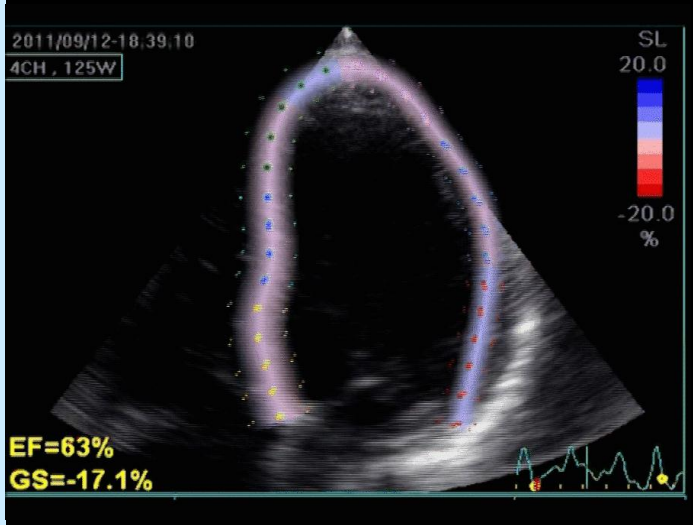

Diastolic Stress Testing

EAE Teaching Course

Sofia, Bulgaria 2012

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Why would we want to assess diastolic function during stress?

1. Find a diagnosis for the breathless patient
   " to assess exertional breathlessness, you must exert the breathless!"
2. Assessing disease severity and prognosis
3. To define patients who may benefit from therapy
   - "patient targeted therapy"

Potential tools

- Volumetric assessments
- E/e’
- Torsion/ twist
- Lung comets
- Pulmonary artery pressure
- Biochemical

Exercise vs. Pharmacological "stress"

Exercise

- ↑SV and ↑afterload
- ↑preload
- Functional status
- Very safe

- Respiratory/ other movement
- Often in early recovery

Dobutamine

- ↑↑SV and ↓afterload
- ↓preload
- No functional status
- Arrhythmias (uncommon)

- Good quality images

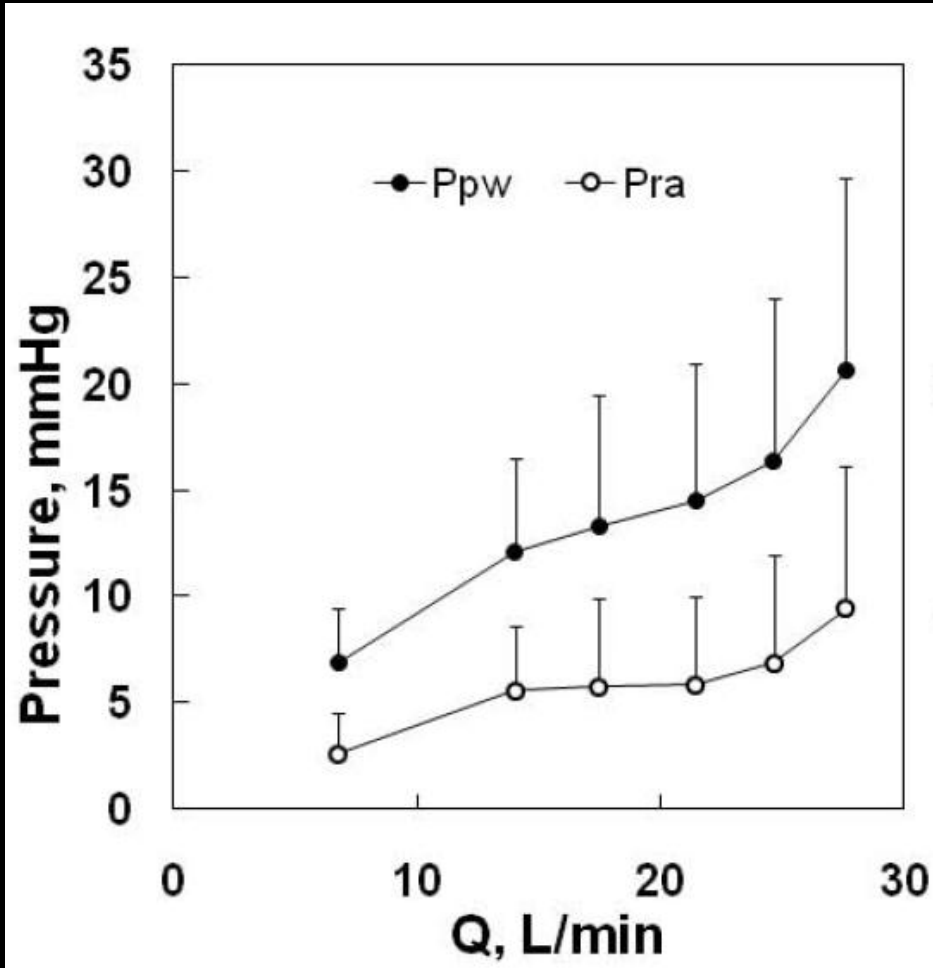
- Real-time

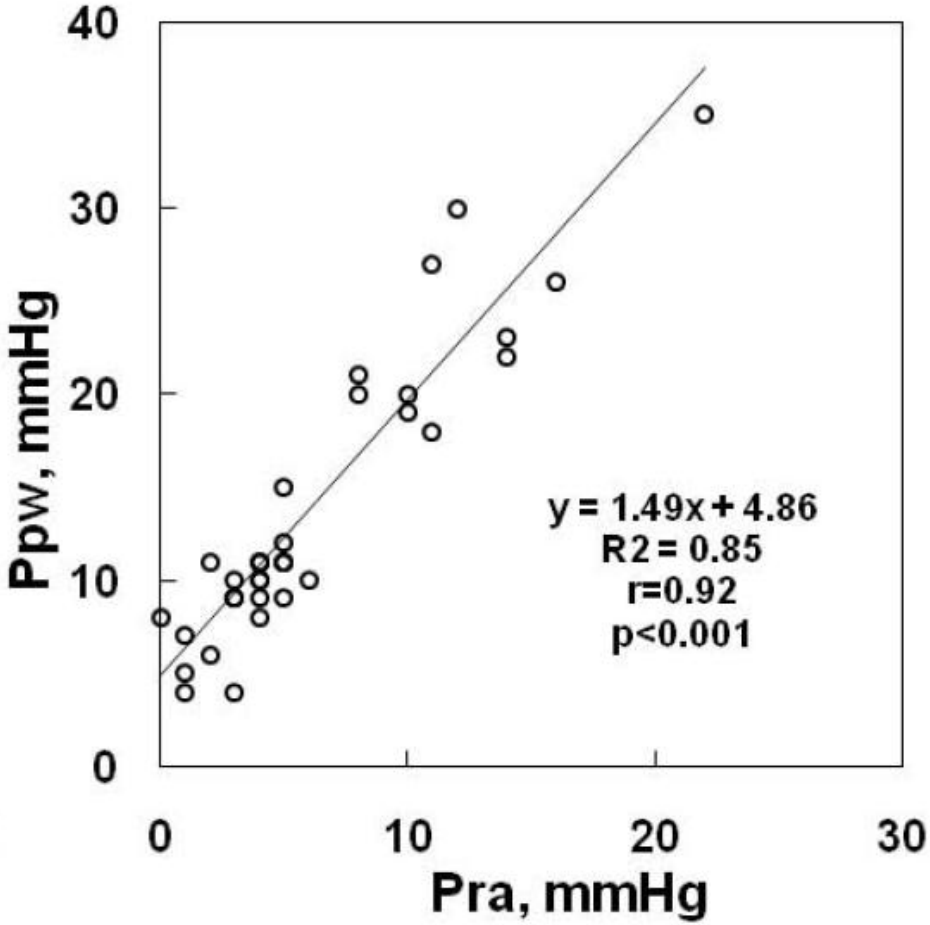
Heart failure limits exercise in everyone

Heart failure: cardiac output insufficient to meet O_2 demands

- In health and disease exercise capacity is closely associated with maximal oxygen consumption
  - O_2 delivered x O_2 metabolized
- Cardiac output explains ~75% of variability in oxygen utilisation
- HFPEF and a world-champ ion athlete:
  - the exercise limitations are similar
  - the workload differs

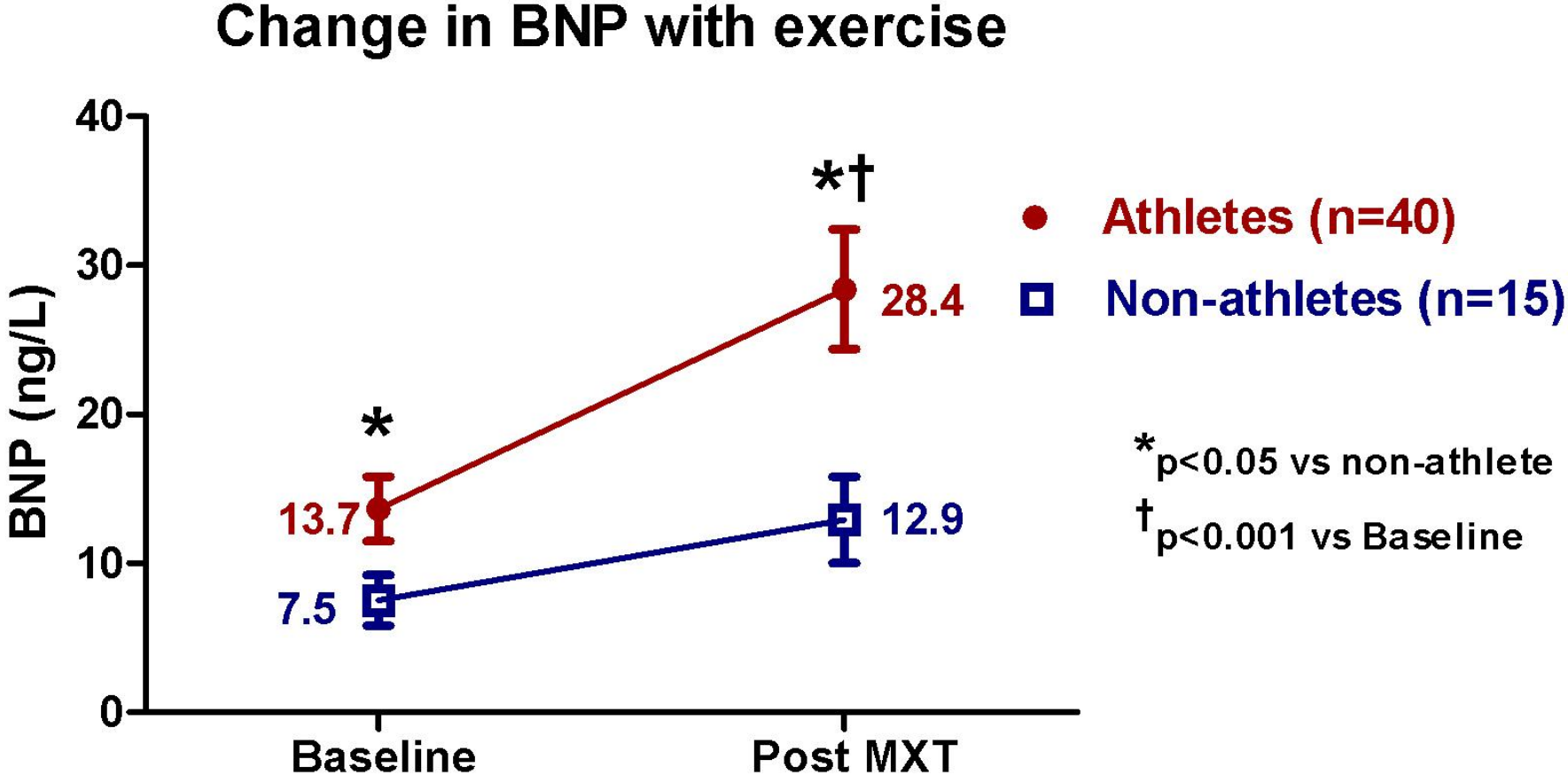
Atrial pressures during exercise in health



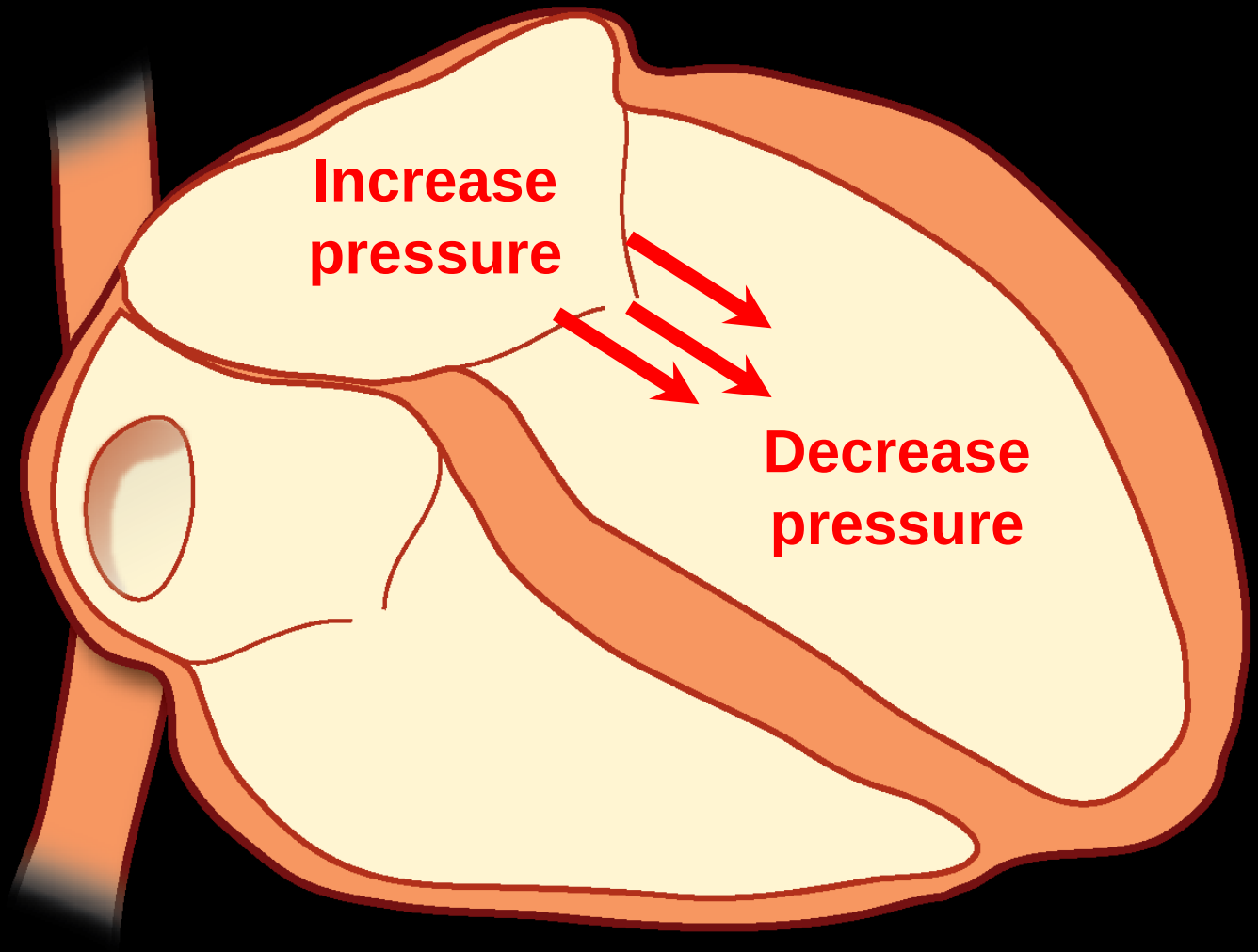


Reeves JT, Wagner PD et al. Operation Everest II Respir Physiol 80:147-154, 1990 and J Appl Physiol 63: 531-539, 1987

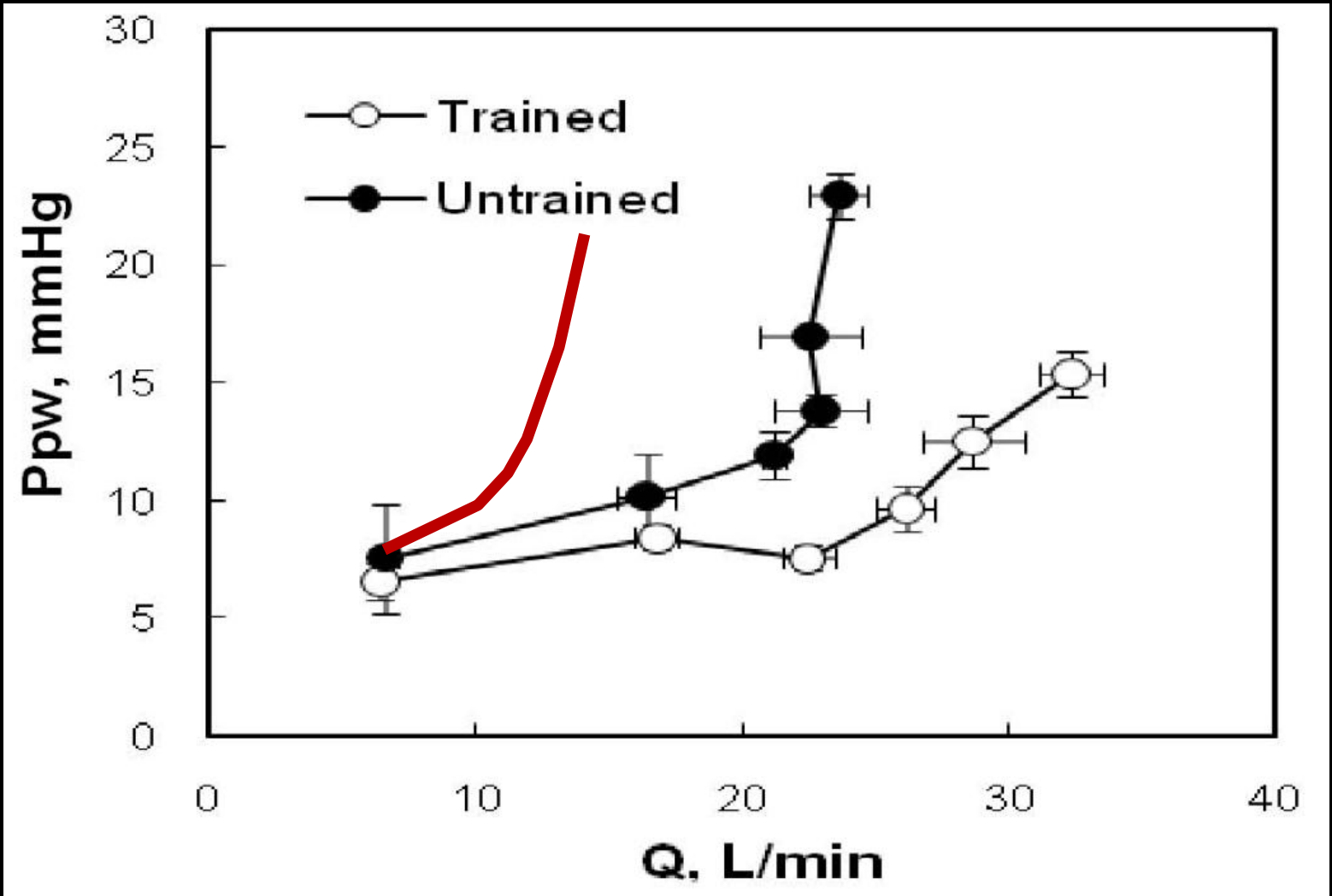
BNP as a surrogate of acute ventricular stretch



Flow and pressure with exercise

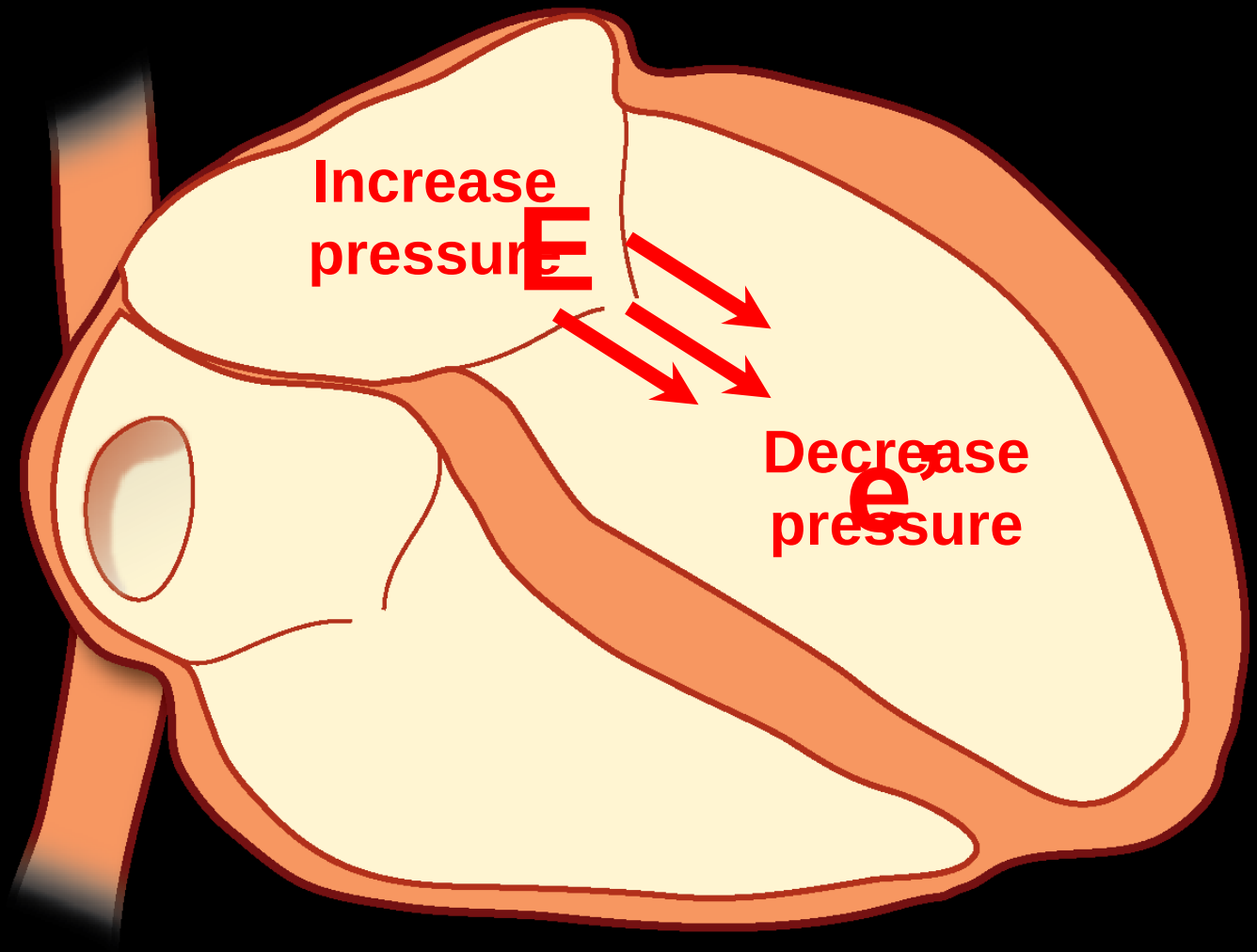


The difference is in the workload

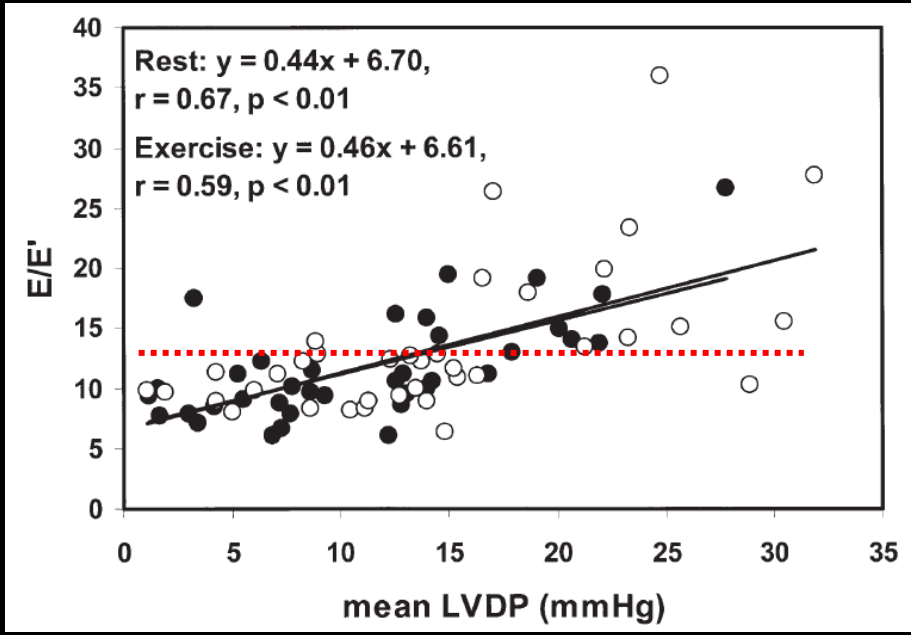


Stickland et al. *J Appl Physiol* 2006

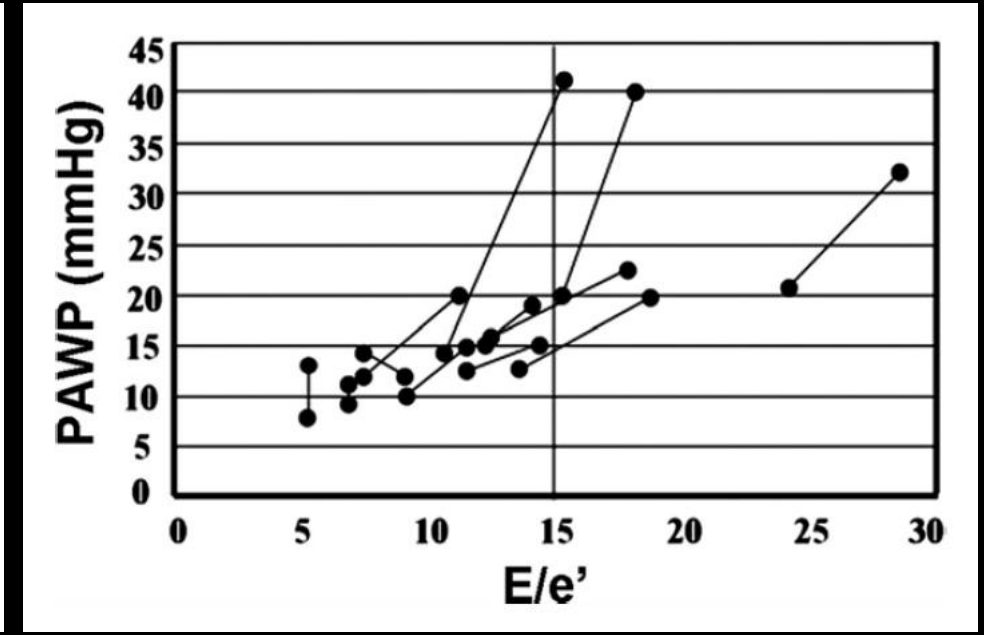
E/e’ as a measure of LA pressure



E/e’ as a measure of diastolic filling pressures

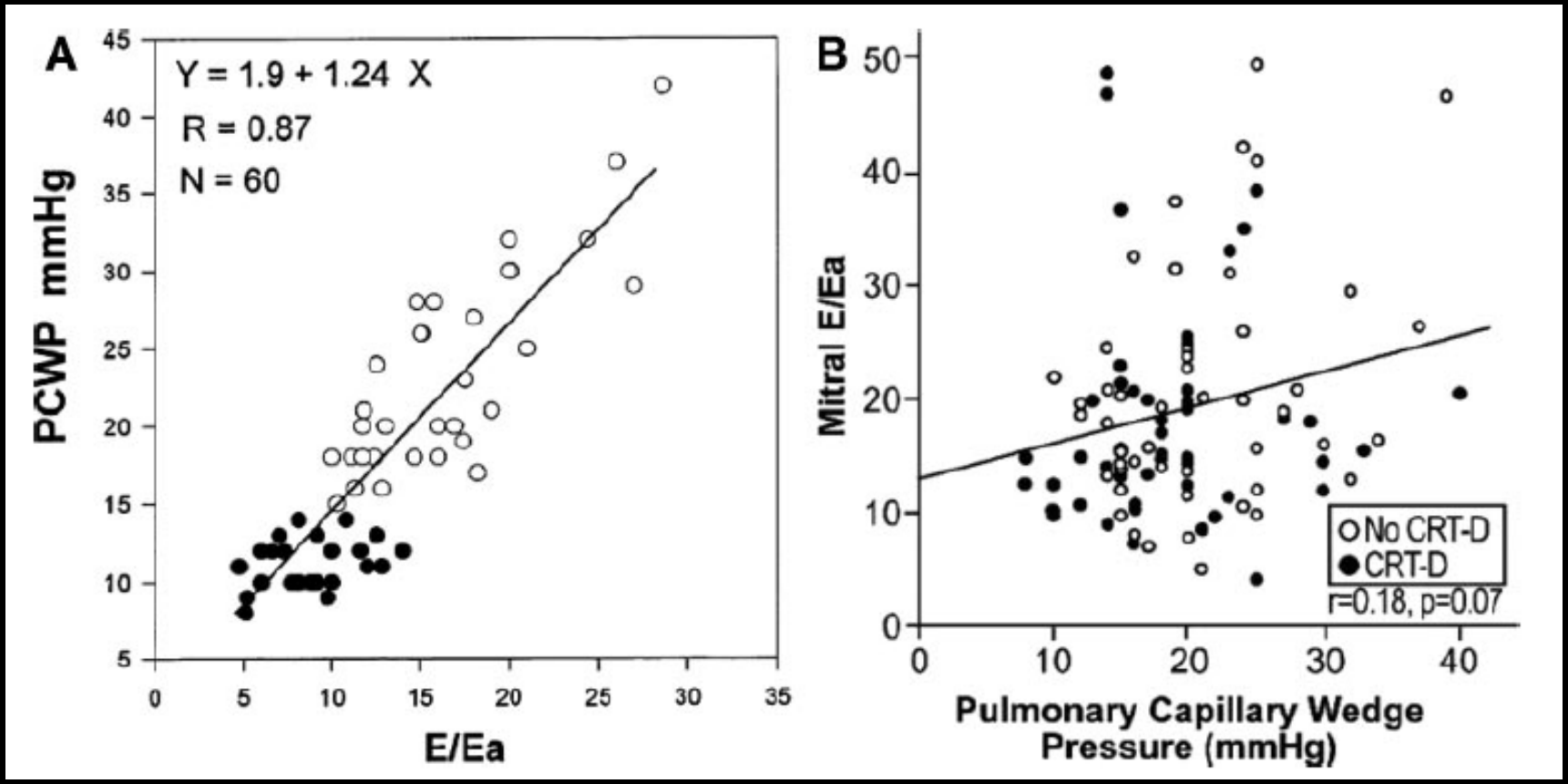


Burgess, Marwick JACC 2006



Talreja, Oh JASE 2007

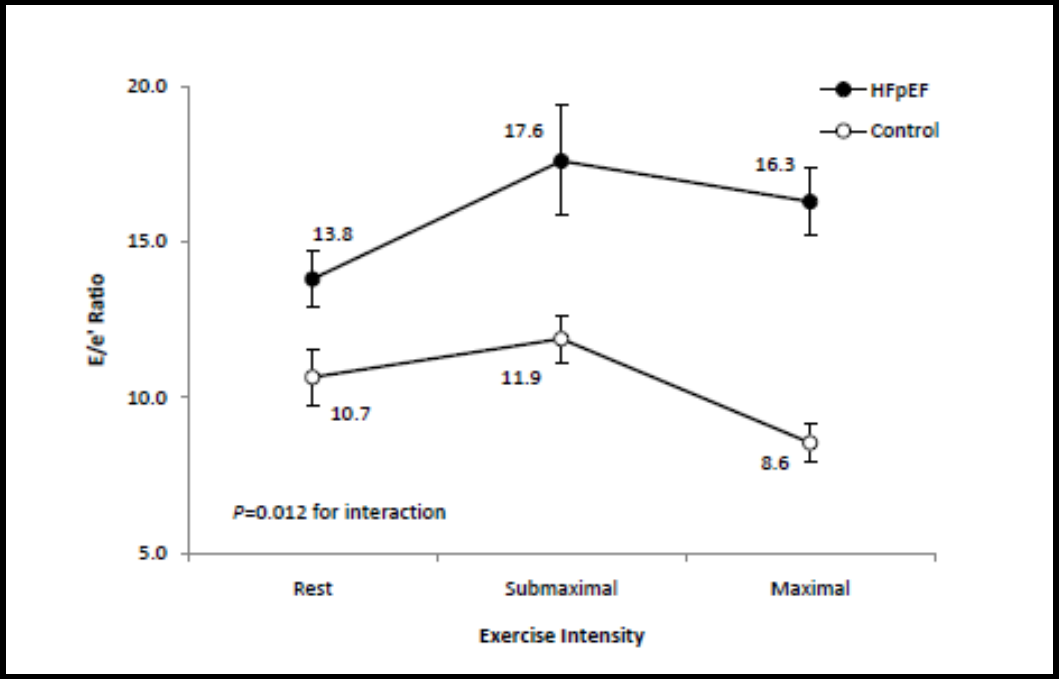
Caveats I



Nagueh *JACC* 1997 vs. Mullens *Circulation* 2009

Caveats II

- Data is acquired during recovery and compared with pressures obtained at peak exercise
- Delay varies with pathology
- ? Measuring slow recovery rather than exercise pressures



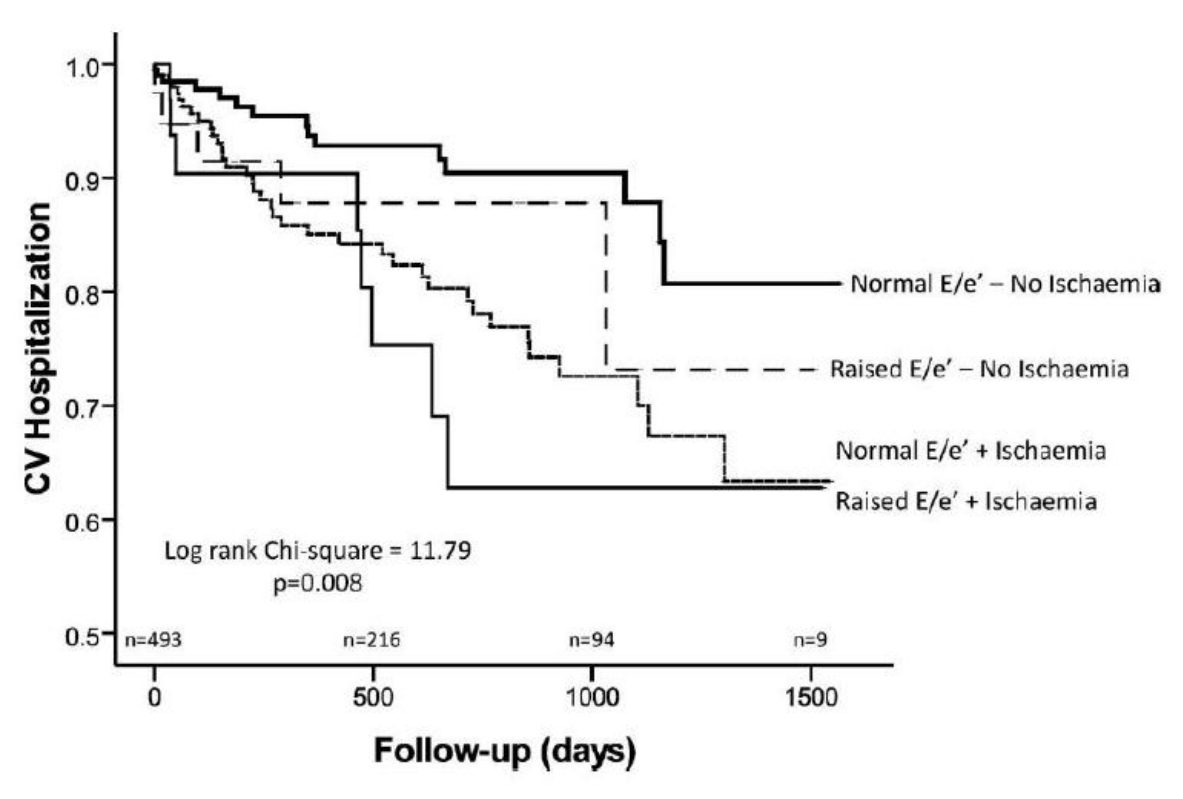
Holland, Marwick *Am J Hypertension* 2008

Can we improve HFPEF diagnosis with exercise E/e' ?

- Holland, Marwick *Heart* 2010
  - Resting criteria for HFPEF
  - Add E/e' with exercise
  - Exclude ischemia testing with exercise
  - Add objective exercise intolerance
- 13/436 breathless patients met all criteria for HFPEF
- Relevant to patient selection for trials

Exercise E/e' and prognosis

- 538 patients 'clinically indicated stress test'.
- E/e' >2SD from normal (14.5)
- Outcome CVS hospitalisation in 5 years



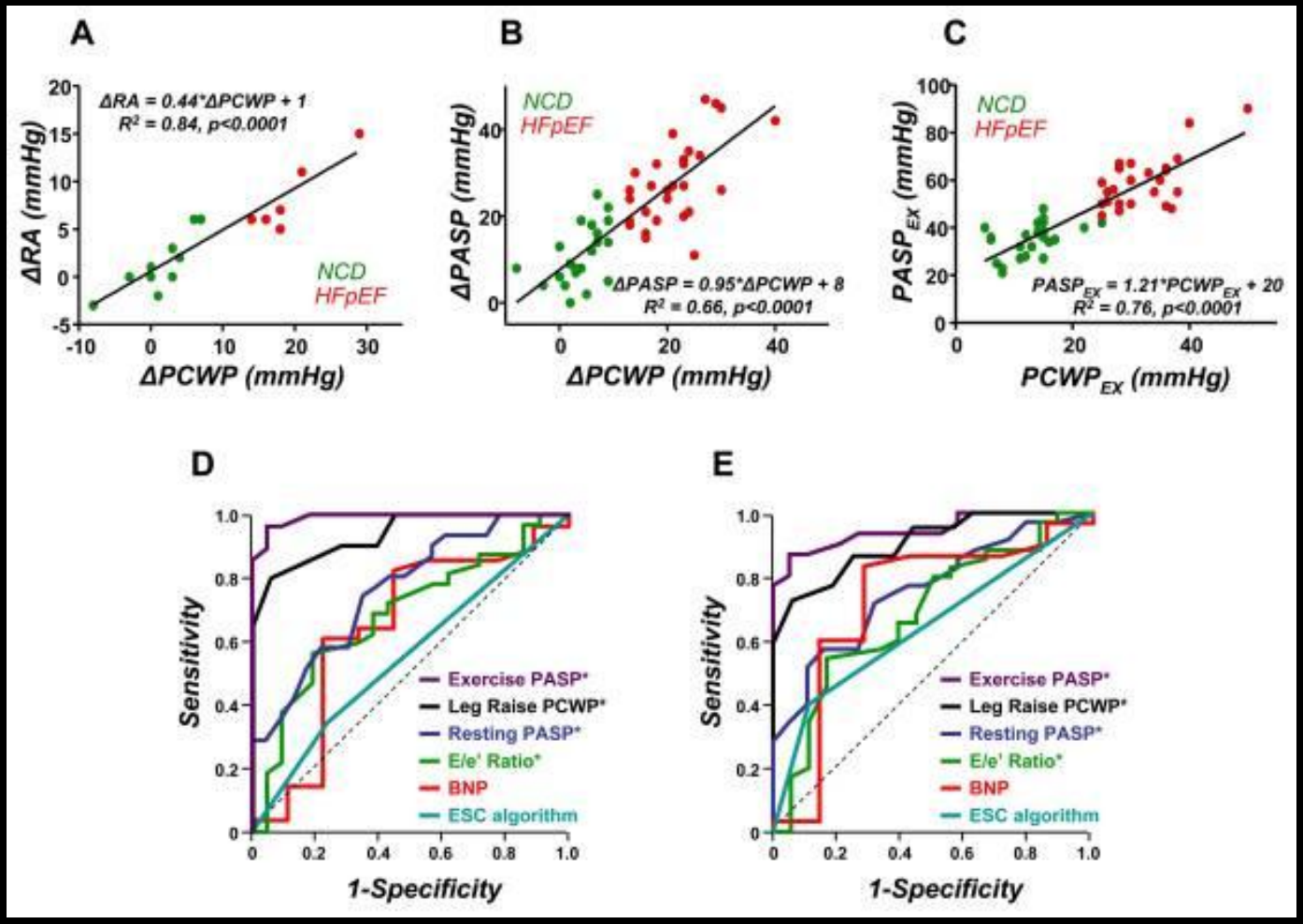
Holland, Marwick *Circ CVI* 2010

Summary of exercise E/e’

- ???? Measures LV filling pressures
- Probably does measure a sub-optimal cardiac response to exercise
- Need to wait for EA splitting maybe an advantage
- Moderately helpful in predicting prognosis
- Easy to add to standard exercise echo testing

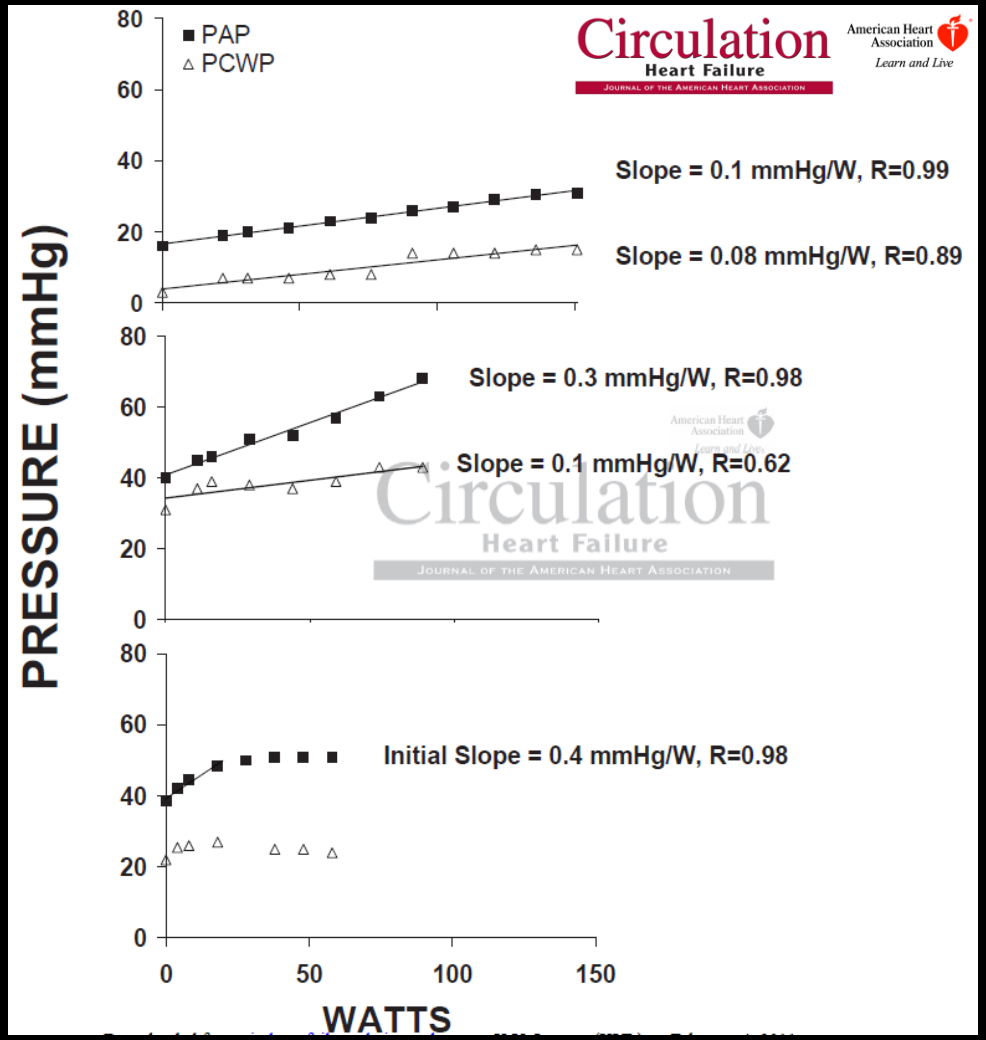
Pulmonary Artery Pressures

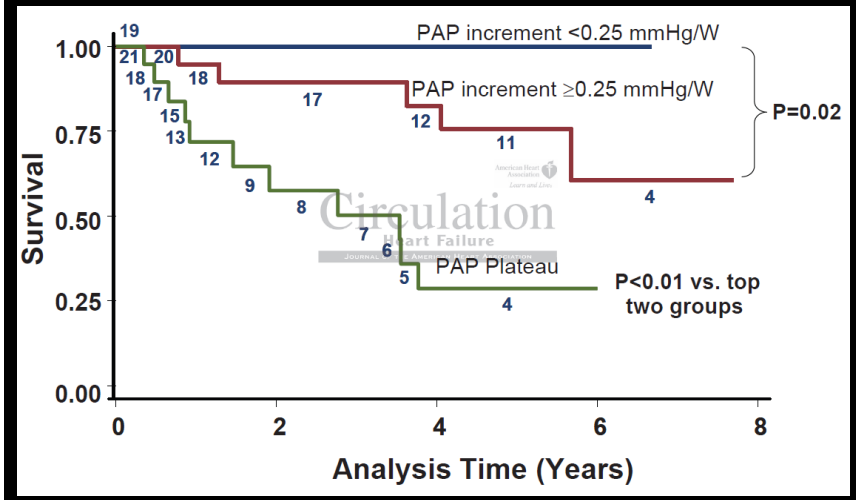
- Invasive hemodynamic studies to diagnose HFPEF (defined as Ex PCWP > 25mmHg) in 55 breathless patients



Borlaug et al. *Circ Heart Failure* 2010

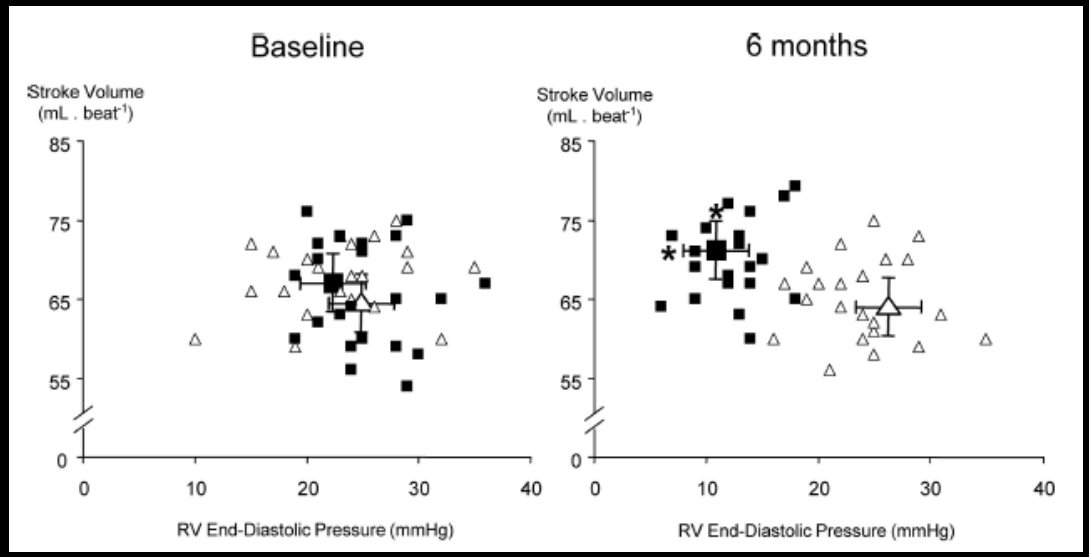
Failure to increase PAP with exercise is associated with a poor prognosis

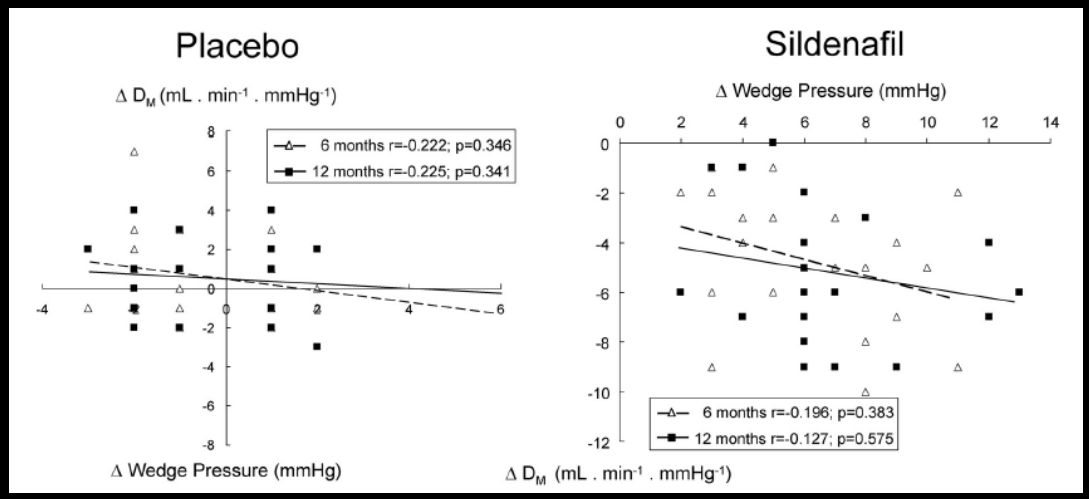




Lewis, Semigran et al.
Circ Heart Failure 2011

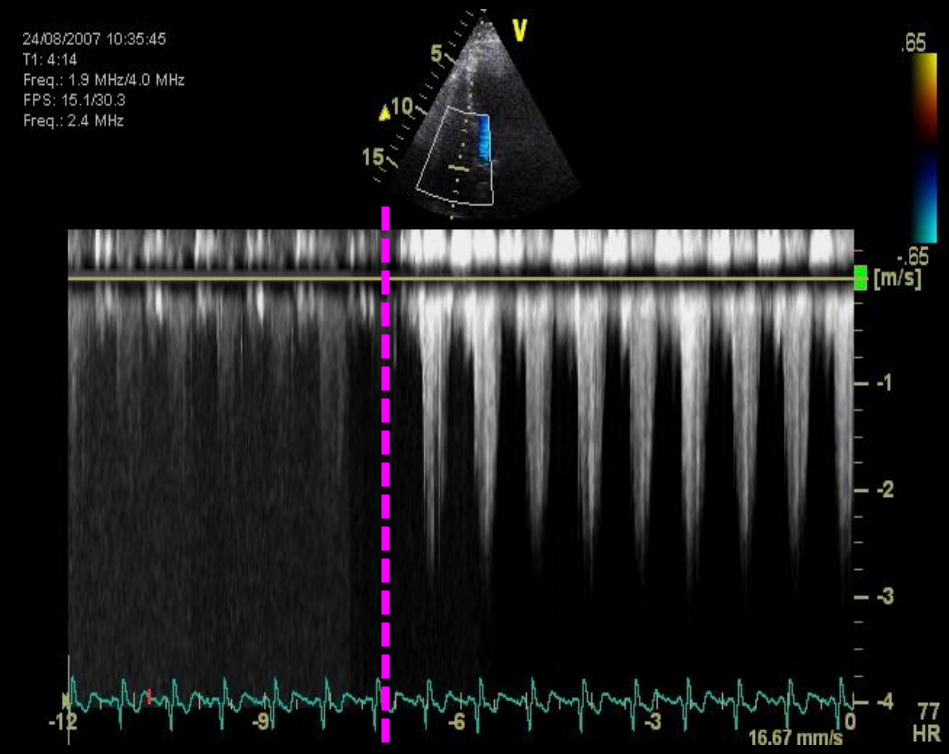
Pulmonary vasodilators as therapy for HFNEF?

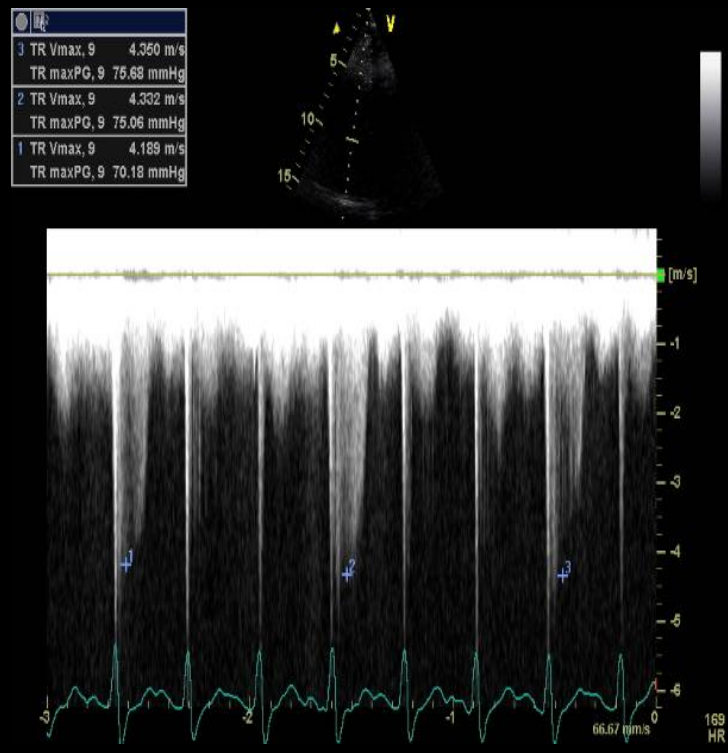




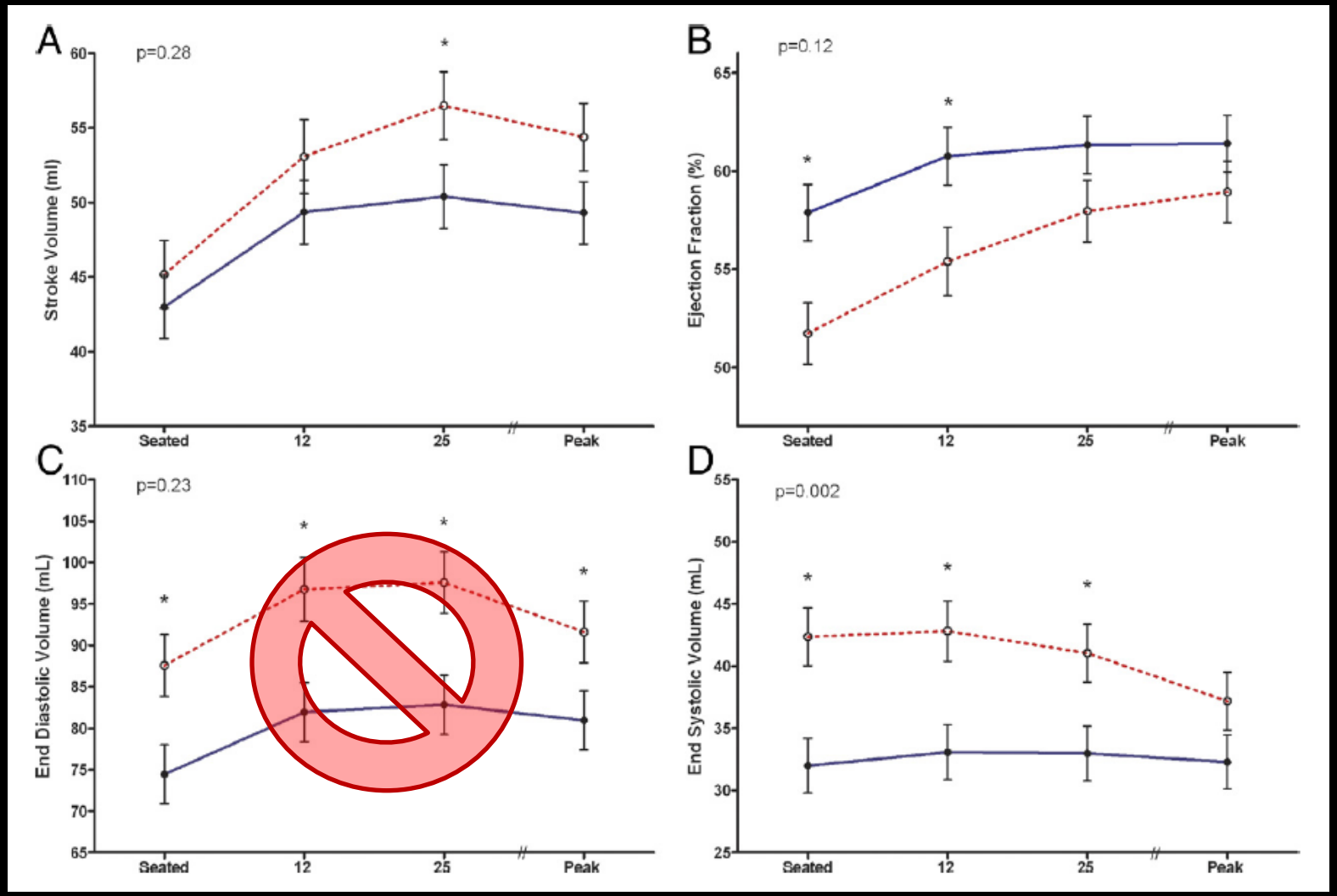
Guazzi et al. *Circulation* 2011

Echo estimates of PASP





Volumes, HFPEF and exercise



Haykowsky, Kitzman et al. *JACC* 2011

HFNEF and exercise

- Consistent finding of reduced contractile reserve rather than filling impairment
- However:

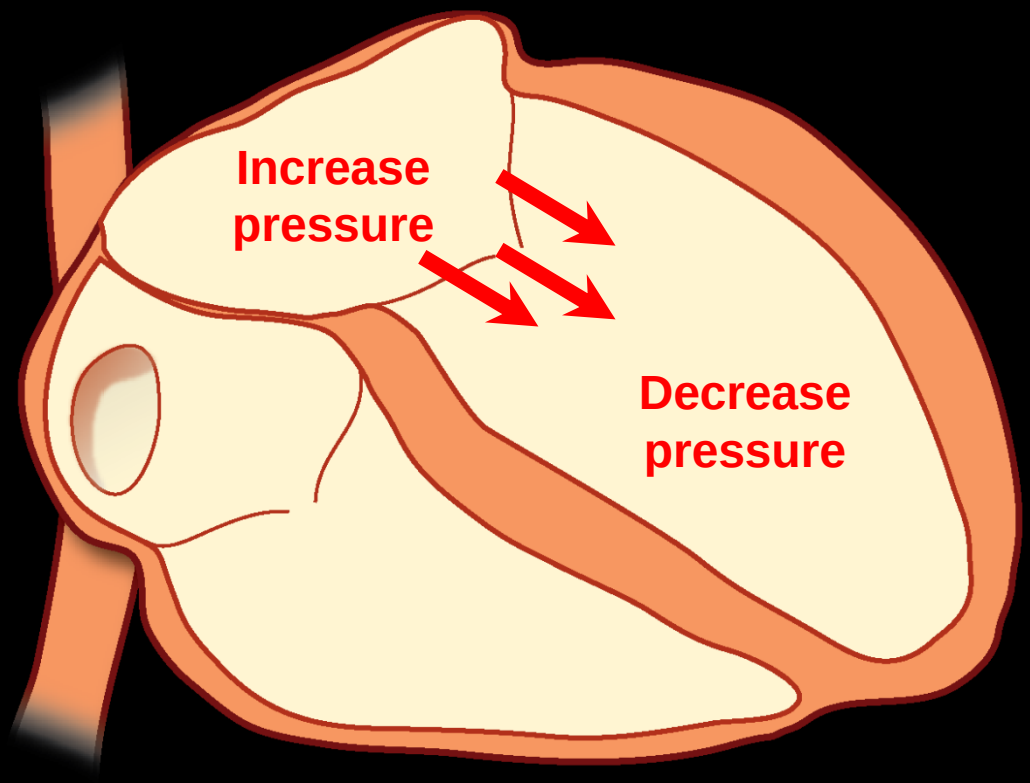
  ? chronotropic incompetence = filling impairment

	Kitzman et al. (8) HFPEF vs. AMC	Borlaug et al. (9) HFPEF vs. ASCC	Ennezat et al. (11) HFPEF vs. HYPER	Borlaug et al. (10) HFPEF vs. AMC	Borlaug et al. (10) HFPEF vs. HYPER	Maeder et al. (37) HFPEF vs. AMC	Current Study HFPEF vs. AMC
Peak Vo_2	↓	↓	NR	↓	↓	↓	↓
ΔCO	↓	↓	↓	↓	↓	↓	↓
ΔA-Vo_2 Diff	↓	NR	NR	NR	NR	↔	↓
ΔHR	↓	↓	↔	↓	↓	↔ supine, ↓ upright	↓
ΔEDV	↓	↔	↔	↔	↔	NR	↔
ΔESV	↔	NR	↓	↓	↓	NR	↓
ΔSV	↓	↔	↓	NR	NR	↓	↔
ΔEF	↓	↓	↓	↓	↓	NR	↓
ΔSVR	NR	↓	↓	↓	↓	↓	↔

Haykowsky, Kitzman et al. *JACC* 2011

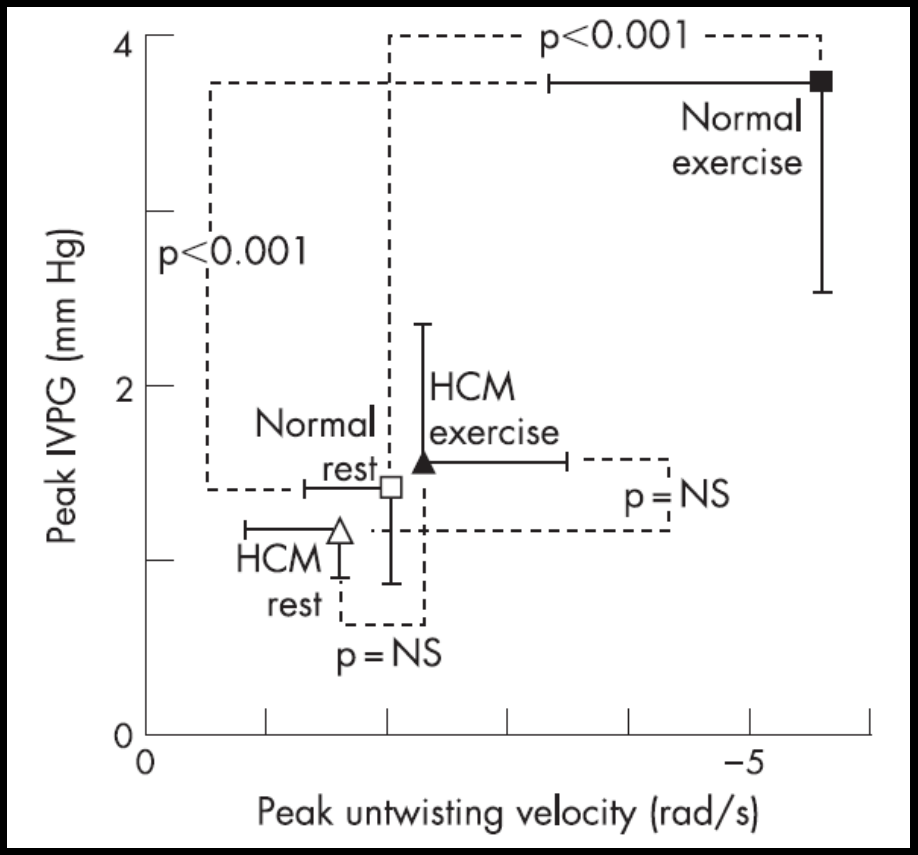
SYSTOLIC AND DIASTOLIC FUNCTION ARE INSEPARABLE

Flow and pressure with exercise

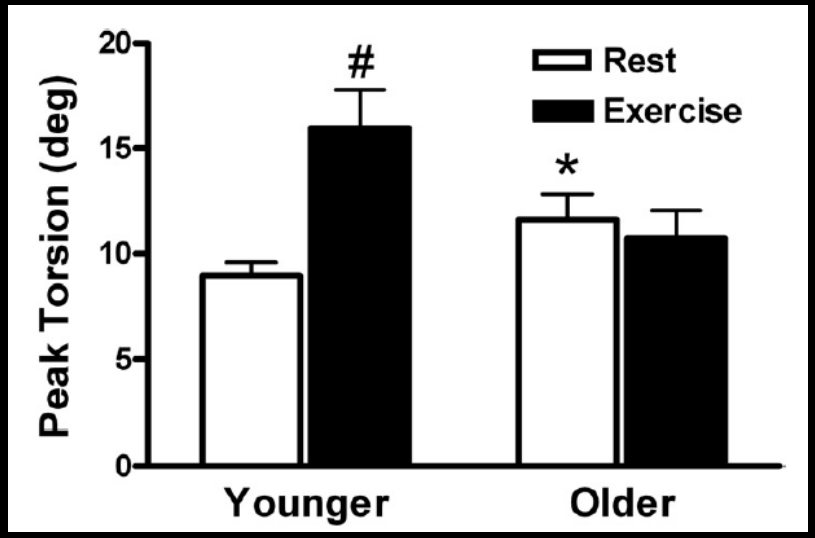


The best way of decreasing early diastolic suction is with effective systolic contraction

Torsional reserve

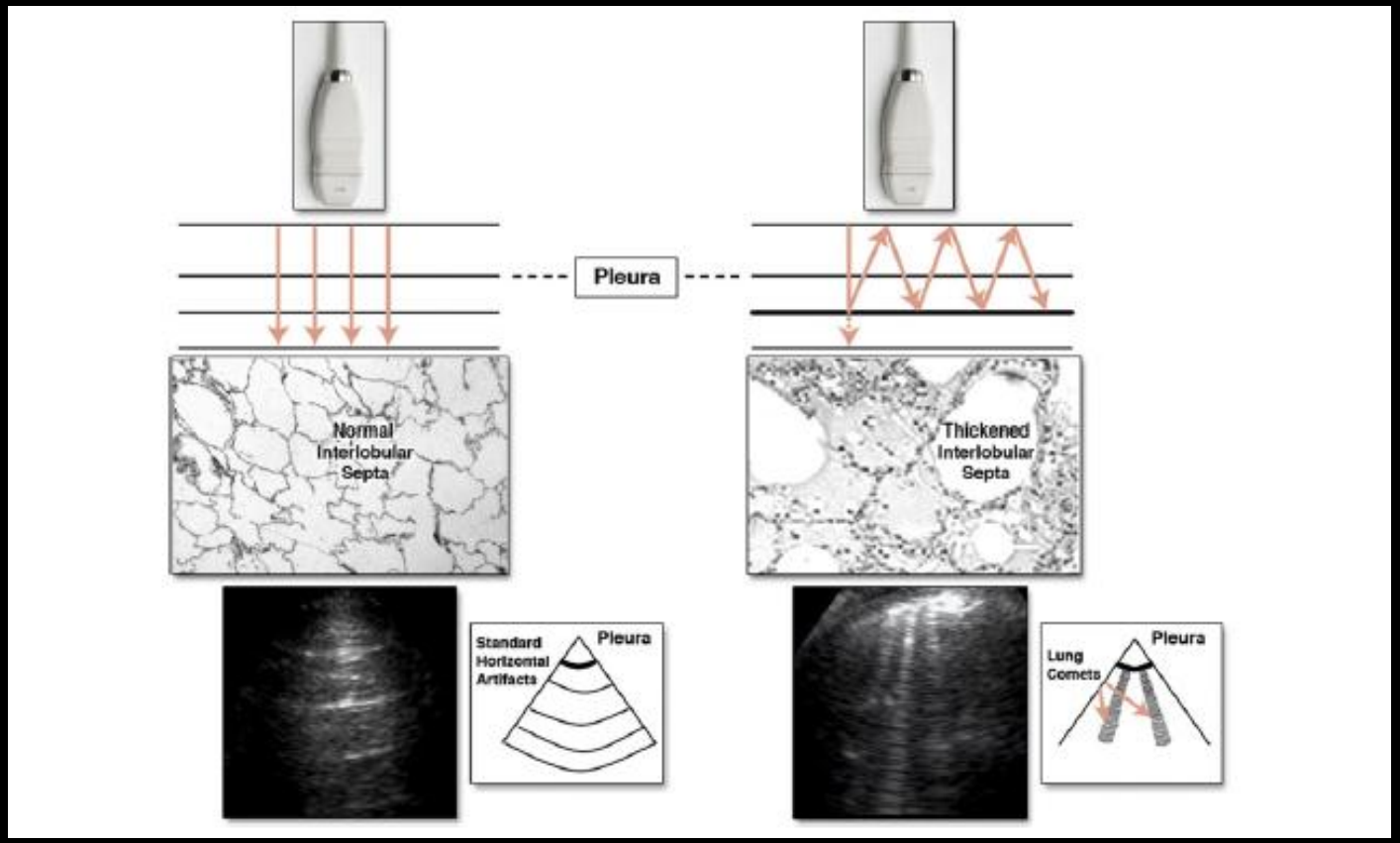


Notomi et al. *Circ* 2006



Burns et al. *JASE* 2008

Direct assessment of exercise-induced heart failure



Sicari et al. *JASE* 2006

Conclusions

- Exercise intolerance (not resting symptoms) is the most frequent complaint of our patients

To assess exertional breathlessness we must exert the breathless

Conclusions

- ‘Diastolic stress testing’ is possibly an artificial premise
- Measures of systolic function at least as important
- Potential diagnostic and prognostic benefits in incorporating stress E/e’
- PASP estimates may be at least as instructive and should be attempted in all stress studies

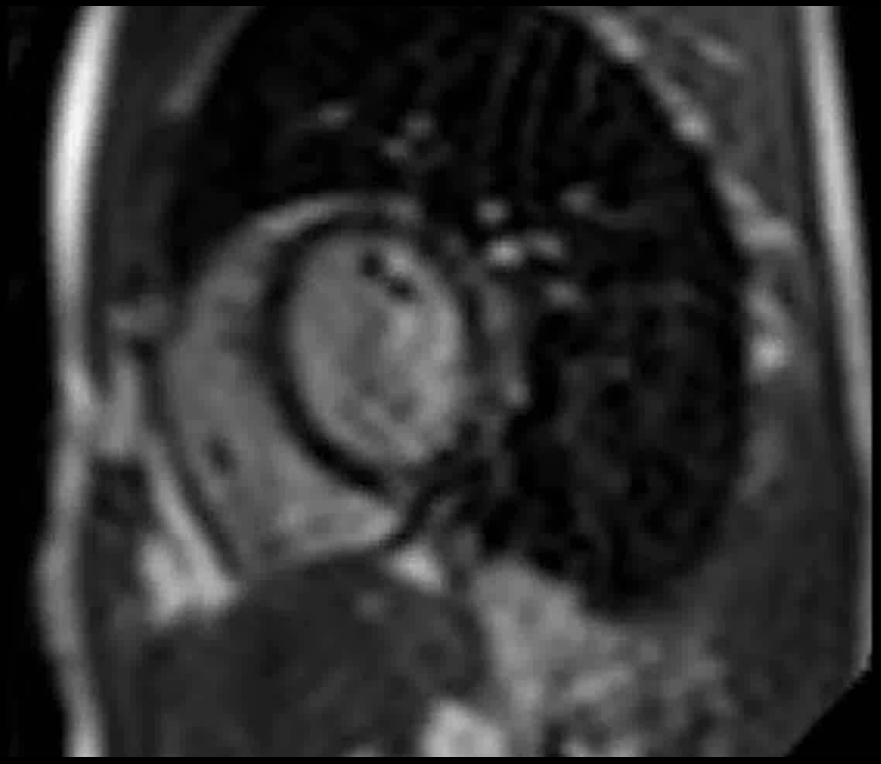
a CMR approach

N = 18 healthy subjects
15 ♂, 3 ♀
Age: 32 ± 8 years

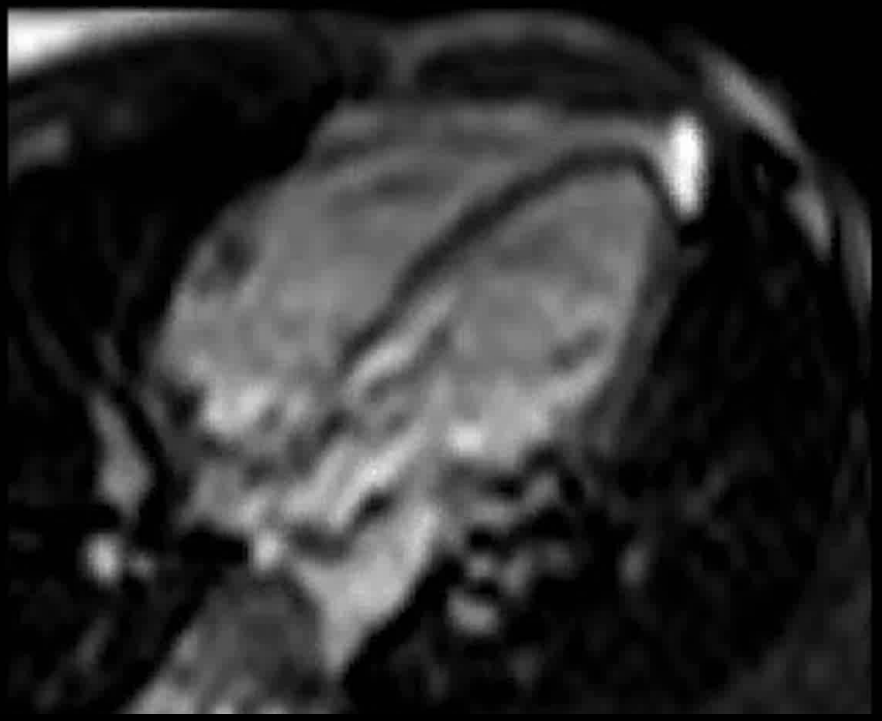
Rest: 65 ± 11 bpm
Moderate exercise: 114 ±16 bpm
Strenuous exercise: 153 ±11 bpm

CMR imaging @ 168 bpm (215W)

Short axis



Horizontal long axis



CMR imaging @ 168 bpm (215W)

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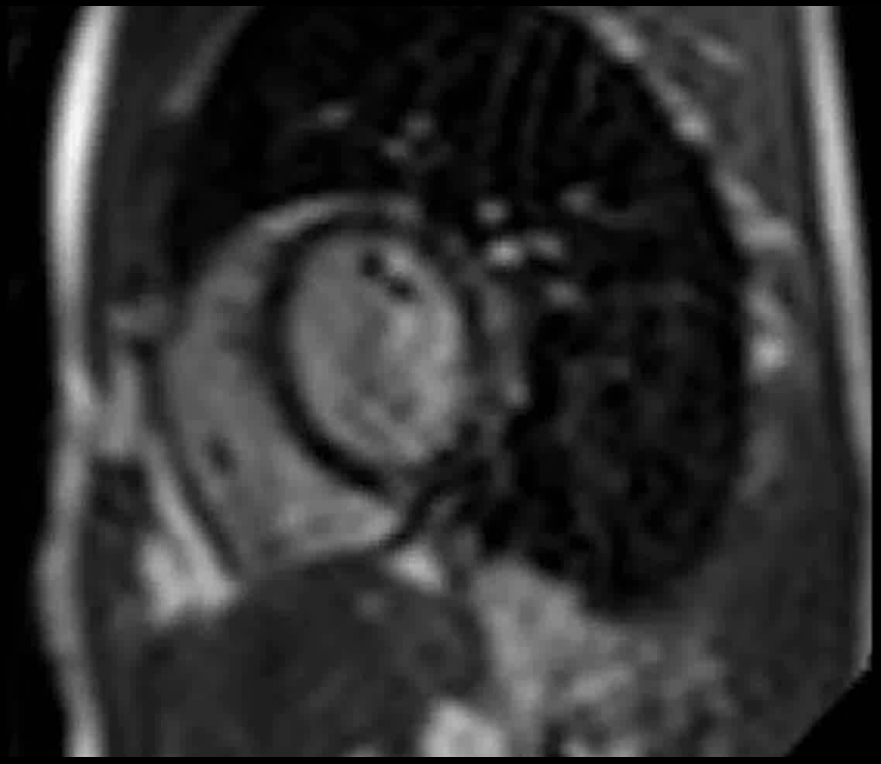

Horizontal long axis