Stress Echo in Pulmonary Hypertension

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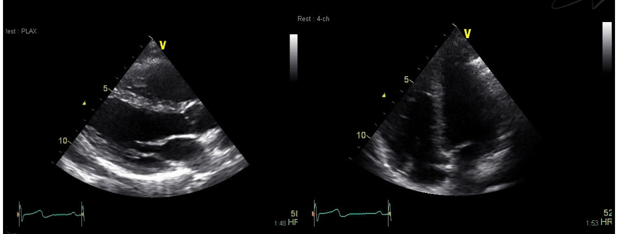
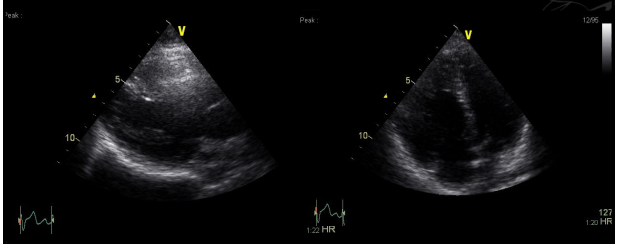
Stress Echo in Pulmonary Hypertension

- Should we do it?
- How should we do it?

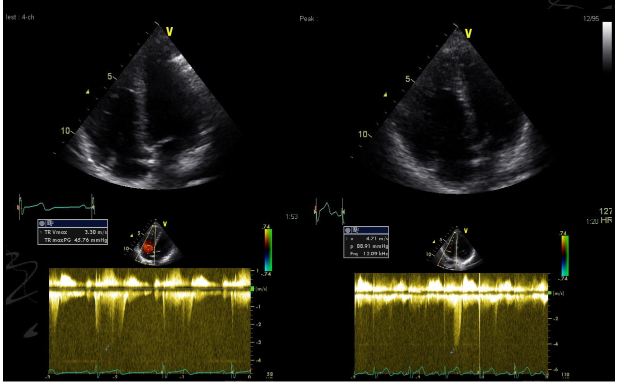
30 Y.O. With Dyspnoea



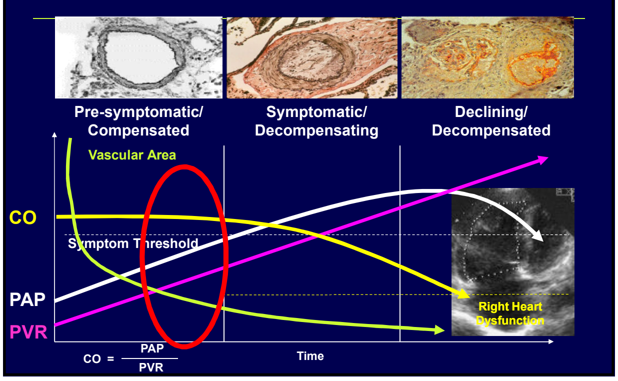
Treadmill Stress



Pre & Post



Pulmonary Arterial Hypertension (PAH)



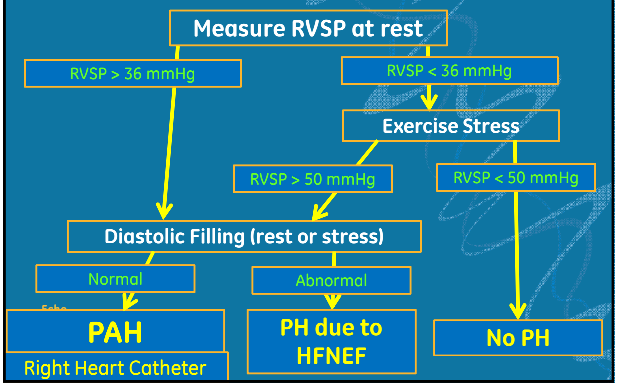
Past Definition of Pulmonary Arterial Hypertension

- Mean PA pressure > 25 mmHg at rest
- Mean PA pressure > 30 mmHg with exercise
- In the presence of a normal PCWP (≤ 15 mmHg)

Why Might Assessment of PA Pressure With Exercise Be Useful?

- Pressure, resistance & flow are intimately related
- As flow increases, resistance must fall or else pressure will rise
- “Stress testing” to increase flow may unmask inability of the pulmonary vasculature to cope with increased flow

Dyspnoea In An Ideal World



Post Dana Point Definition of PAH

- Mean PA pressure > 25 mmHg at rest
- In the presence of a normal PCWP
- Mean PA pressure 20 – 25 uncertain

Why was exercise removed?

Possible Reasons

- Too confusing
- Pressure is the wrong parameter
- Lack of understanding about normal PA pressure responses to exercise
- Difficulty standardising measurement
- No longitudinal data
- All of the above

- “Potential weaknesses of the current definition include the fact that the level, type, and posture of exercise have not been specified. Furthermore, the normal exercise pulmonary arterial pressure (PAP) varies with age”

Badesch et al. *JACC* 2009

Effect of Age on mPAP with Exercise

Age	Slight ULN	Submax ULN
< 30	29 mmHg	33 mmHg
30 – 50	30 mmHg	36 mmHg
> 50	45 mmHg	47 mmHg

Echo Australia 2010

Badesch et al. *JACC* 2009

The Problem In PAH

$$CO = \frac{PAP}{PVR} \Rightarrow PAP - PCWP = PVR \times CO$$

Elevated PAP may be due to

- Elevated PVR (resistance dependent)
- Increased CO (flow dependent)
- Increased PCWP

Echo Australia 2010

Pulmonary vascular resistance is the real problem in PAH

Right Heart Cath - Rest

TPG = 17 mmHg

PVR = 4.1 Wood Units

Right Heart Cath - Exercise

- Straight Leg Raising
- PA pressure rose - 59 / 22 (mean 38) mmHg
- PCWP remained normal – 9 mmHg

Echo Australia 2010

Effect of Age on mPAP with Exercise

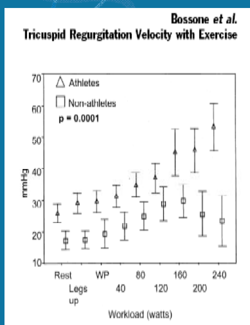
Age	Slight ULN	Submax ULN
< 30	29 mmHg	33 mmHg
30 – 50	30 mmHg	36 mmHg
> 50	45 mmHg	47 mmHg

Echo Australia 2010

Badesch et al. *JACC* 2009

Exercise Induced Pulmonary Hypertension

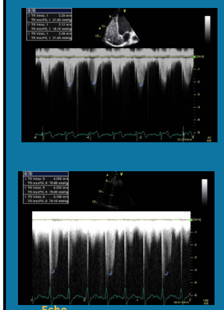
In well trained athletes, exercise results in hypoxia and increases in pulmonary pressures

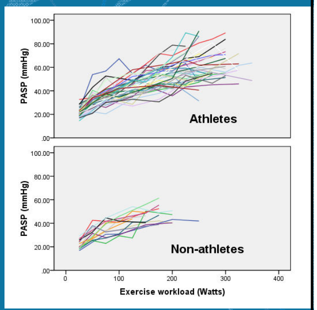


Echo Australia 2010

Bossone et al. *JACC* 1999

Exerecise Haemodynamics In Athletes



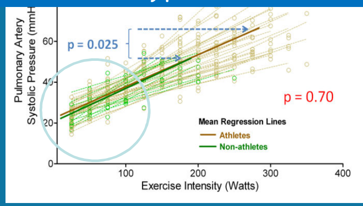


LaGerche et al. *Unpublished*

PA Pressure vs Load

Pulmonary artery pressure

Flow - Dependent Pulmonary Hypertension



LaGerche et al. *J Appl Physiol* 2010 epub

The Problem In PAH

$$CO = \frac{PAP}{PVR} \Rightarrow PVR = \frac{PAP - PCWP}{CO}$$

Elevated PAP may be due to

- elevated PVR (resistance dependent)
- increased CO (flow dependent)

Pulmonary vascular resistance is the real problem in PAH

Case

- 66 Y.O. female
- Limited scleroderma Dxed 2004
- Hyperlipidaemia
- Previous lumbar laminectomy

- Exertional dyspnoea & chest tightness
- Coronary angio (elsewhere) – normal coronaries, but pulmonary pressure not assessed
- CT chest – mild fibrotic change

Case

- Lung function tests
  - Normal spirometry
  - DLCO 73% predicted
- Echocardiogram
  - Normal LV & RV function
  - Estimated RVSP = 30 mmHg

Exercise RHC

- RHC 21/9/07
  - RIJV approach

PCWP - 13 mmHg RA – 4 mmHg

PA – 24 / 12 (18) mmHg

TPG – 5 mmHg C.O. – 5.16 Lt/min

PVR – 1.0 Wood Units

- BNP – 57 pg/ml

Exercise RHC

- Supine Bicycle Exercise to 75W
- Peak HR 101

NO PULMONARY HYPERTENSION WITH EXERCISE

PVR – 1.4 Wood Units

- BNP – 65 pg/ml

Exercise-Induced PAH

Table 1. Demographic and CPET Variables

	Normal (n=16)	Exercised-Induced PAH (n=78)	Resting PAH (n=15)
Age, y	45.9±14.9	58.8±15.1*	58.5±15.7*
Female gender, %	68.8	65.8	46.7
Body mass index	25.5±4.2	30.2±5.3*	28.1±6.2
Work max, W	155.5±43.1	90.3±41.7*	70.0±41.5*
$\dot{V}O_2$max, mL/min	2022±468	1284±58*	1127±507*
$\dot{V}O_2$max, % predicted	91.7±13.7	66.5±16.3*	55.8±20.3*†
$P(A-a)O_2$max, mm Hg	14.7±7.6	32.0±18.0*	52.7±17.3*†
CaO_2, mg/mL	19.0±1.2	18.0±2.5	16.8±3.3
$PaCO_2$max, mm Hg	32.9±4.4	35.1±6.1	37.1±7.6
$\dot{V}CO_2$max, mL/min	2380±722	1561±705*	1310±626*
mPAP rest, mm Hg	13.9±2.9	18.6±3.2*	30.9±8.9*†
mPAPmax, mm Hg	27.4±3.7	36.6±5.7*	48.4±11.1*†
PCWPmax, mm Hg	14.8±4.5	15.0±2.4	15.2±3.1
$Q_t$max, L/min	15.5±3.2	11.4±3.0*	10.4±3.6*
$Q_t$max, % predicted	99.4±11.1	83.1±18.9*	71.8±22.4*†
PVR rest, dyne · s · cm^{-5}	154±61	223±82*	352±141*†
PVRmax, dyne · s · cm^{-5}	62±20	161±60*	294±158*†
RAPmax, mm Hg	9.1±3.5	9.6±3.0	11.0±6.1
RVEFmax	0.58±0.06	0.53±0.08*	0.43±0.11*†
$\dot{V}_E/\dot{V}CO_2$ at anaerobic threshold	36.0±8.9	37.8±8.0	43.1±6.9*

$P(A-a)O_2$ indicates alveolar-arterial difference in partial pressure of O_2; $\dot{V}CO_2$, carbon dioxide production.
*$P<0.05$ vs normal; †$P<0.05$ vs exercised-induced PAH.

Tolle et al. *Circ* 2008

Practicalities of Exercise RHC

- Exercise to fatigue
- Measure C.O. immediately before exercise ceases
- Measure PAP and PCWP immediately after removing load, but with legs still spinning
- Thermodilution cardiac output may be inaccurate with severe TR

Utility of Exercise Right Heart Cath

?Useful to exclude PAH as a cause of symptoms

Demonstration of elevated PCWP with exercise

Can we use exercise to identify PAH?

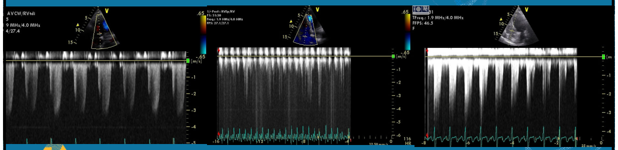
You need to know:

- Amount of exercise
- Pulmonary pressures at that level of exercise
- Perhaps the slope of the CO – PA pressure curve provides information
- More work required for this to be a reliable modality

Can We Use Stress Echo?

The Problems Are Technical

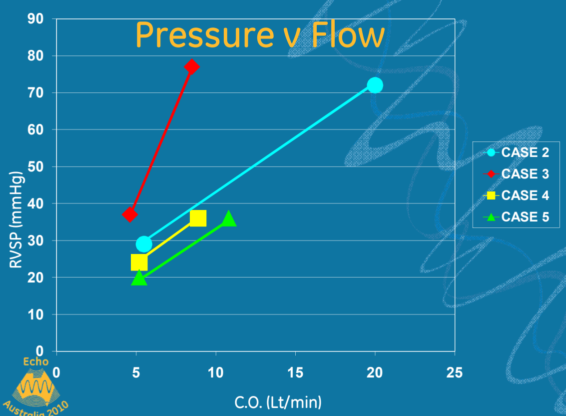
- Treadmill exercise – inability to quickly record TR jet
- Bicycle exercise better
- Inability to accurately record TR jet



Practicalities

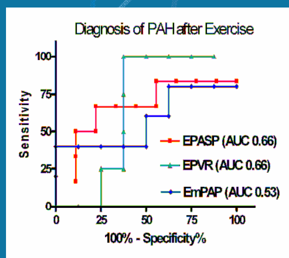
- Need IV access for contrast
- Modify stress echo protocol on machine for additional measures
  - Apical RV view
  - CW of tricuspid regurgitation
  - Mitral inflow
  - E'
  - ?LVOT VTI
- May only need low level stress

Pressure v Flow



Exercise Echo in Scleroderma

- Echo cut-off 40 mmHg
  - 100% sensitivity
  - 16% specificity
- Echo cut-off 55 mmHg
  - 66% sensitivity
  - 77% specificity



Burns et al. *CSANZ* 2009 (abs)

Stress Echo in PAH

- Some theoretical basis
- Exercise needs to be standardised
- Further validation required