Applications of Stress Echocardioraphy

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The clinical Impact of Echocardiography

★**Most Used Cardiac Imaging test**

- 23 million echo studies in US annually
- 2.5 million stress echos

★**Most common use:**

- Assessment of LV functio
- Valvular heart disease
- Haemodynamics

★**Essential in management of all forms of heart disease**

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Stress Echocardiography

Established methodology for:

- Diagnosis of CAD - pretest probability
- Assessing functional significance of coronary stenosis
- Establish magnitude of ischaemia
- Assessing recoverable myocardium
- Assessing patients with valvular heart disease
- Assessing patients prognosis
- Prior to administrating chemotherapy in high risk patients

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Cardio-Oncology

Effects of treatment

Cardiovascular complications - cardio toxicity

- heart failure - myocarditis (chemotherapy)
- valvular heart disease (radiation therapy)
- constrictive pericarditis (radiation therapy)
- early coronary artery disease (radiation therapy)

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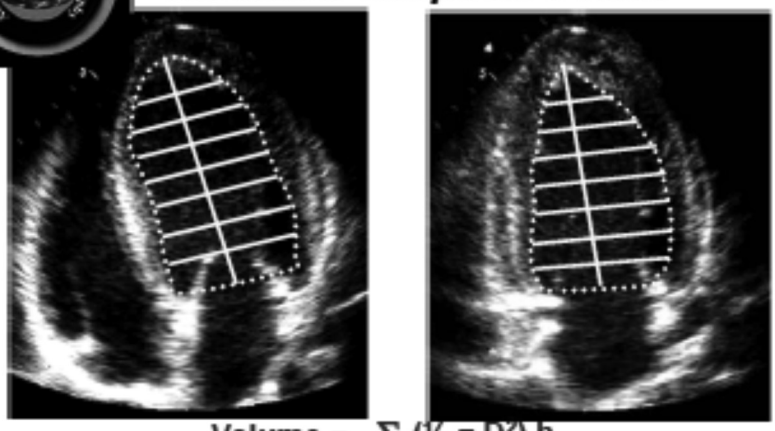
QUANTITATIVE STANDARD

Modified Simpson's Rule



Volume = $\sum (\frac{\pi}{4} D^2) h$

EF = EDV - ESV / EDV

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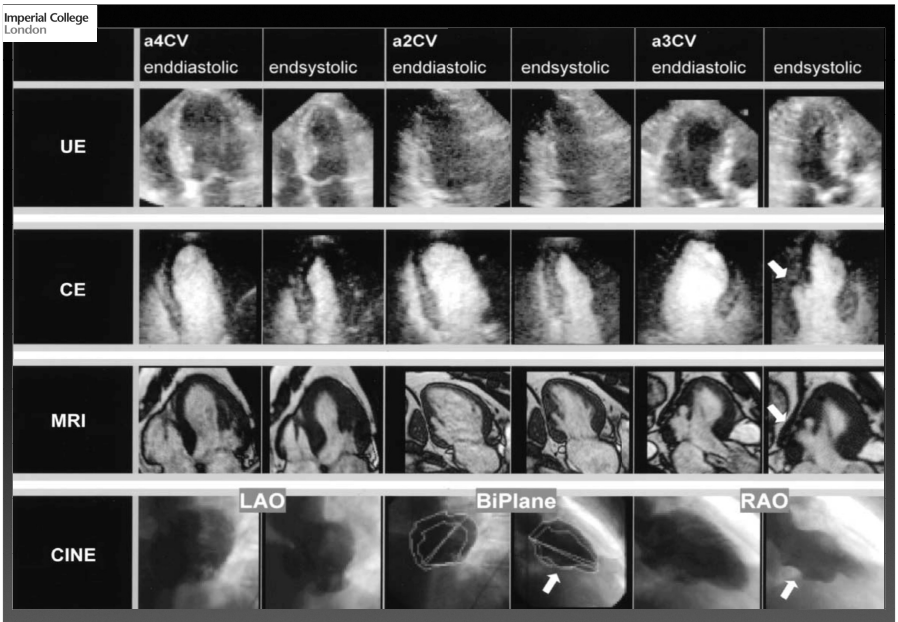

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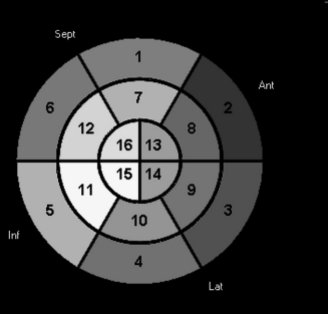
Quantification in 3D



EDV	135.15 ml
ESV	53.09 ml
SV	82.06 ml
EF	60.72 %
SDI16	3.3 %

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Stress Echocardiography

Cardio-Oncology-potential use

- Patients undergoing regiments associated with ischaemia (fluorouracil, bevacizumab, sorafenib, sunitinib)
- Evaluation of subclinical LV dysfunction
- Evaluation of contractile reserve in patients with cardio toxicity (low dose)

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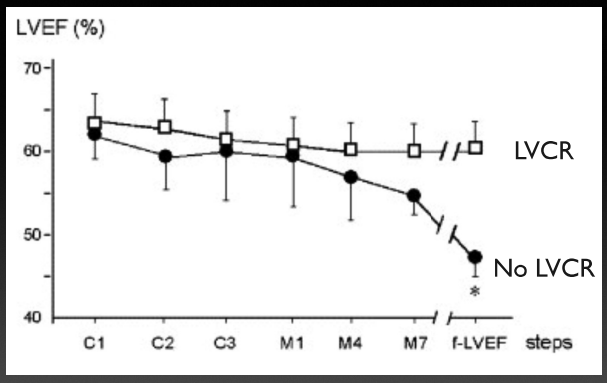
Contractile reserve in patients with cardio toxicity (low dose)



Follow-up

Civelli M et al. Int J Cardiol; 2006:120-126

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Stress Testing and Valve Disease

- Assessing severity of Aortic Stenosis (low gradient severe AS)
- Assessing severity of Mitral regurgitation (functional)
- Assessing myocardial ischaemia in valve disease

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Stress Testing and Valve Disease

Which Test?

- Dobutamine reduces preload and afterload and therefore has a confounding effect on MR
- DSE may be useful in ischaemic MR to evaluate myocardial viability when surgical intervention or CRT
- Exercise echocardiography remains the best stress modality in patients with ischaemic MR to evaluate any dynamic component
- Quantitation of MR should be assessed at rest and at peak exercise Both the Doppler volumetric and PISA methods can be used
- Estimation of the systolic pulmonary pressure at rest and at exercise are important as well as the E:e' ratio at rest and at exercise
- Evaluation of wall-motion and myocardial viability are essential components of the stress

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Exercise echocardiography to be considered

Which patient?

- Patients with LV dysfunction with exertional dyspnoea *out-of-proportion* to the resting dysfunction or MR
- Patients with pulmonary oedema without obvious cause
- For stratifying mortality risk in heart failure patients
- Before surgical revascularisation when moderate MR

Prior to stress testing, a complete echocardiogram should be performed at rest, particularly in patients in whom coronary artery bypass grafting is planned and mitral valve repair/replacement is considered

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Stress Echocardiography in Valvular Heart Disease

Ischaemic mitral regurgitation

- Dynamic MR in acute transient ischaemia
- Chronic functional MR related to LV dysfunction

At rest: regurgitant volume depends on:

- systolic pressure gradient across the orifice
- duration of systole
- ERO dimension

During exercise:

- systolic pressure gradient increases
- duration of systole decreases
- regurgitant volume strictly dependent on the size of ERO

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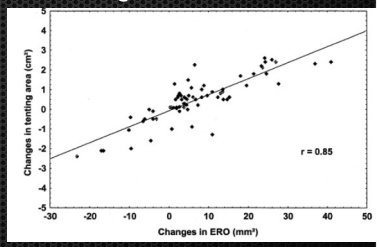
Stress Testing and Valve Disease

Mechanisms of ischaemic MR

- Exercise-induced changes in ERO can occur without evidence of myocardial ischaemia
- Changes in the ERO during exercise unrelated to degree of MR under resting conditions
- Progressive dilation of mitral annulus & tenting area during exercise associated with worsening of MR



- Improved wall thickening in basal segments reduced MR during exercise by decreasing mitral annular distortion and tethering forces

Lancellotti P, Lebrun F, MD, Pierard L. JACC 2003;42:1921

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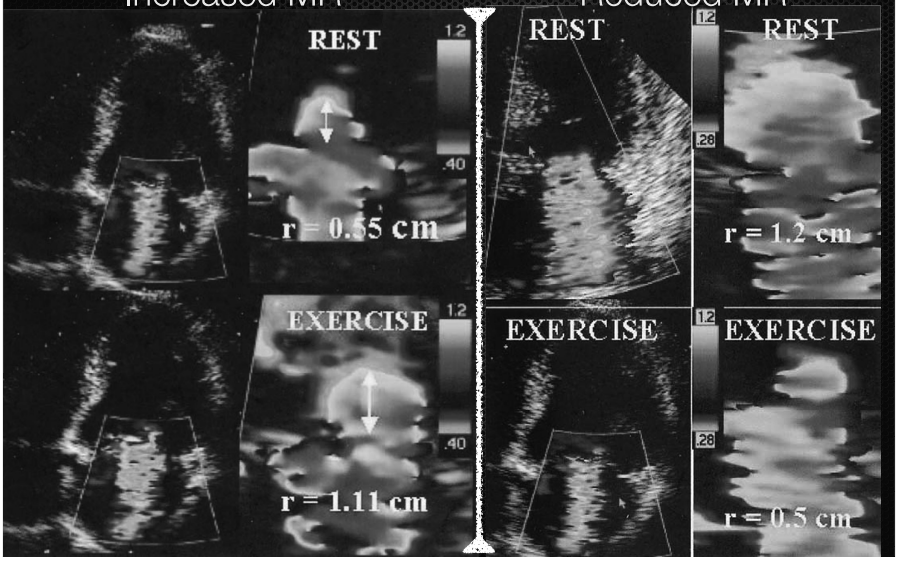
Mechanisms of ischaemic MR

Increased MR | Reduced MR



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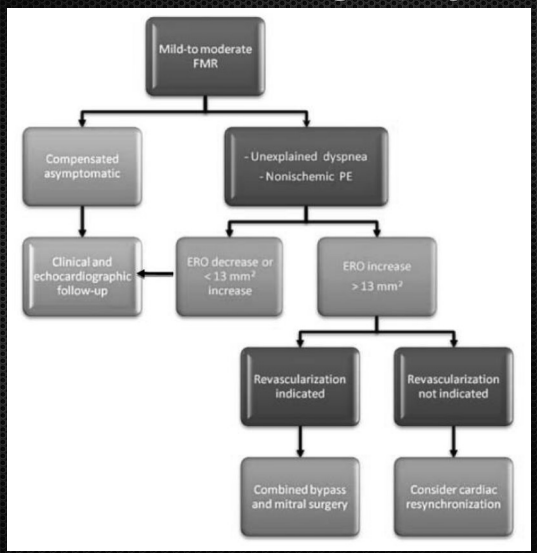
Algorithm of clinical use of exercise echocardiography in FMR



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Stress Testing and Valve Disease

One stop shop!

- ★ Assess anatomy
- ★ Assess valve function in real-time
- ★ Assess reversible ischaemia
- ★ Assess perfusion in real-time
- ★ Fast! 1h with the report!
- ★ No post-processing fiddling!
- ★ High success rate!
- ★ Best for F/U
- ★ Best outcome data!
- ★ Cost-effective!

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Diastolic Stress Echocardiography

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Indications

Symptoms:

- Breathlessness on exertion
- exhaustion
- poor exercise tolerance

In patients with:

- Preserved EF
- Mild or without diastolic dysfunction
- Normal LV filling pressures

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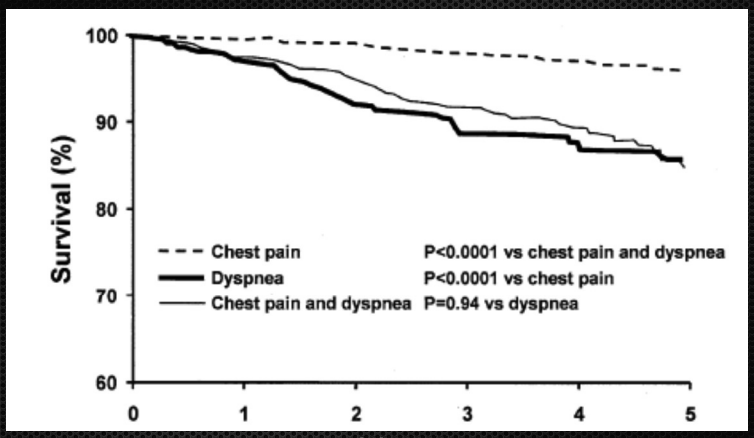
Outcome of patients referred for the evaluation of dyspnea



Bergeron et al. JACC 2004;43:2242-6

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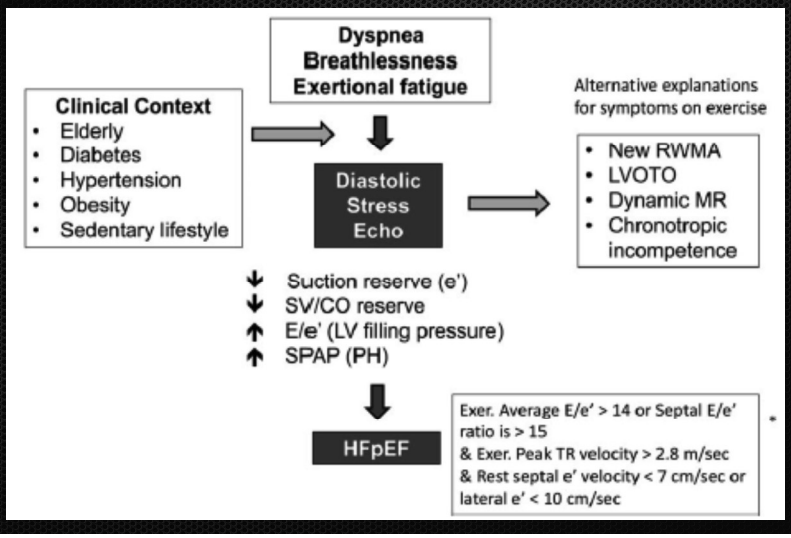
Diastolic SE performed for the assessment of dyspnoea or exertion fatigue



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The ESC algorithm for diagnosis of HFpEF

Symptoms and signs for HF
and
EF≥50%

↓

NT-ProBNP ≥125 pg/ml
or
BNP≥35 pg/ml

No ↓ Yes

LA volume index >34ml/m2
or
LVMI≥115 g/m2(m); ≥95 g/m2 (f)
or
Av. E/e'≥13 and Av. e'<9 cm/sec

No ↓ Yes

No HF | HFpEF

The ASE/EACVI guidelines for assessment of Diastolic Dysfunction

1.Av. E/e'>14
2.Medial e' <7cm/s or lateral e'<10 cm/s
3.TR velocity >2.8 m/s
LA volume index >34 ml/m2

<50% positive	50% positive	>50% positive
↓	↓	↓
Normal	Indeterminate	Diastolic Dysfunction

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Diastolic Stress Echo

At baseline
At each stage
At peak
At recovery

1.MV inflow velocities
2.Mitral annular TDI
3.TR velocity before-after
4.E/e' before-after

At baseline
At recovery

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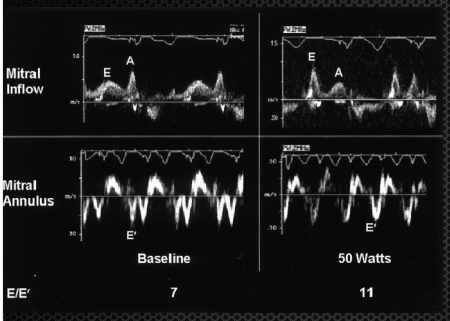
What de we expect?



Normal	Abnormal
E ↑	E ↑↑
e' ↑	e' ↔
E/e' ↔ ↓	E/e' ↑

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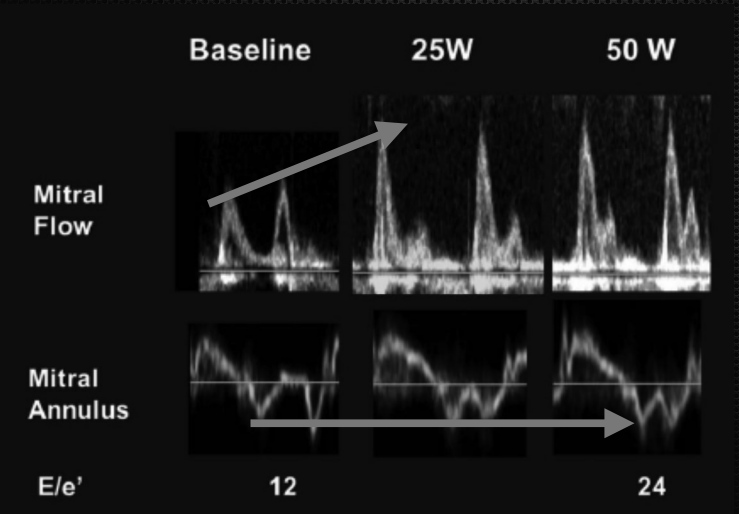
71 year old M with exertion SOB



Mitral flow and annular velocity at rest and during supine exercise

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Interpretation

Positive

- Peak average E/e' >14
  or
  Peak septal E/e' >15
- Peak TR >2.8 m/s
- Baseline sept e' <7 cm/s
  or
  Baseline lat e; <10 cm/s

Negative

- Peak average E/e' <10
  or
  Peak septal E/e' <10
- Peak TR <2.8 m/s

Indeterminate

- Peak average E/e' 10-14
  or
  Peak septal E/e' 10-15

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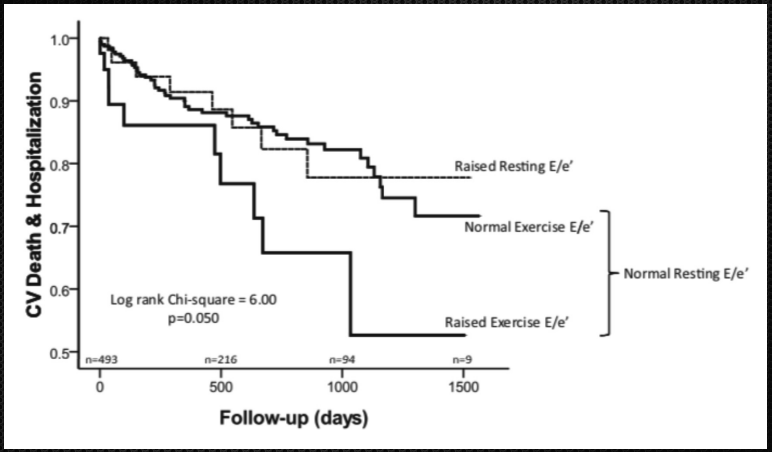
Survival



Holland et al. Circ Cardiovasc Imaging. 2010;3:149-156

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Hypertrophic Cardiomyopathy

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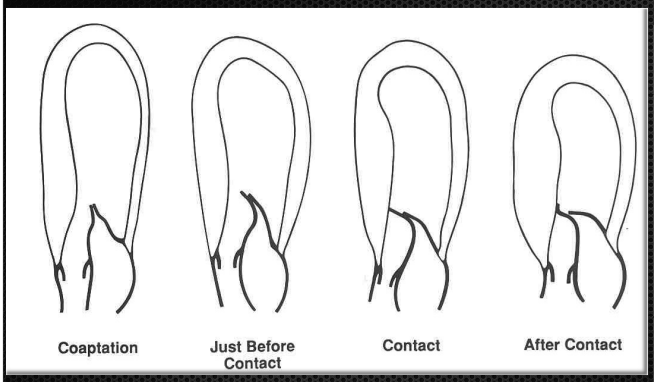
LV Outflow Tract Obstruction



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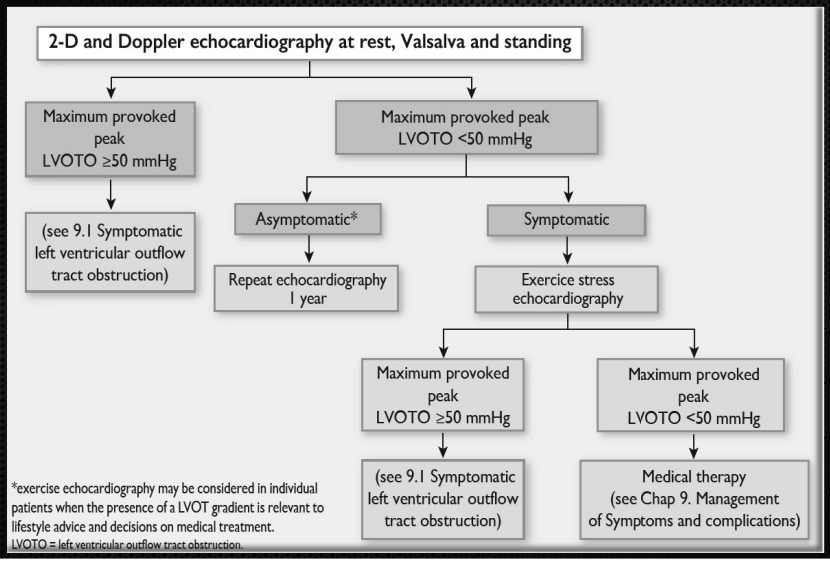
Echocardiography: LV Outflow Tract Obstruction

- *Systematically exclude obstruction unrelated to SAM, including sub-aortic membranes, mitral valve leaflet abnormalities and mid-cavity obstruction.*
- *The presence of a central or anteriorly directed jet of mitral regurgitation should raise suspicion of an intrinsic mitral valve abnormality and prompt further assessment.*

Protocol for the assessment and treatment of left ventricular outflow tract obstruction



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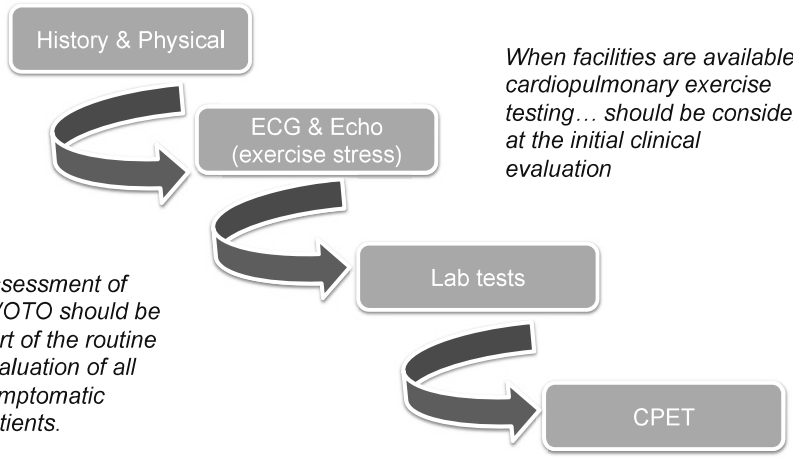
Investigation of Heart Failure Symptoms



When facilities are available, cardiopulmonary exercise testing… should be considered at the initial clinical evaluation

Assessment of LVOTO should be part of the routine evaluation of all symptomatic patients.

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Patients with heart failure and preserved LV ejection fraction (≥50%)

Recommendations	Class	Level
In patients in NYHA functional Class II–IV with an LVEF ≥50% and no evidence for resting or provocable LVOTO, ß-blockers, verapamil or diltiazem should be considered, to improve heart failure symptoms.	IIa	C
Low-dose loop and thiazide diuretics should be considered in patients in NYHA functional Class II–IV with an EF ≥50%, and no evidence for resting or provocable LVOTO, to improve heart failure symptoms.	IIa	C

www.escardio.org/guidelines European Heart Journal (2014);35:2733–2779 - doi:10.1093/eurheartj/ehu284

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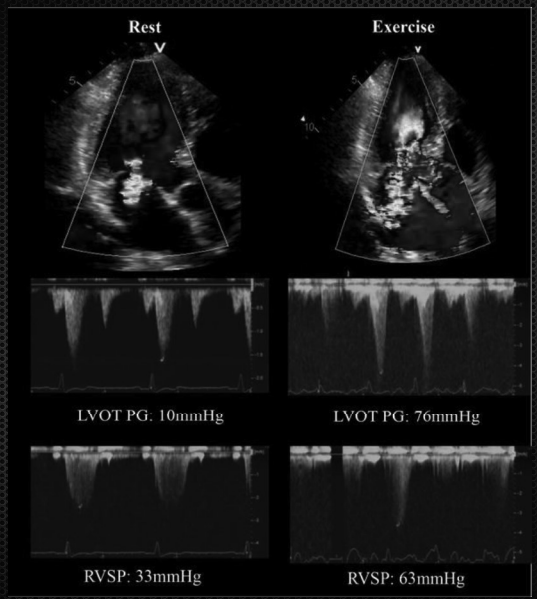
Exercise-induced LVO abstraction



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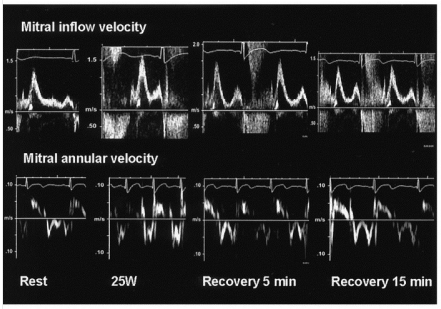
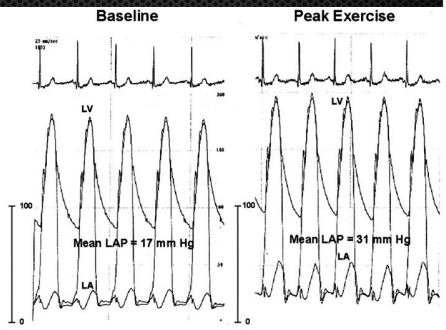
68 yo HCM patient and exertion dyspnoea



A



B

During exercise:
Increased early E wave
shortened DT
Increased LA pressure

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Pulmonary Hypertension

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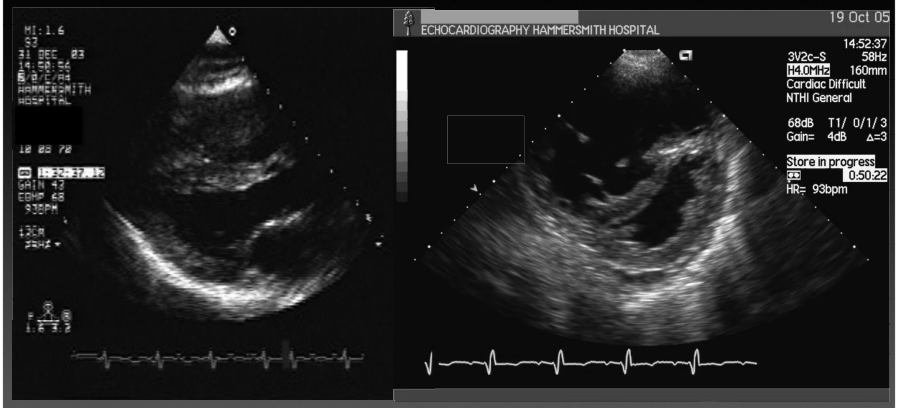
Pulmonary Hypertension



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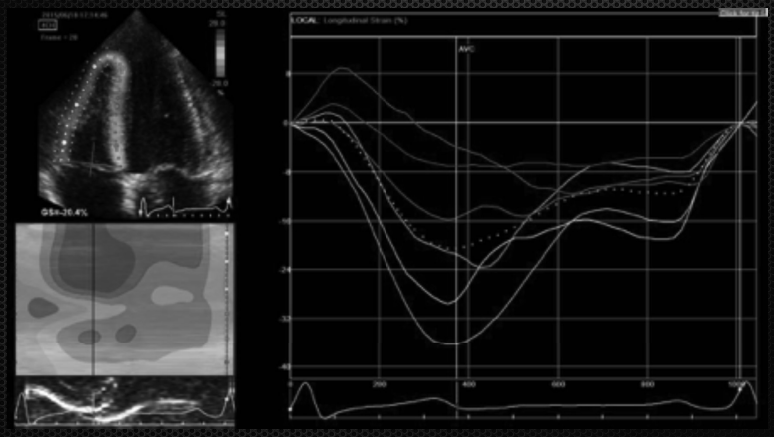
RV function & Prognosis in Pulmonary Hypertension



*Rehman BM et al European Heart Journal - Cardiovascular Imaging (2017) **0**, 1–8*

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Resting right ventricular function is associated with exercise performance in PAH, but not in CTEPH

Michaela Beatrice Rehman[1,2]*, Luke S. Howard[3], Luc P. Christiaens[2], Dipender Gill[3], J Simon R. Gibbs[3], and Petros Nihoyannopoulos[1]

N=88, PAH 46, CTEPH 42

pre-capillary

RV function by GLS and FAC

TR, S', TAPSE, AT, RA, MPI, EI

CPET

Cycle ergometer

Symptom limited

VO_2, VE/VCO_2

*Rehman BM et al European Heart Journal - Cardiovascular Imaging (2017) **0**, 1–8*

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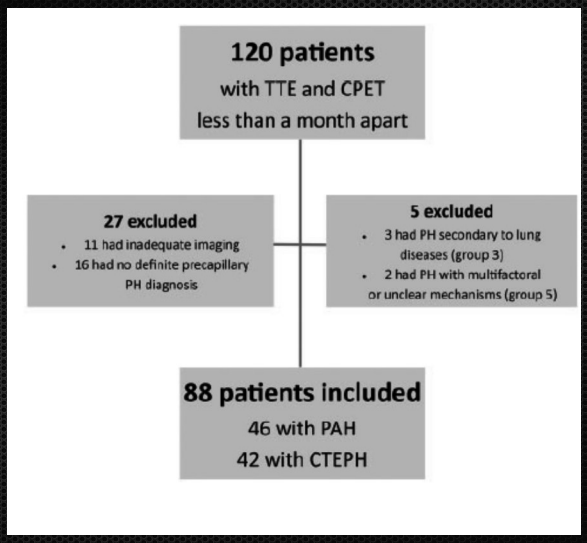

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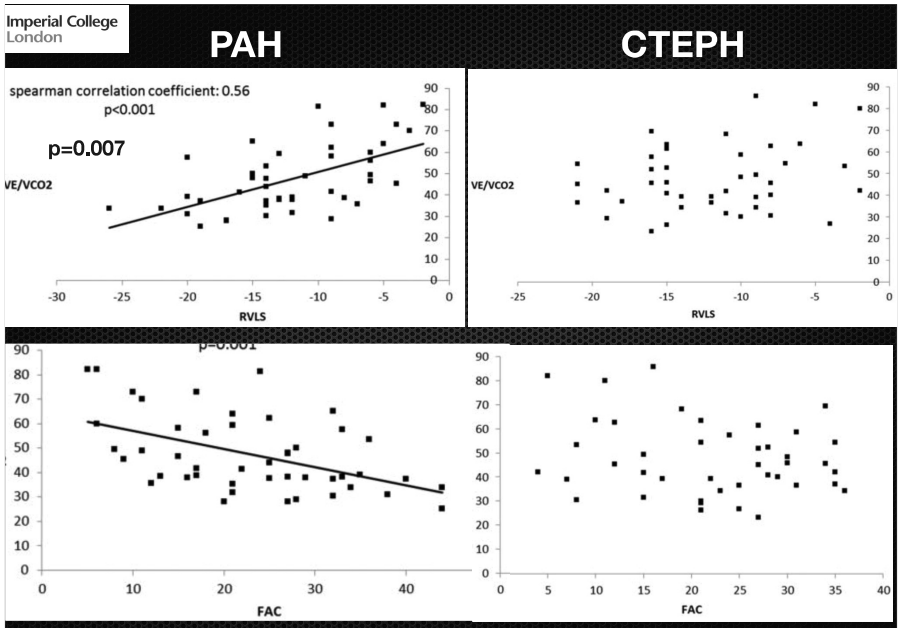

*Rehman BM et al European Heart Journal - Cardiovascular Imaging (2017) **0**, 1–8*

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Applications of Stress Echocardioraphy

Summary

- Cost-effective
- Widely available
- Chose most appropriate protocol
- Standardised protocols
- In valvular heart disease when discrepancy occur
- Diastolic stress echocardiography
- Use with CTPX when possible
- Training

谢谢！

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