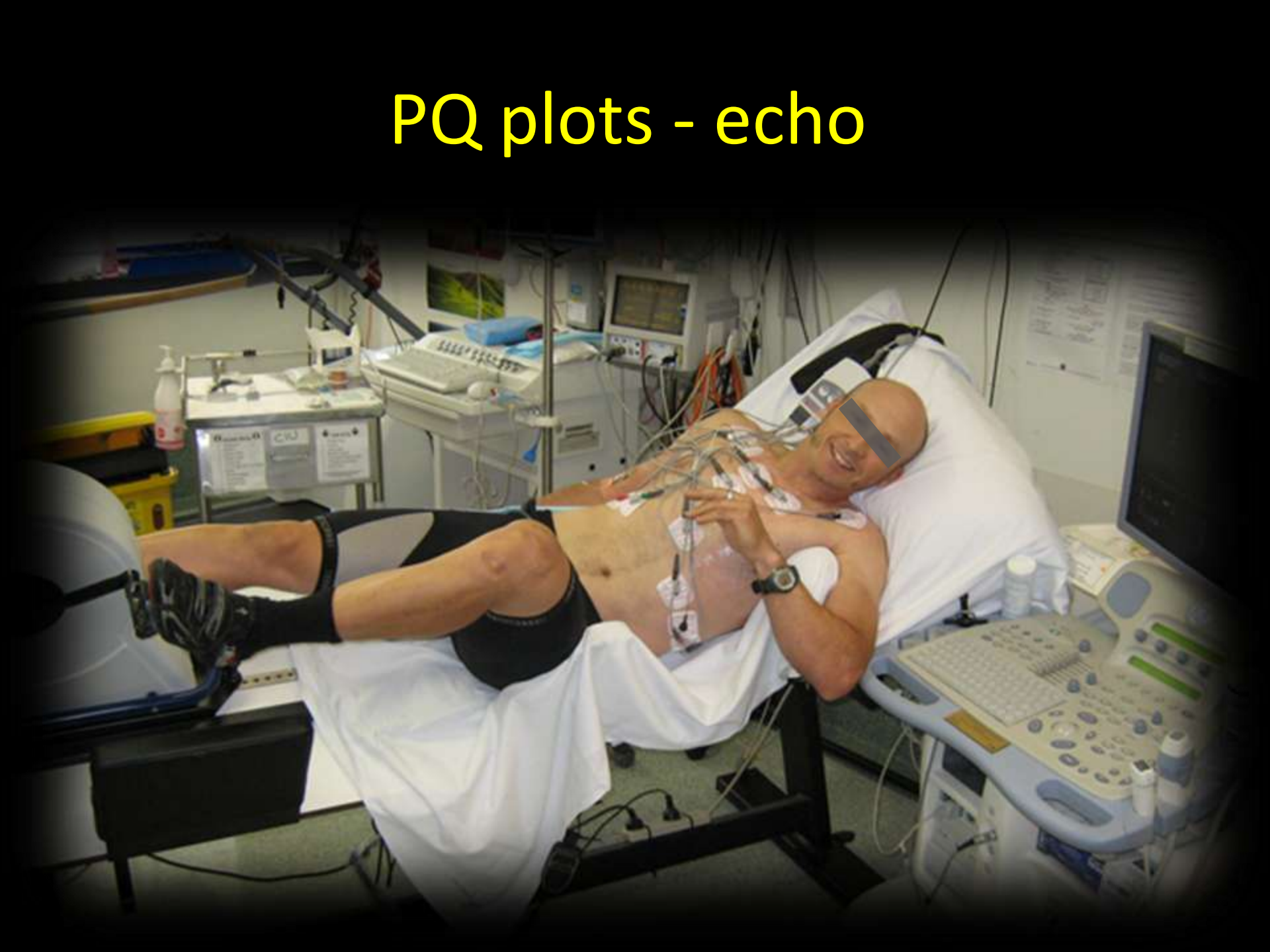
# Normal vs. abnormal pulmonary vascular function




Lewis et al. *Circulation* 2013

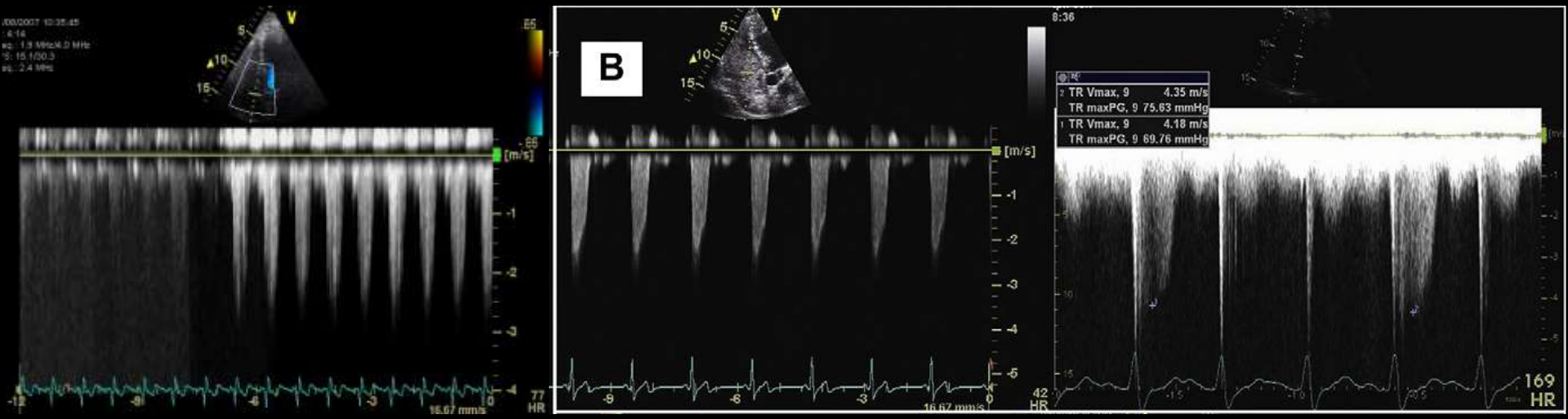
**mPAP > 3 x cardiac output is abnormal**

# PQ plots - echo

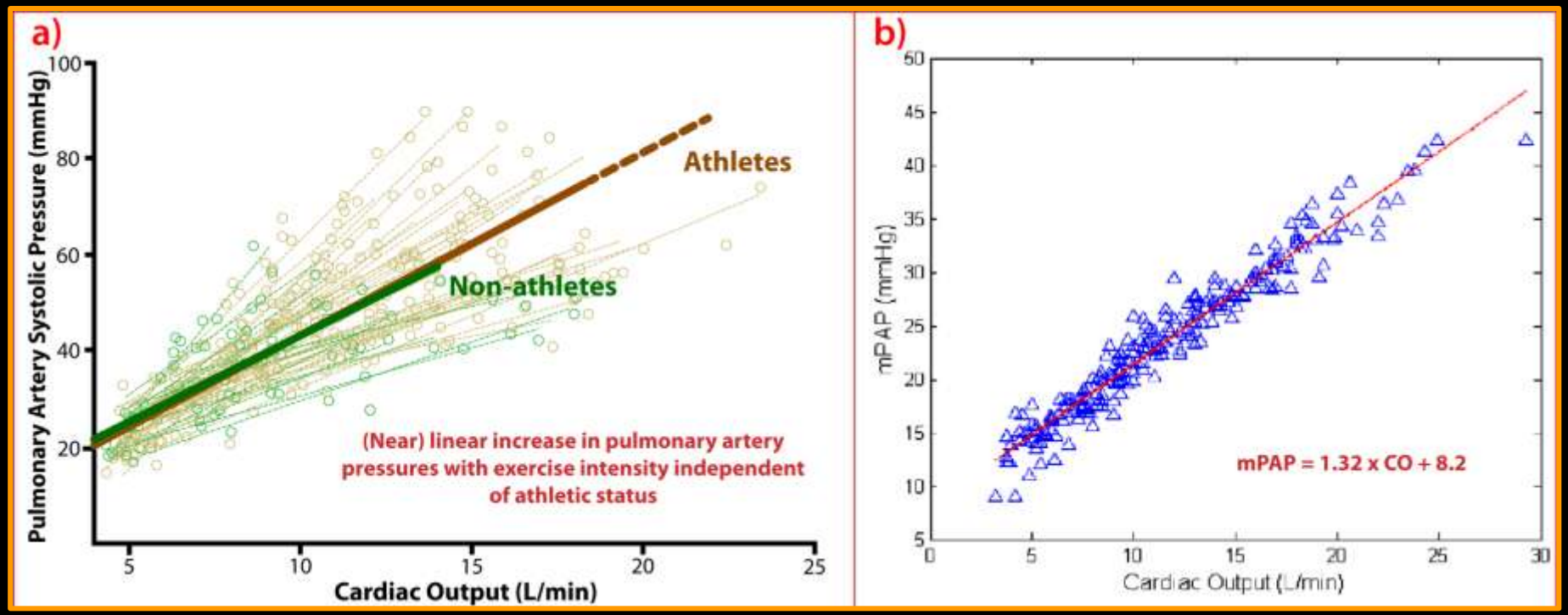


# TR for estimation of PASP

- Trans-tricuspid pressure gradient related to the velocity of regurgitant blood
- $P = 4 \times TRV^2$
- Can use agitated contrast
- mPAP = 0.6 x SPAP + 2 (Chemla et al. *Chest* 2004)



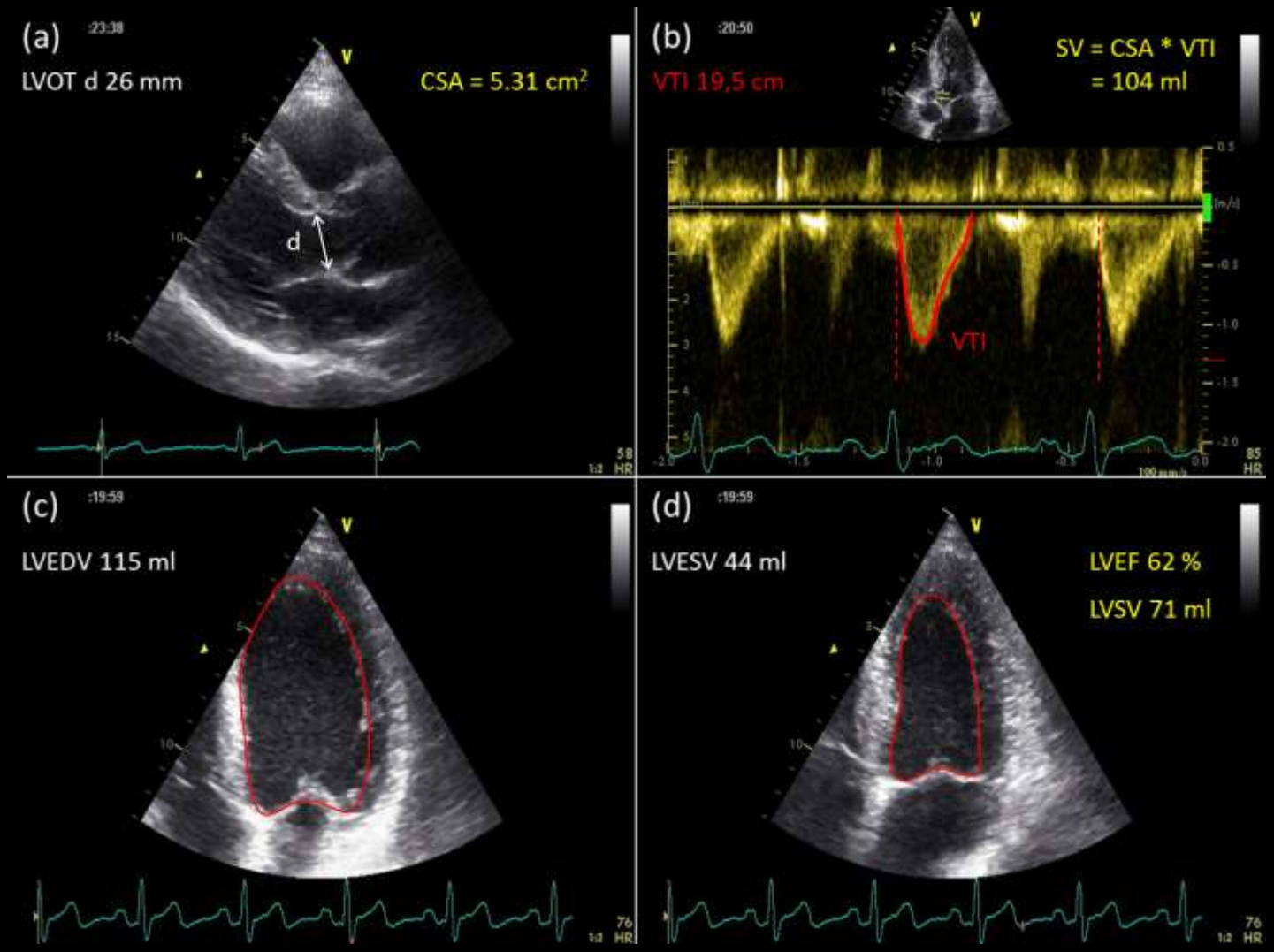
# PAP increase during ex in healthy subjects




La Gerche et al. *J Appl Physiol. 2010;109:1307-1317*

Argiento et al. *J Am Soc Echocardiograph. 2007;20:270-275*

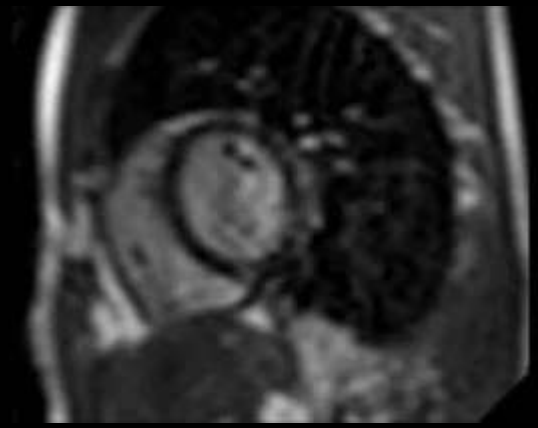
# Estimate CO with output

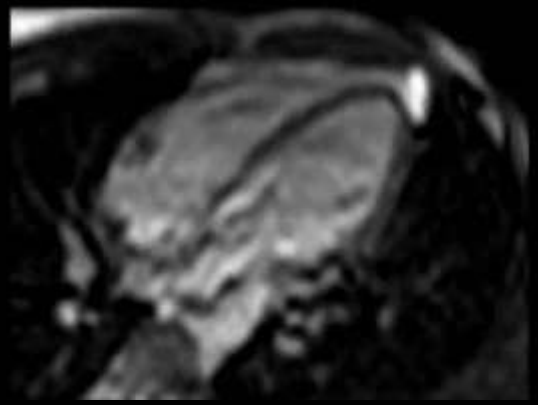


# PQ plots - catheter

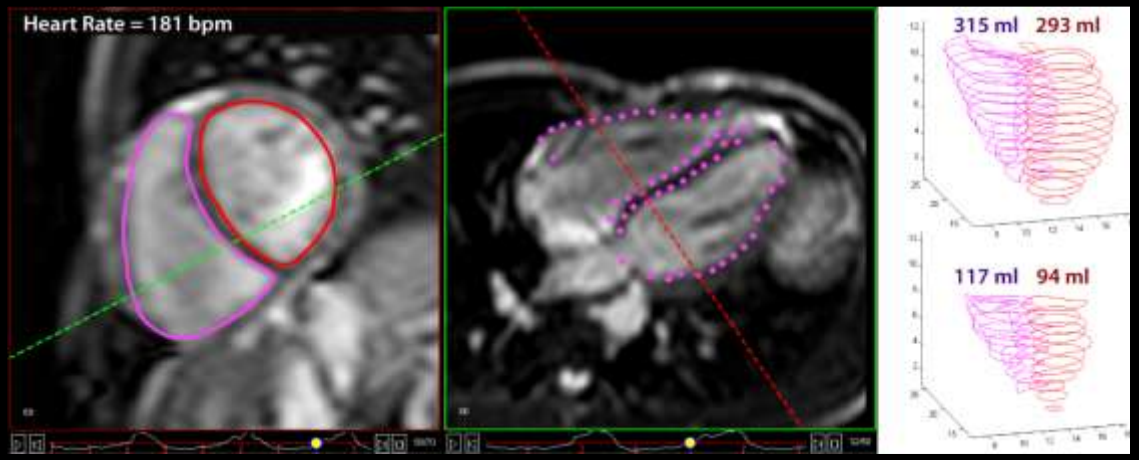
? gold standard
but no assessment of ventricular function

# Accurate exercise pressure / volumes



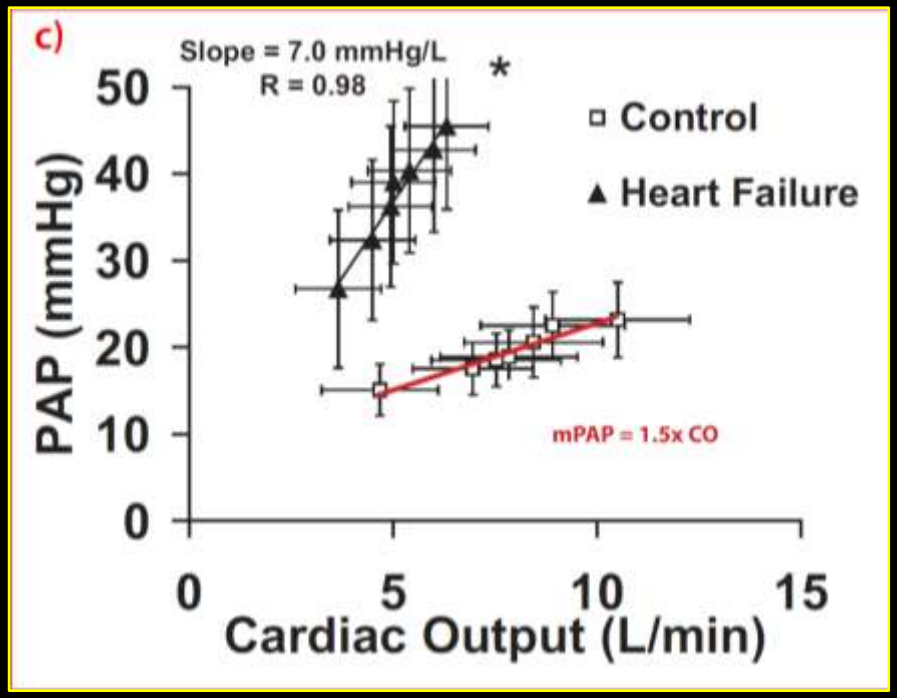


***during*** intense exercise & free breathing

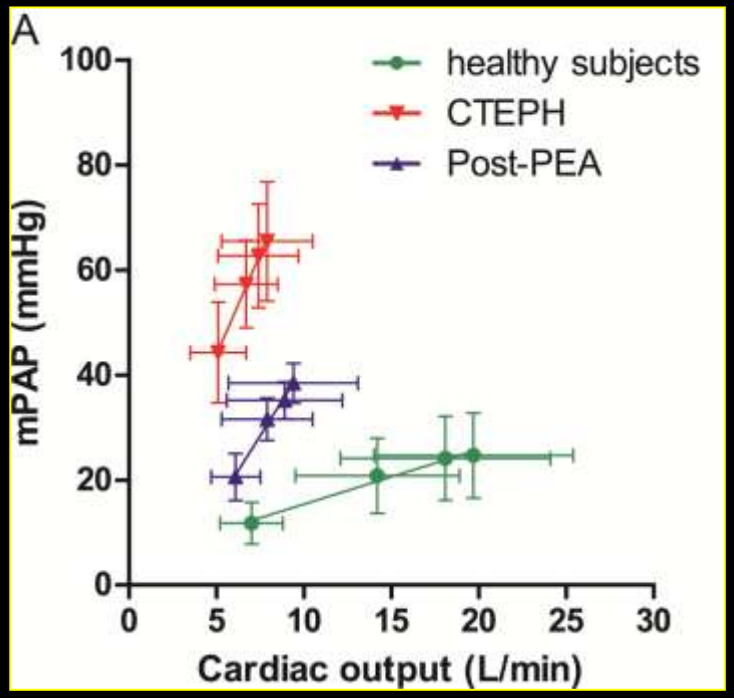



La Gerche et al. *Circ Imaging* 2013

# Normal vs. abnormal pulmonary vascular function

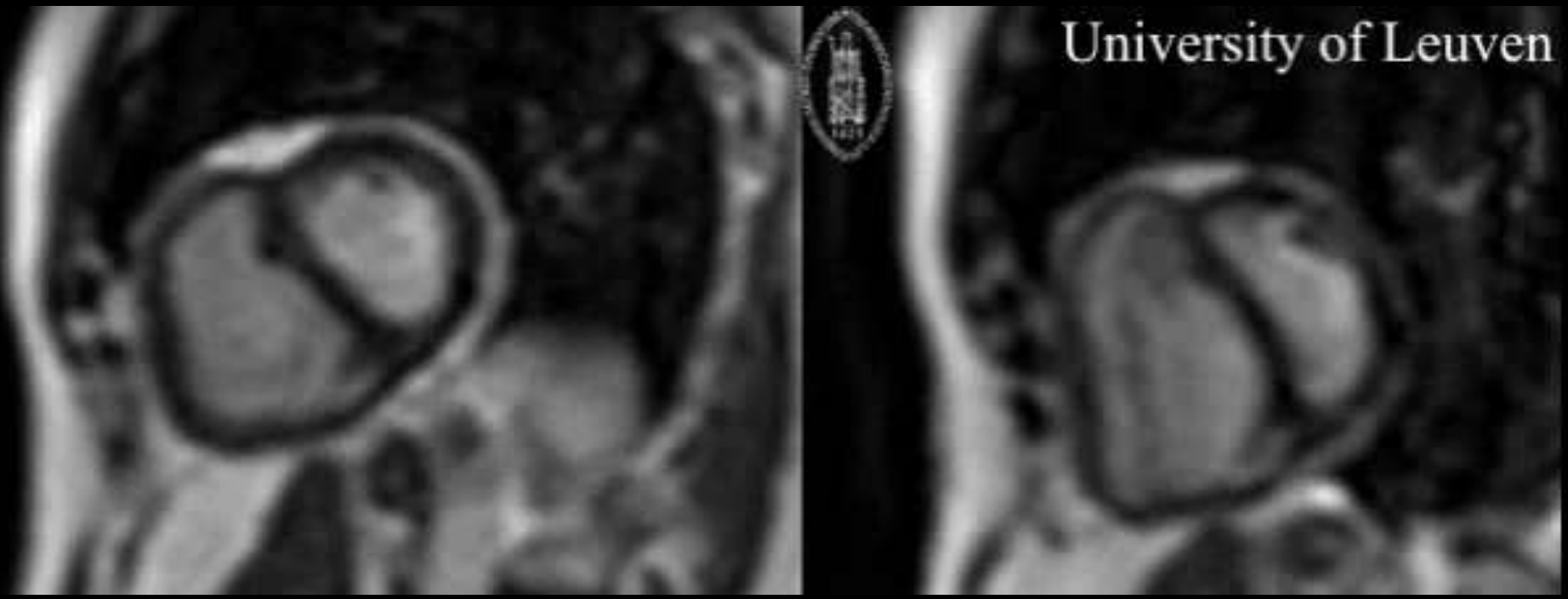



G Lewis et al. *Circ Heart Fail* 2011

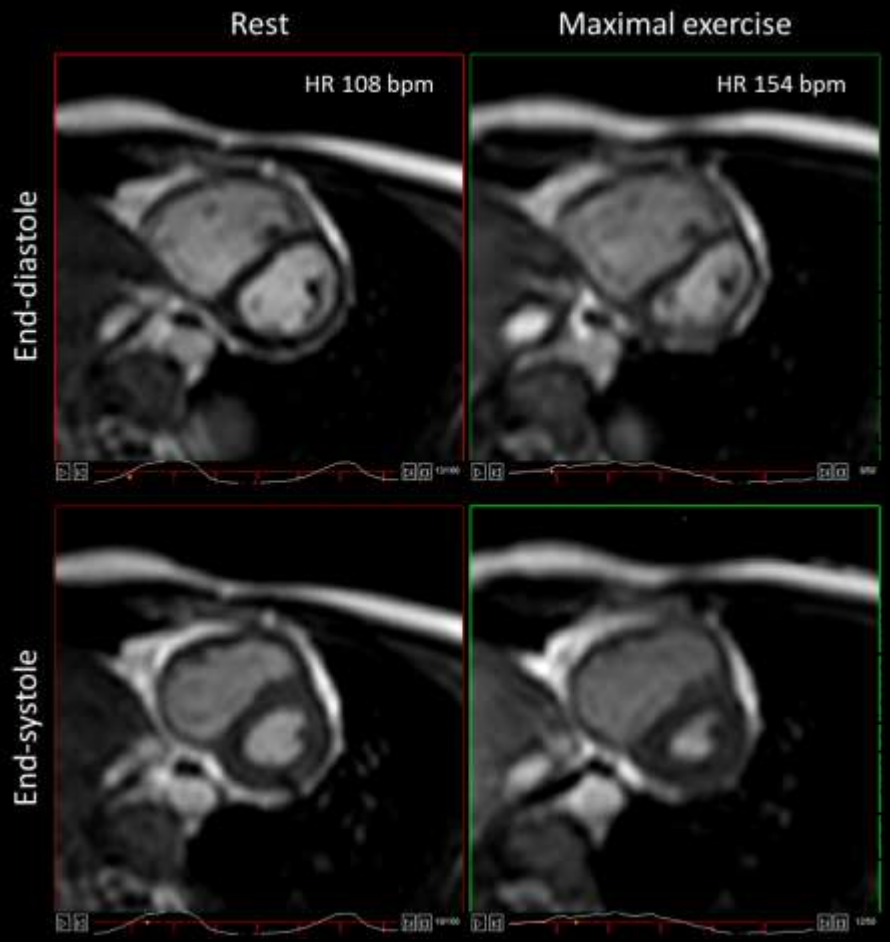


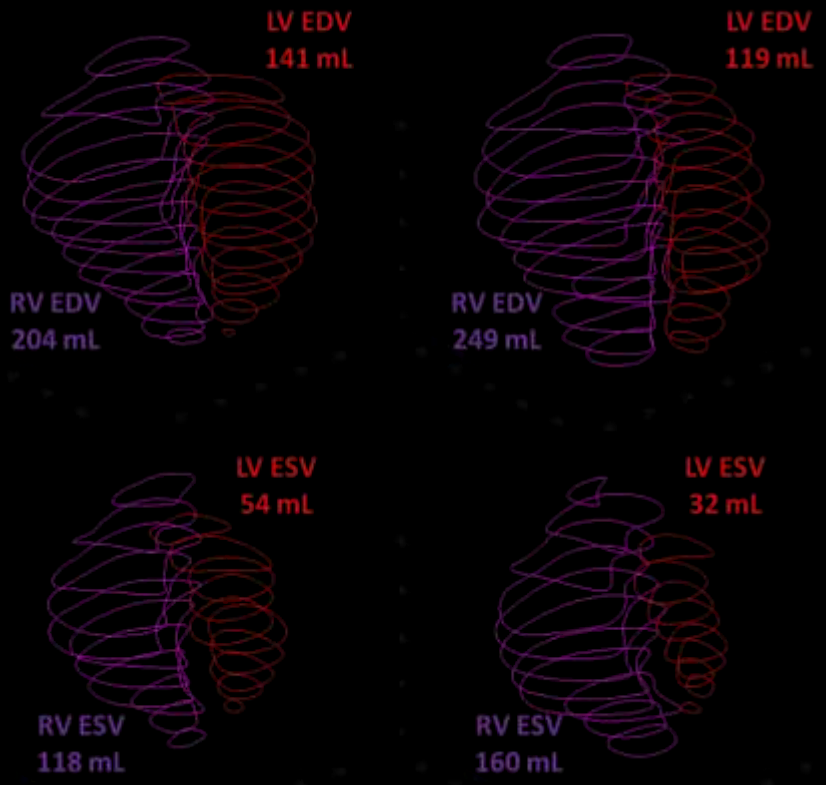

G Claessen *YIA AHA Chicago 2014*

# Impact of pulmonary vascular disease on RV function



# RV dysfunction in CTEPH



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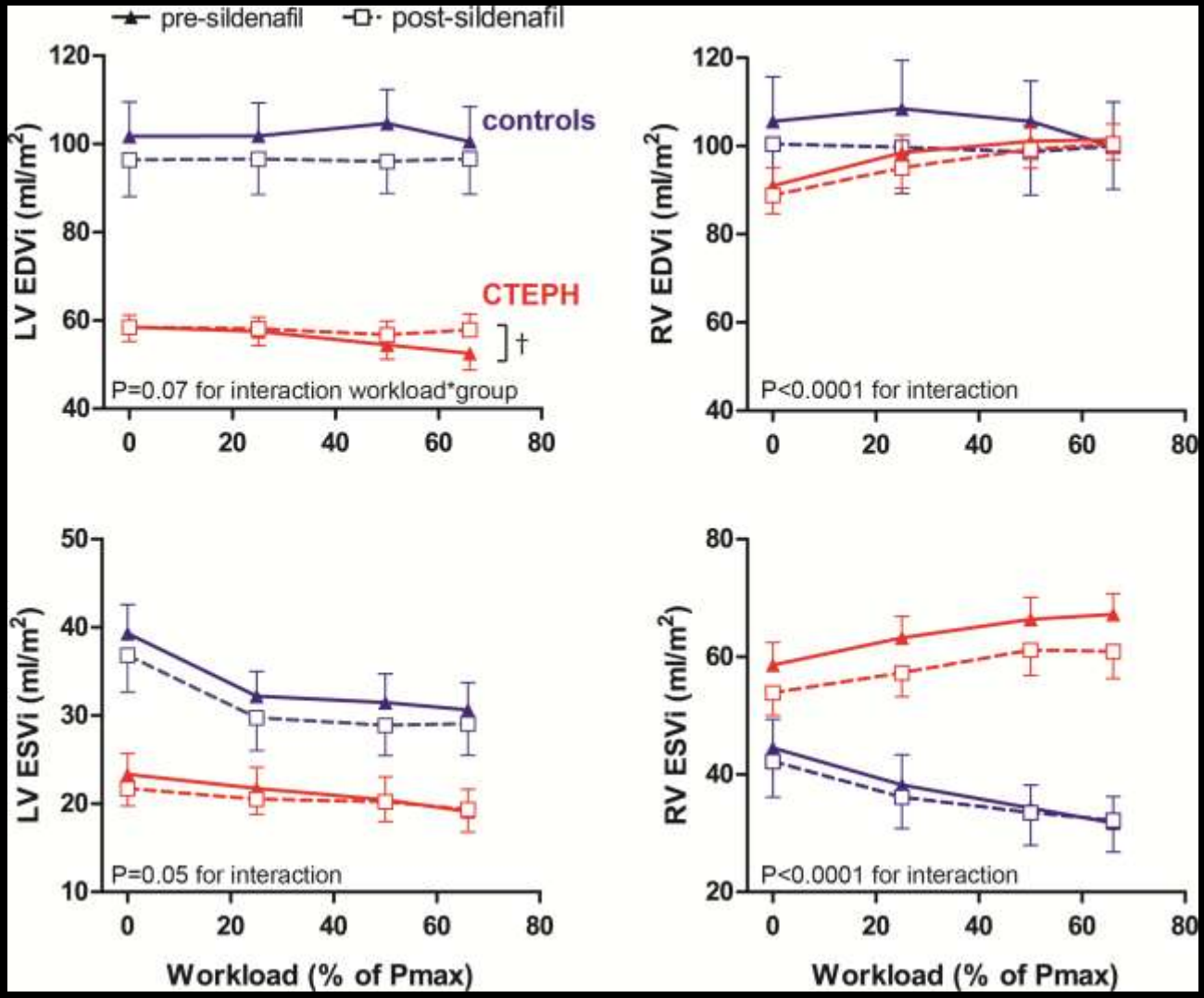
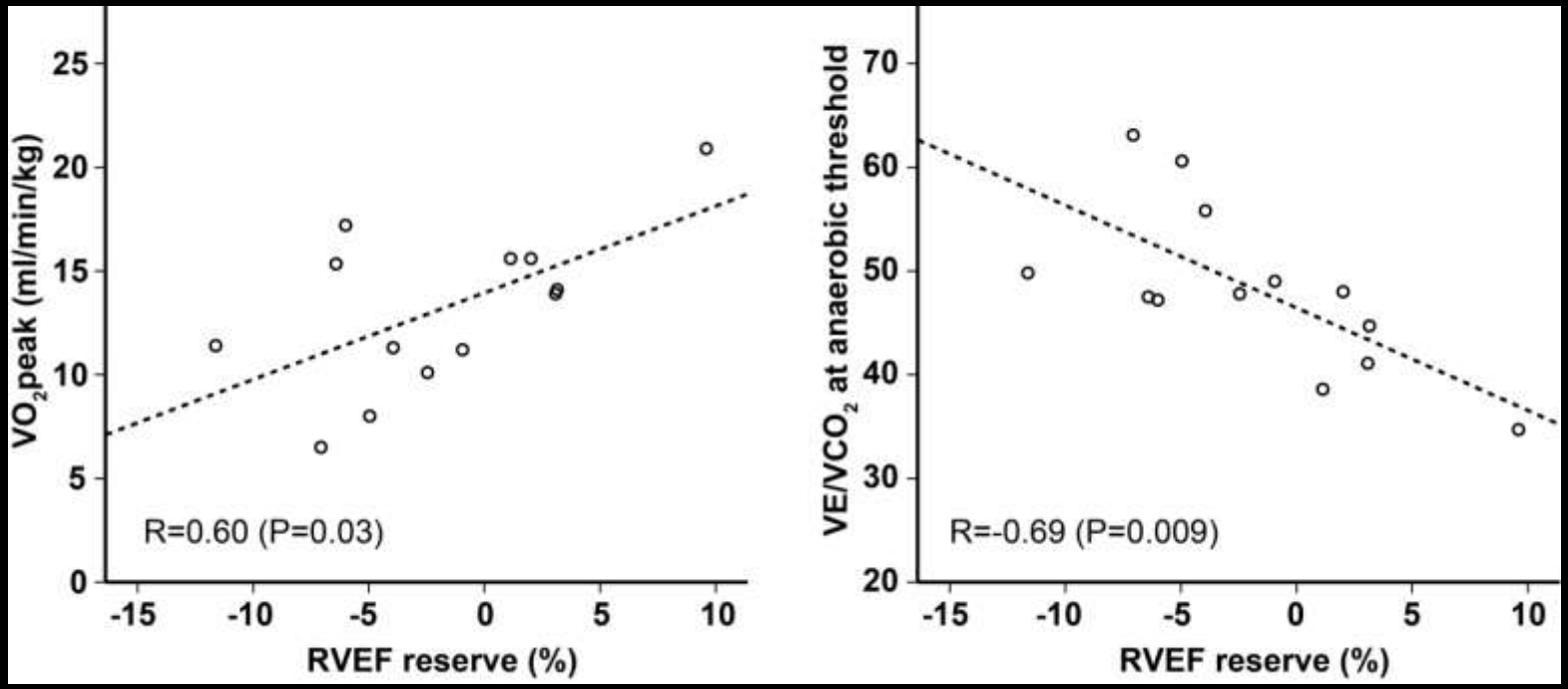
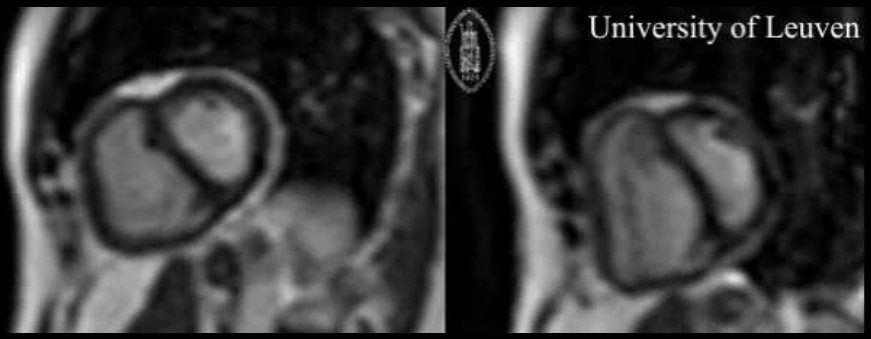



Claessen et al. *Unpublished*

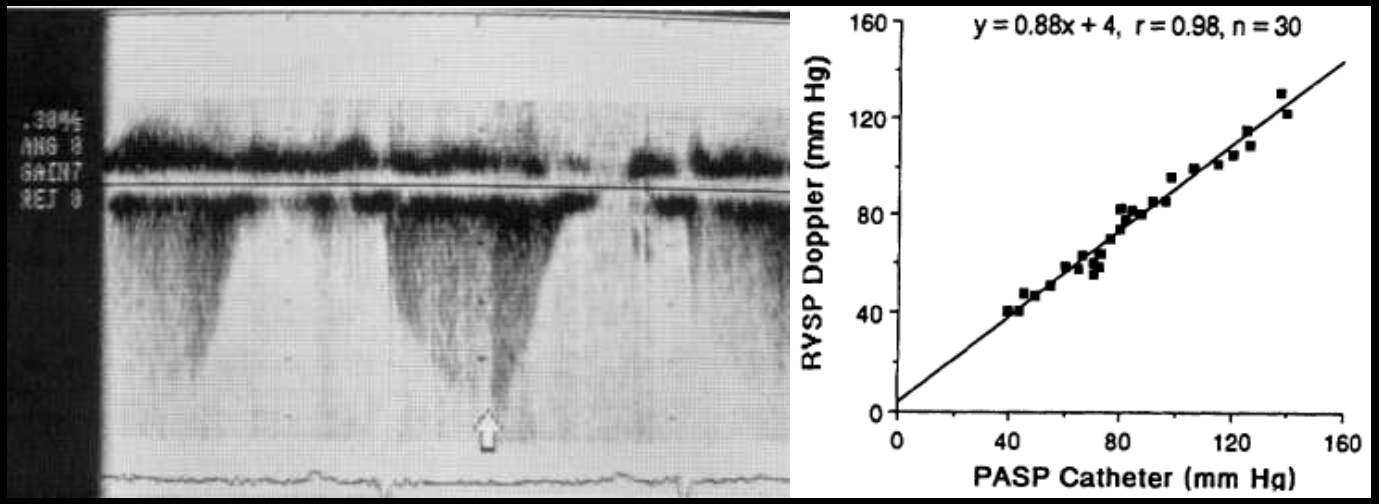
# RV reserve correlates with exercise capacity – resting measures DO NOT



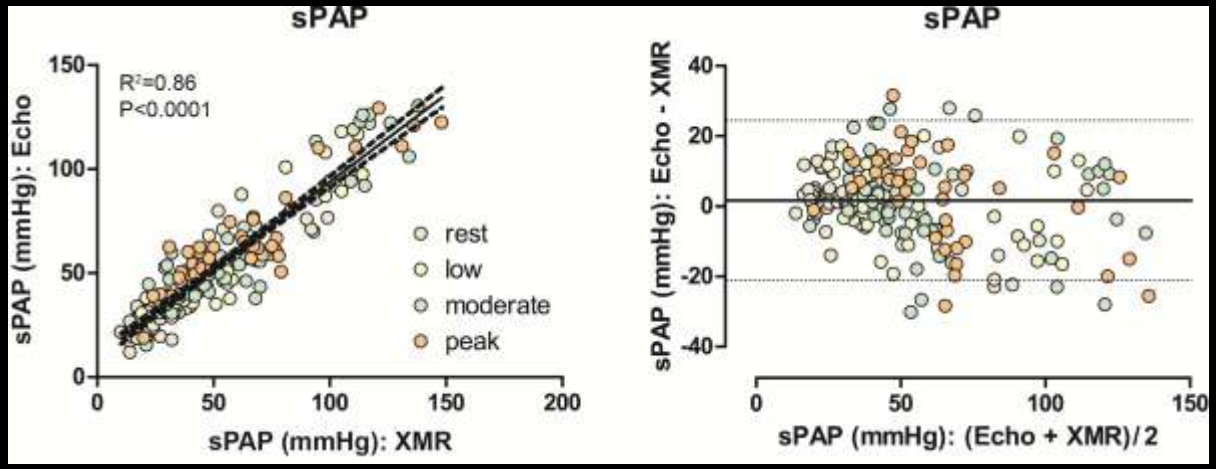

Claessen et al. *Unpublished*



# But I don’t have a bike in my CMR!




Himmelman et al. *Circulation* 1989




Claessen, La Gerche et al. *Unpublished*

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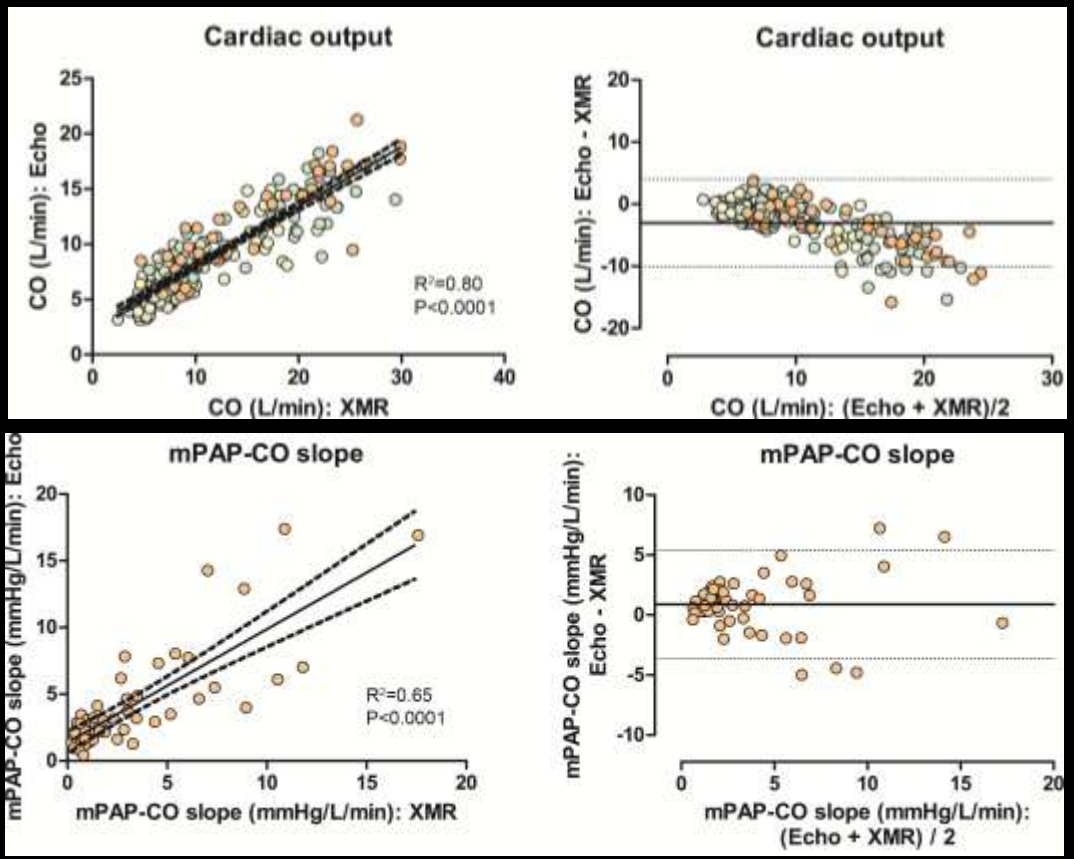
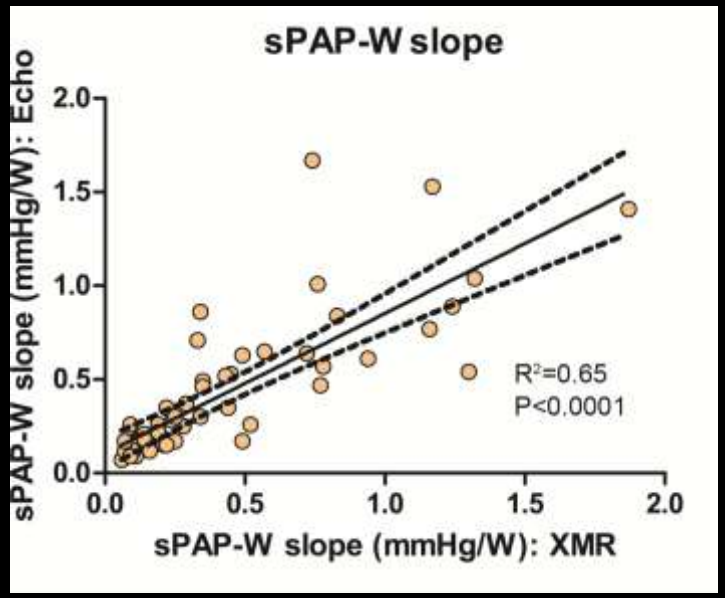
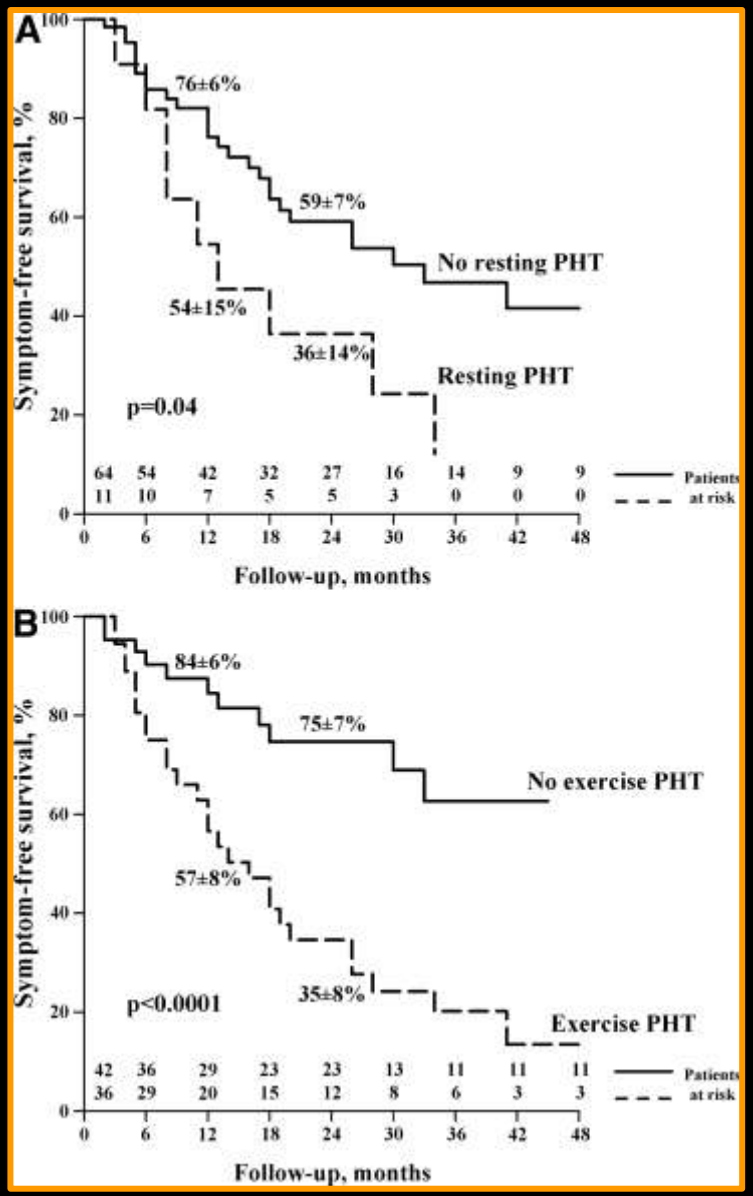



Claessen, La Gerche et al. *Unpublished*

# Ex-induced sPAP in mitral valve disease




- Exercise-induced sPAP associated with a 3 fold increased risk of developing symptoms at 3 years

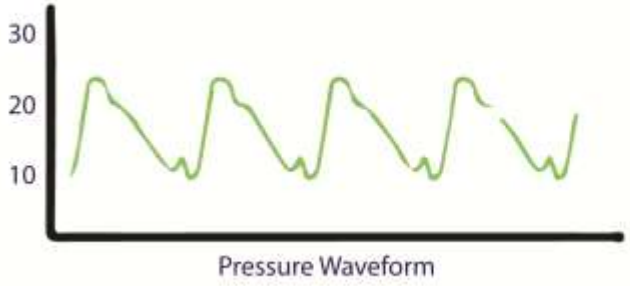
⇕

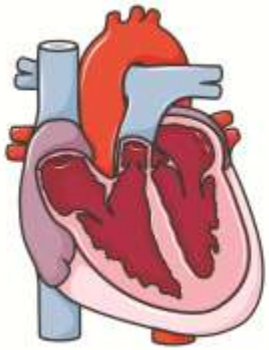
more predictive than resting sPAP

- Best cutoff value of PASP during exercise for predicting events was 56 mm Hg

Magne J et al. Circulation 2010;122:33-41

# Relationship between PAP, RV function & vascular load

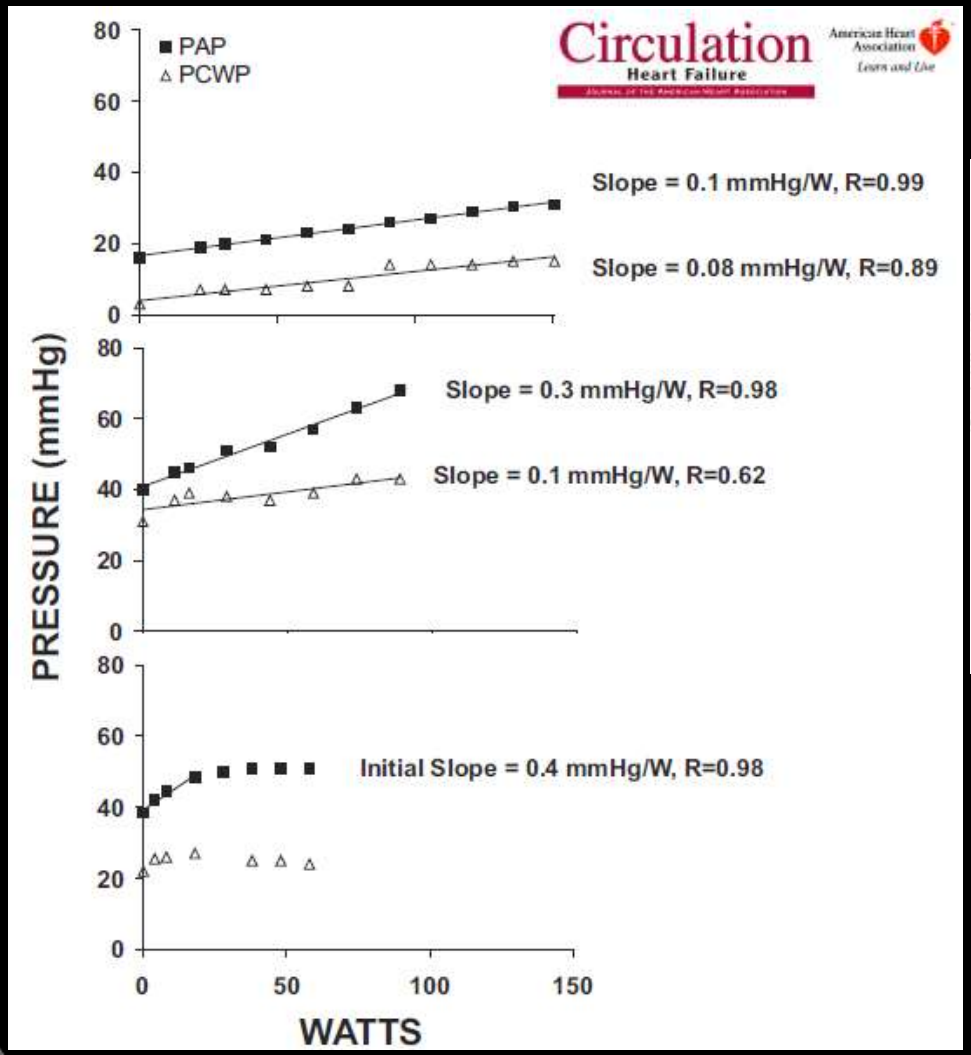


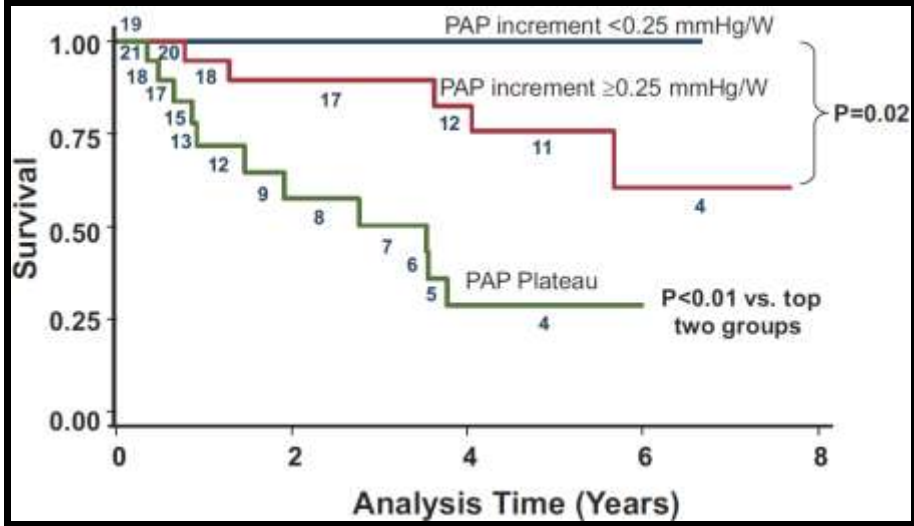



**Pulmonary Artery Pressure** = **Pump** (RV function) x **Load** (**Pulmonary**: Resistance & Compliance; **Left heart**: Left atrial pressure)

La Gerche et al. *The Right Heart* Springer Press

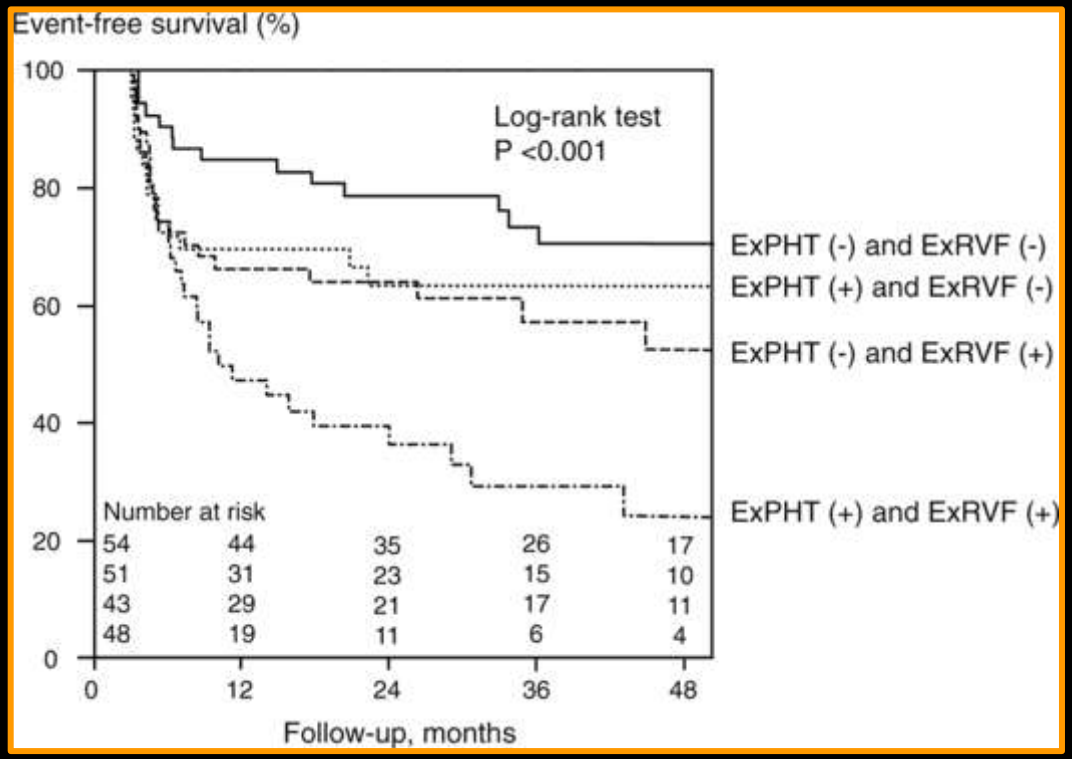
# Failure to increase PAP with exercise is associated with a poor prognosis




Lewis, Semigran et al.
*Circ Heart Failure* 2011

# Exercise TAPSE and sPAP



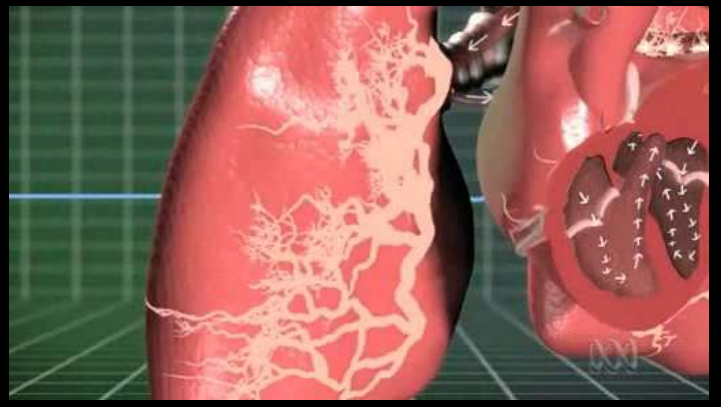

Ex-induced RV dysfunction incremental prognostic value in management of asymptomatic MR

ExPHT: sPAP during ex > 54 mmHg

ExRVF: TAPSE during exercise <19 mm

Kusunose K et al. Circ Cardiovasc Imaging 2013;6:167-176

# Exercise right heart haemodynamics - summary



- What is EIPH? *Excessive increase in PAP for given CO*
- Exercise estimates of PASP and CO are feasible
- Importance of exercise testing in:
  - Breathless patients (diagnosis)

  *"To assess exertional breathlessness you must exert the breathless"*

  - Patients with heart disease (prognosis)

  *Poor RV reserve = poor exercise capacity and ↑mortality*

# Acknowledgements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