Τι πρέπει να γνωρίζει ο πνευμονολόγος για την καρδιοπνευμονική δοκιμασία άσκησης;

Μπούτου Αφροδίτη
MD, MSc, PhD

Πνευμονολόγος, Επιμελήτρια Β’, Πνευμονολογική Κλινική ΕΣΥ, ΓΝ «Γ. Παπανικολάου», Θεσσαλονίκη

No conflict of interest to declare

Καρδιοπνευμονική δοκιμασία άσκησης (CPET)

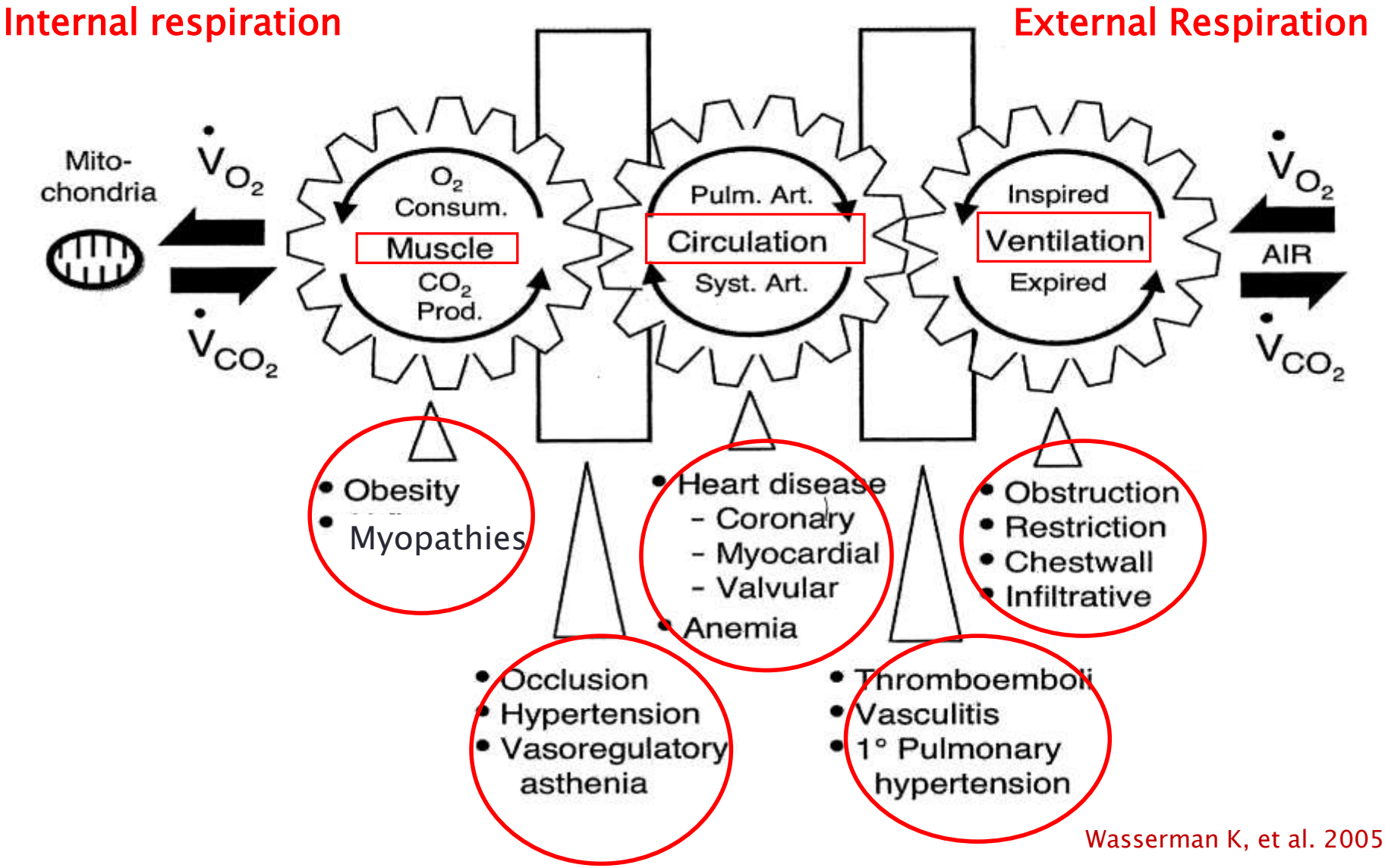
Wasserman et al., 2005

"Η CPET αποτελεί την δοκιμασία άσκησης που δίνει την δυνατότητα της ταυτόχρονης εκτίμησης της ***κυτταρικής, αναπνευστικης, καρδιαγγειακής, αιμοποιητικής, νευροψυχιατρικής και μυοσκελετικής*** απάντησης σε καθορισμένο βαθμό άσκησης, δηλαδή σε καθορισμένο βαθμό μεταβολικού stress."

ERS Task Force 2007

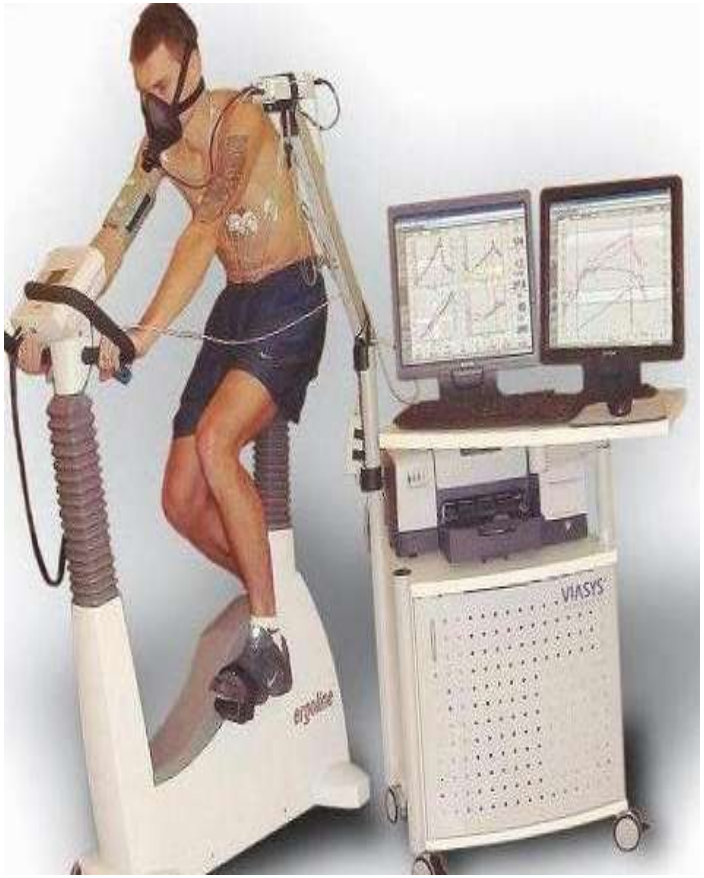
"Cardiopulmonary exercise testing (CPET) should be considered the ***gold standard*** for evaluating the ***causes of exercise intolerance*** in patients with ***pulmonary and cardiac*** **disease**, and is based on the principle that ***system failure*** typically ***occurs*** while the system (e.g. muscle–energetic, cardiovascular or pulmonary) is ***under stress***."

Φυσιολογία της άσκησης



Wasserman K, et al. 2005

CPET: Καταγραφή παραμέτρων



Κυλιόμενος Τάπητας ή Κυκλοεργόμετρο

1. Έργο άσκησης σε Watt

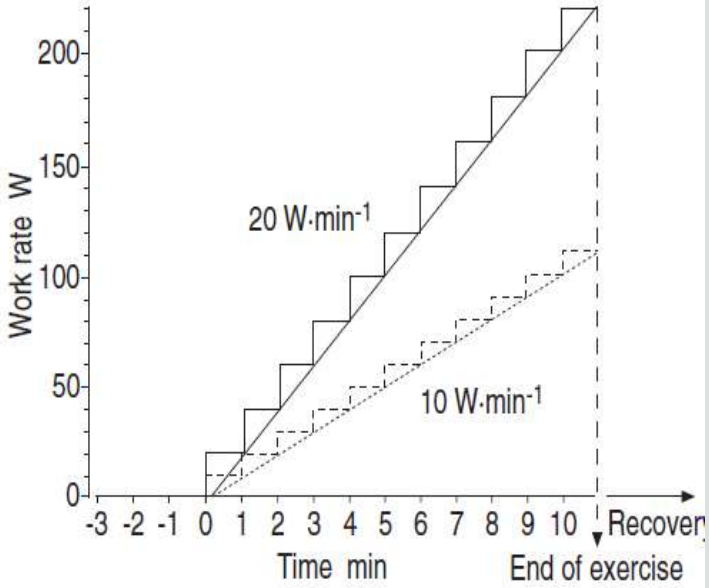
Αναπνευστικό Monitoring

1. Αναλυτής αερίων
   - εκπνεόμενο και εισπνεόμενο O2 και CO2.
2. Οξύμετρο
   - SpO2
3. Αρτηριακή γραμμή
   - SaO2, PaO2, PaCO2, pH, HCO_3^-, P(A–a)O2,Hb, γαλακτικό.
4. Κλίμακα Borg
   - δύσπνοια
5. Σπιρόμετρο
   - V_E, V_T, fr, καμπύλη ροής-όγκου, εισπνευστική χωρητικότητα, δυναμική υπερδιάταση.

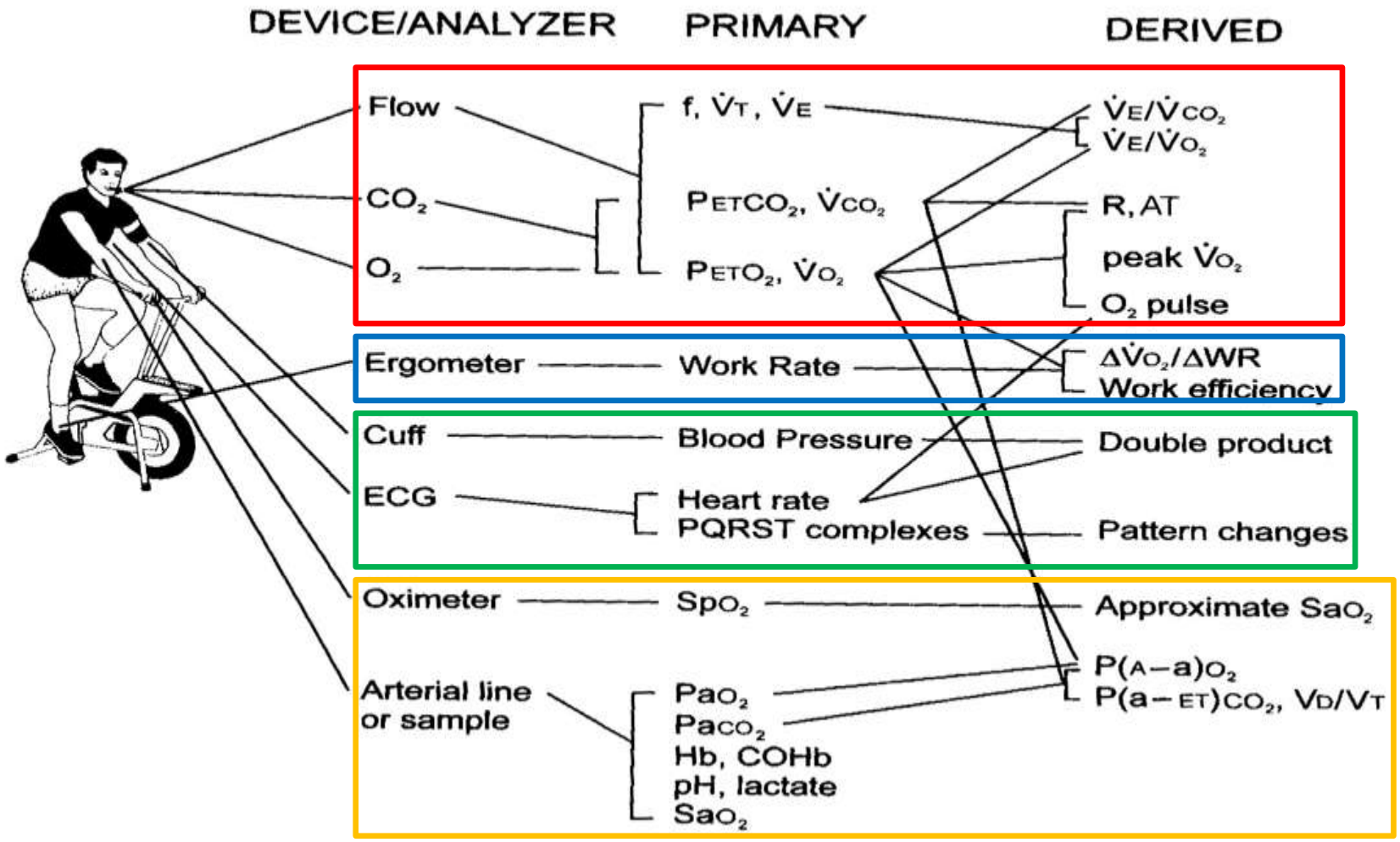
Καρδιαγγειακό Monitoring

1. ΗΚΓ
2. Αρτηριακή πίεση
3. Καρδιακή συχνότητα

Πρωτόκολλα CPET

Test Category	Protocol	Equipment
Incremental CPET (ICPET)		-cycle ergometer -treadmill
Endurance CPET (ECPET)	Moderate (60%) or high intensity (75-80%)	-cycle ergometer -treadmill

Μετρούμενες και υπολογιζόμενες παράμετροι σε CPET



Μεταβλητές CPET και φυσιολογικές λειτουργίες I

Μέτρηση	Φ. λειτουργία
VO_2	Παράγωγο καρδιακής παροχής (CO X $C(a\text{-}v)O_2$)
Peak VO_2	Μέγιστη VO_2 κατά τη μέγιστη προσπάθεια
AT	Η υψηλότερη VO_2 που μπορεί να επιτευχθεί χωρίς γαλακτική οξέωση
$\Delta VO_2/\Delta WR$	Δείκτης σύζευξης εσωτερικής με εξωτερική αναπνοή
VO_2/HR (O_2 pulse)	Παράγωγο όγκου παλμού (SV X $C(a\text{-}v)O_2$)
Heart Rate Reserve (HRR)	Διαφορά μεταξύ μετρούμενου και προβλεπόμενου καρδιακού ρυθμού στην peak VO_2 (εφεδρεία καρδιακού ρυθμού)
VE = VA+VD	Συνολικός αερισμός (VE= Vt X RR)
VR= MVV-Peak VE	Επιπλέον διαθέσιμος αερισμός στο τέλος της άσκησης (εφεδρεία αερισμού)
VE/VCO_2	Δείκτης Ventilatory efficiency (λίτρα του αερισμού που απαιτούνται για απομάκρυνση 1lit CO_2)
$PETCO_2$	Δείκτης Ventilatory efficiency (συχέτιση με Vt, RR, Vd/Vt, VCO_2, $PACO_2$ και $PaCO_2$)
$PETO_2$	Ακολουθεί τις τιμές του PaO_2 (δε συμπίπτει απόλυτα)

Μεταβλητές CPET και φυσιολογικές λειτουργίες II

Variables Reflecting Cardiovascular Function	Variables Reflecting Ventilatory Function	Variables Reflecting Pulmonary Gas Exchange Efficiency
Peak VO2	VE	VE/VCO2
AT	Vt	PETCO2
ΔVO2/ΔWR	RR	PETO2
VO2/HR	Ventilatory Reserve	SpO2
ECG	IC, ERV	PaO2
HRR	Pre and Post spirometry	PAO2-PaO2
Blood Pressure		

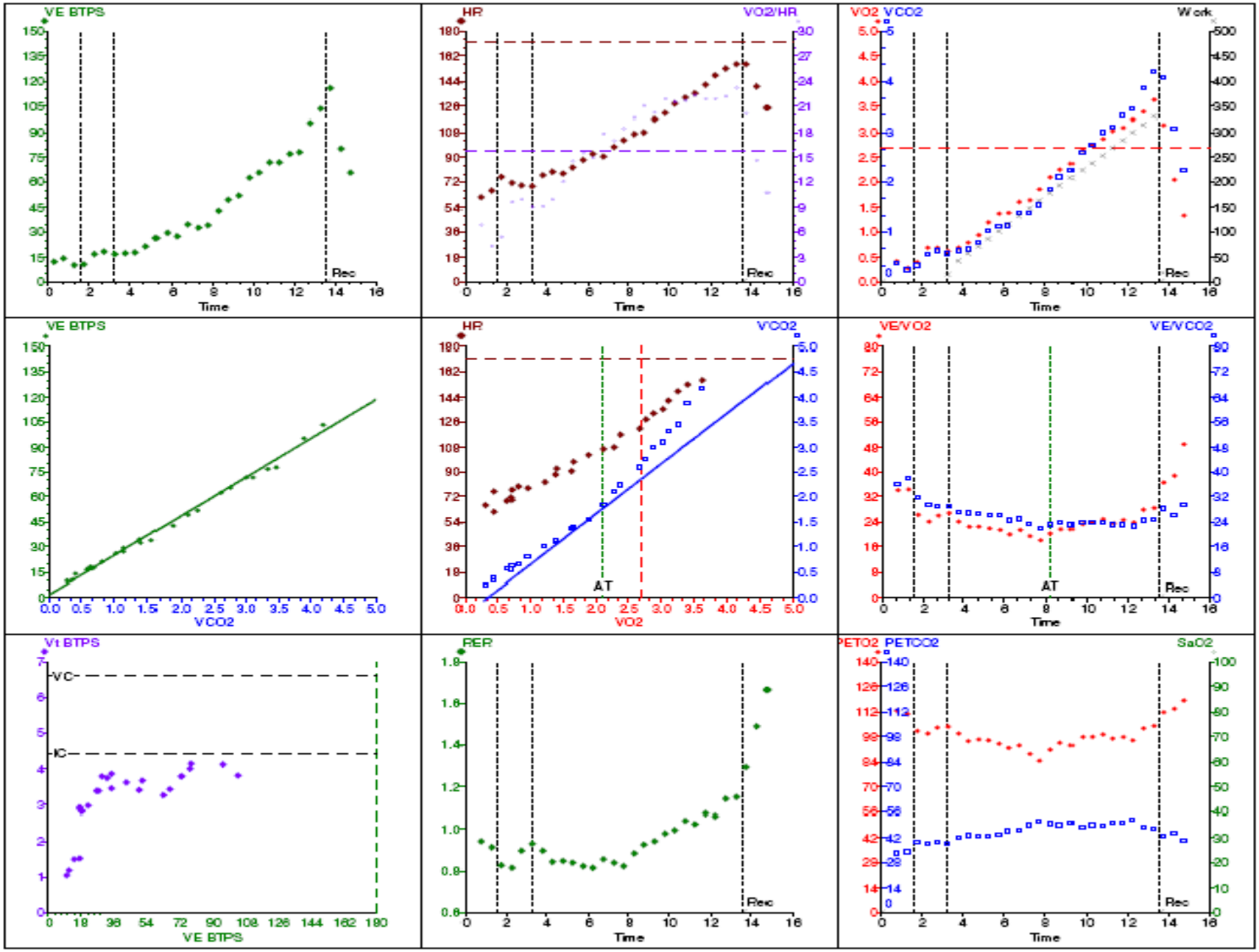
Arena and Sietsema. Circulation, 2011

Μεταβλητές CPET: φυσιολογικές τιμές

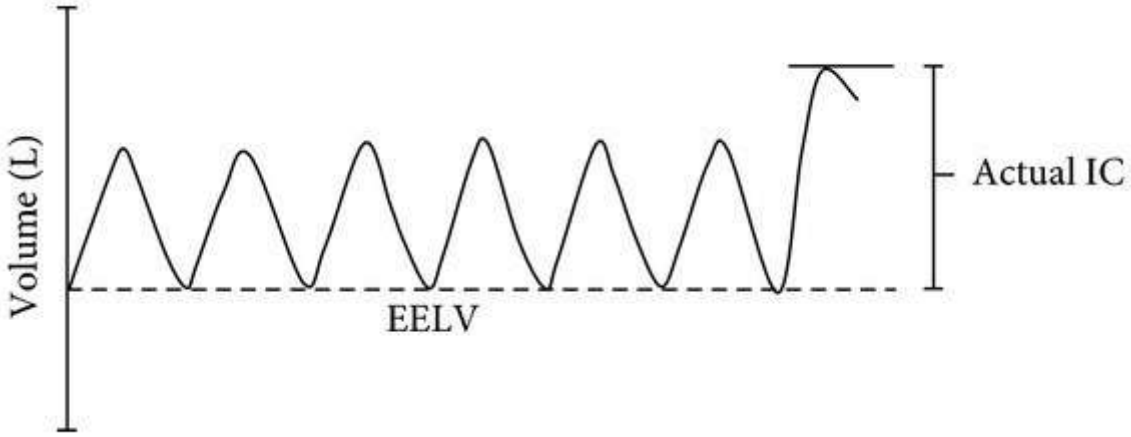
Variables	Criteria of Normality
$\dot{V}O_2$max or $\dot{V}O_2$peak	> 84% predicted
Anaerobic threshold	> 40% $\dot{V}O_2$max predicted; wide range of normal (40–80%)
Heart rate (HR)	HRmax > 90% age predicted
Heart rate reserve (HRR)	HRR < 15 beats/min
Blood pressure	< 220/90
O_2 pulse ($\dot{V}O_2$/HR)	> 80%
Ventilatory reserve (VR)	MVV − $\dot{V}E$max: > 11 L or $\dot{V}E$max/MVV × 100: < 85%. Wide normal range: 72 ± 15%
Respiratory frequency (fR)	< 60 breaths/min
$\dot{V}E/\dot{V}CO_2$ (at AT)	< 34
V_D/V_T	< 0.28; < 0.30 for age > 40 years
Pa_{O_2}	> 80 mm Hg
$P(A-a)O_2$	< 35 mm Hg

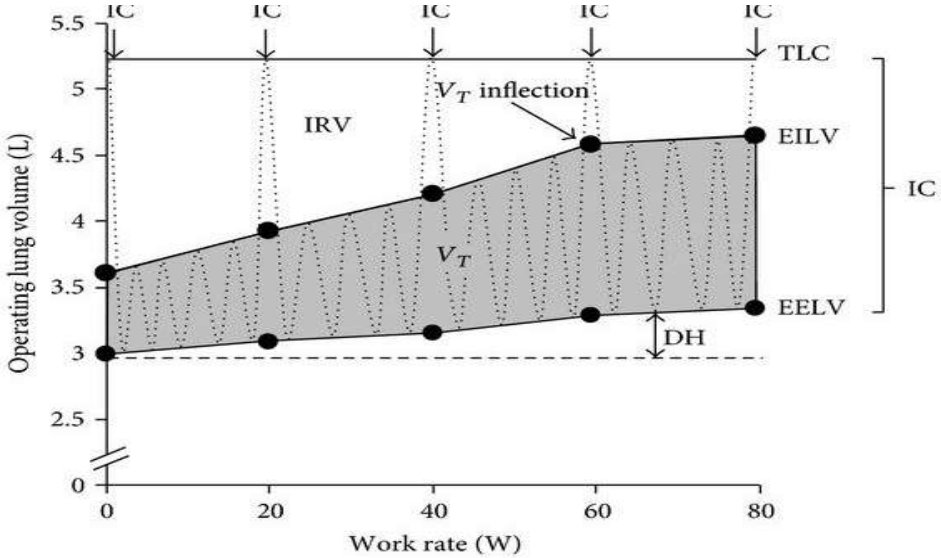
ATS/ACCP statement. Am J Respir Crit Care Med 2003

Wasserman 9-panel plot



CPET και δυναμική υπερδιάταση





(b)

Εργοσπιρομετρία: Ενδείξεις

Evaluation of exercise tolerance
- Determination of functional impairment or capacity (peak $\dot{V}O_2$)
- Determination of exercise-limiting factors and pathophysiologic mechanisms

Evaluation of undiagnosed exercise intolerance
- Assessing contribution of cardiac and pulmonary etiology in coexisting disease
- Symptoms disproportionate to resting pulmonary and cardiac tests
- Unexplained dyspnea when initial cardiopulmonary testing is nondiagnostic

Evaluation of patients with cardiovascular disease
- Functional evaluation and prognosis in patients with heart failure
- Selection for cardiac transplantation
- Exercise prescription and monitoring response to exercise training for cardiac rehabilitation (special circumstances; i.e., pacemakers)

Evaluation of patients with respiratory disease
- Functional impairment assessment (see specific clinical applications)
- Chronic obstructive pulmonary disease
  - Establishing exercise limitation(s) and assessing other potential contributing factors, especially occult heart disease (ischemia)
  - Determination of magnitude of hypoxemia and for O_2 prescription
  - When objective determination of therapeutic intervention is necessary and not adequately addressed by standard pulmonary function testing
- Interstitial lung diseases
  - Detection of early (occult) gas exchange abnormalities
  - Overall assessment/monitoring of pulmonary gas exchange
  - Determination of magnitude of hypoxemia and for O_2 prescription
  - Determination of potential exercise-limiting factors
  - Documentation of therapeutic response to potentially toxic therapy
- Pulmonary vascular disease (careful risk–benefit analysis required)
- Cystic fibrosis
- Exercise-induced bronchospasm

Specific clinical applications
- Preoperative evaluation
  - Lung resectional surgery
  - Elderly patients undergoing major abdominal surgery
  - Lung volume resectional surgery for emphysema (currently investigational)
- Exercise evaluation and prescription for pulmonary rehabilitation
- Evaluation for impairment–disability
- Evaluation for lung, heart–lung transplantation

ATS/ACCP statement 2003

Εφαρμογή CPET στην καθ' ημέρα πράξη

1) Διάγνωση της **δύσπνοιας** ή/και της μειωμένης ικανότητας για κόπωση και των υπεύθυνων **μηχανισμών** της

-συμβολή συννοσηρότητας

-δυσπνοια που δεν εξηγείται επαρκώς με εξετάσεις ηρεμίας

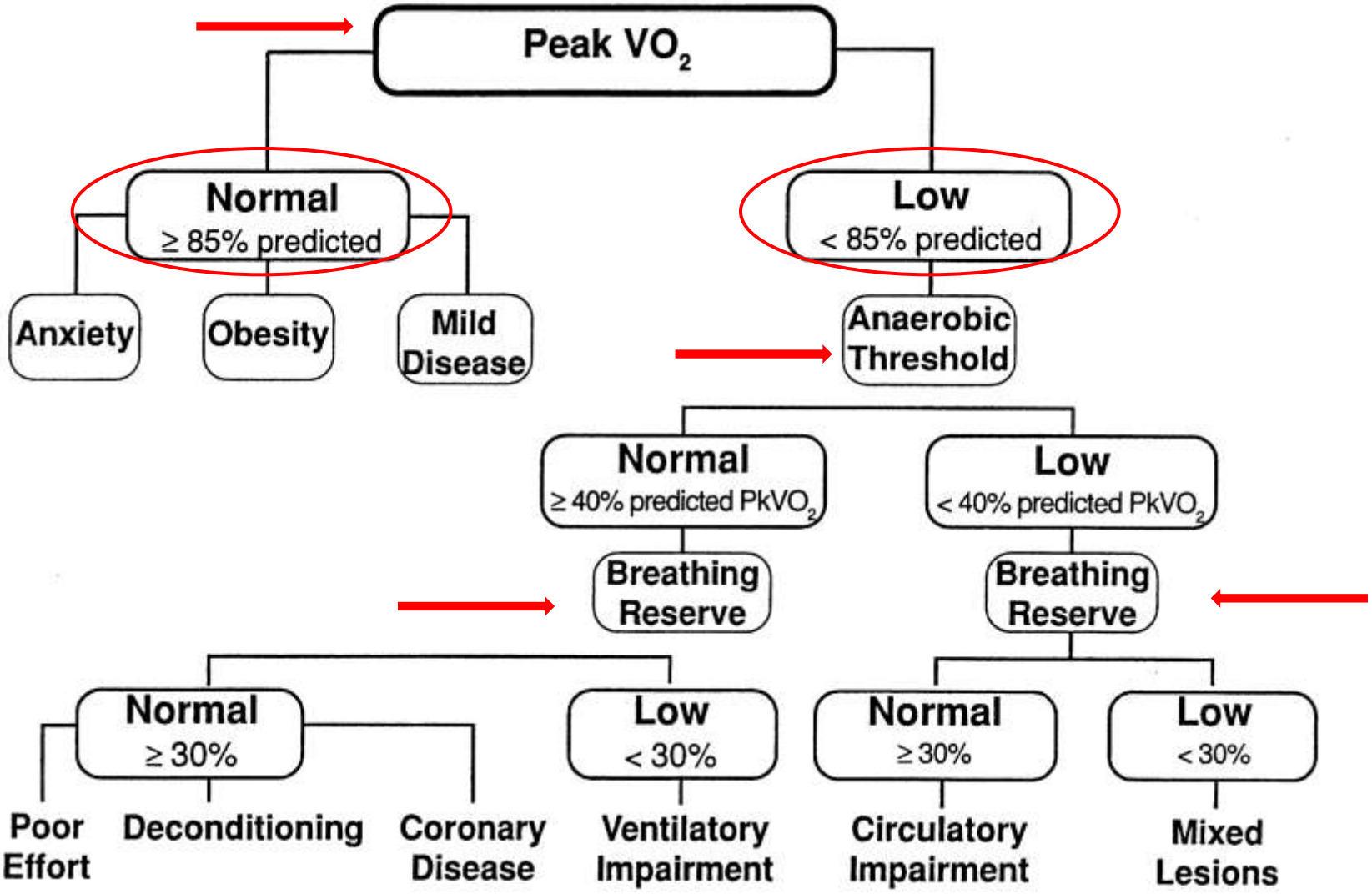
-δύσπνοια αγνώστου αιτιολογίας

2) Λειτουργική και **προγνωστική** εκτίμηση του ασθενή με γνωστή διαταραχή

3) Εκτίμηση της **εξέλιξης** της νόσου και της **ανταπόκρισης** στη θεραπεία

Ferrazza et al. Respiration 2009

Αδρή διαφορική διάγνωση δύσπνοιας στην κόπωση

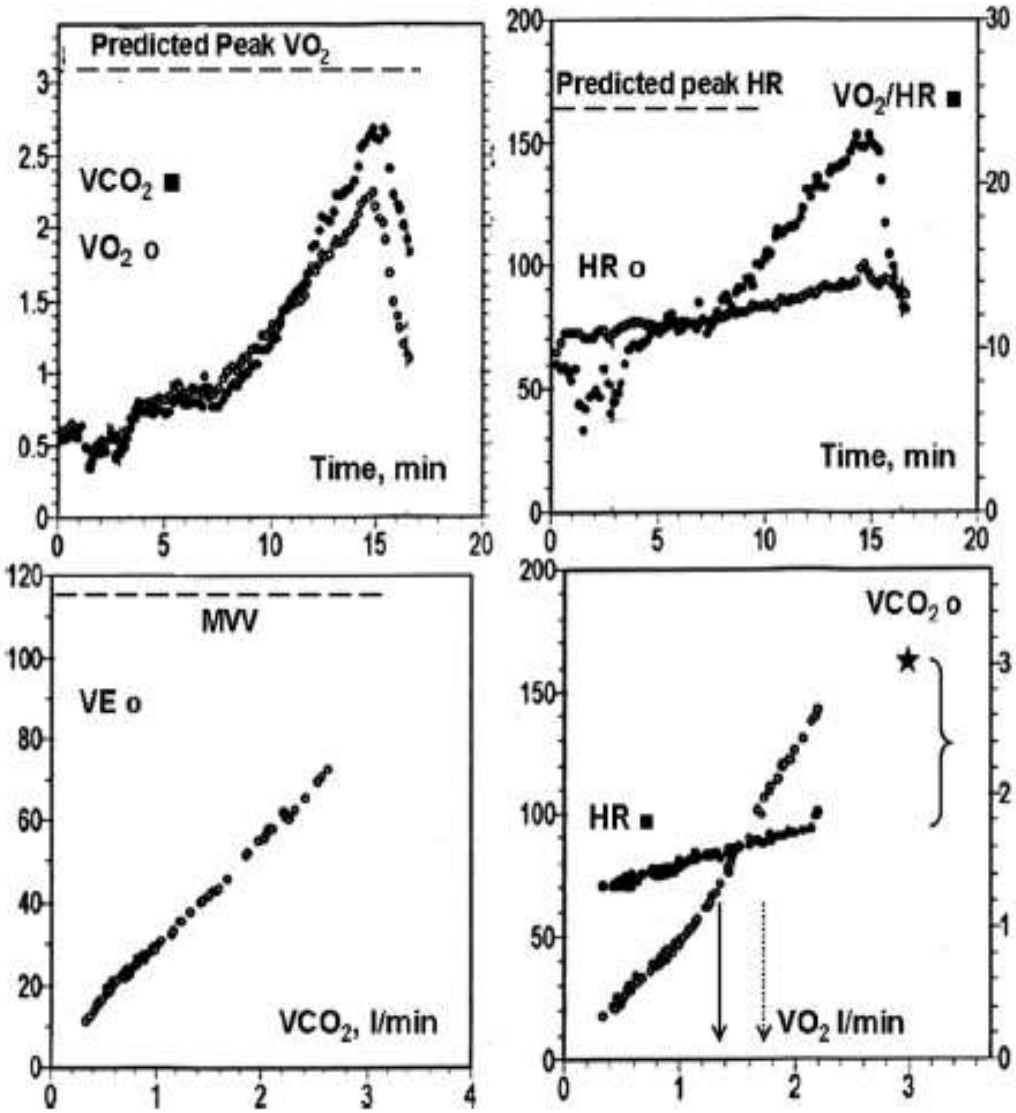


(Look at RER)

(mild)

Milani, R.V. et al. Circulation 2004;110:e27-e31

Περιστατικό 1ο



Ασθενής 55 ετών με:
- ΧΑΠ Σταδίου Ι (FEV1=83%),
- ΣΔ τύπου 2 υπό δισκία,
- ΑΥ υπό αγωγή και
- παχυσαρκία (BMI=31,1 kg/m2),

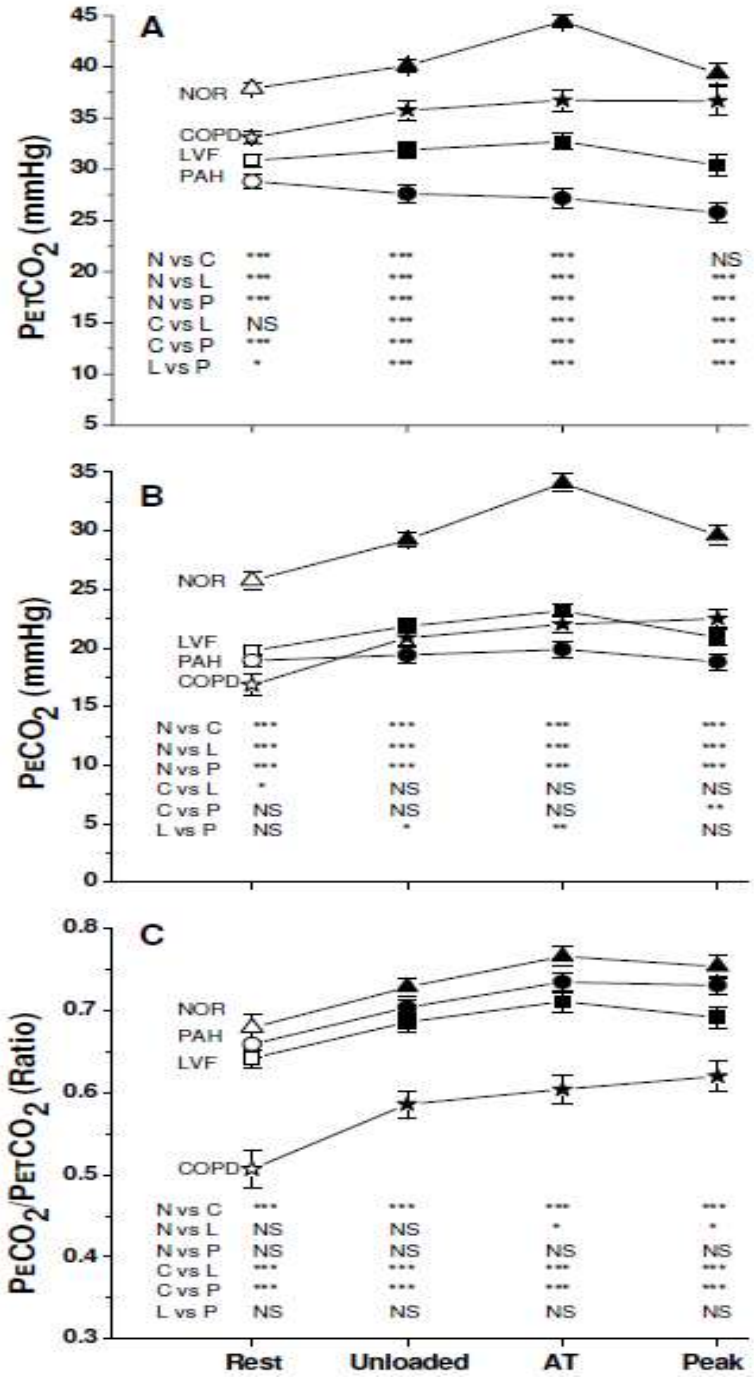
προσέρχεται με δύσπνοια προσπάθειας (MRC=2)

- **VO2 peak**= 78% (↓)
- **HR peak**= 94/min (↓)
- **RER**= 1.2
- **AT**=41% (οριακά κ.φ.)
- **HR vs VO2 slope:** πολύ «ρηχή»

↓

Αρνητική χρονότροπη ανταπόκριση (ισχαιμική νόσος του μυοκαρδίου)

Arena et al Circulation, 2011



Mixed-Expired and End-Tidal CO_2 Distinguish Between Ventilation and Perfusion Defects During Exercise Testing in Patients With Lung and Heart Diseases*

James E. Hansen, MD, FCCP; Gaye Ulubay, MD; Bing Fai Chow, MD; Xing-Guo Sun, MD; and Karlman Wasserman, PhD, MD, FCCP

Chest 2007

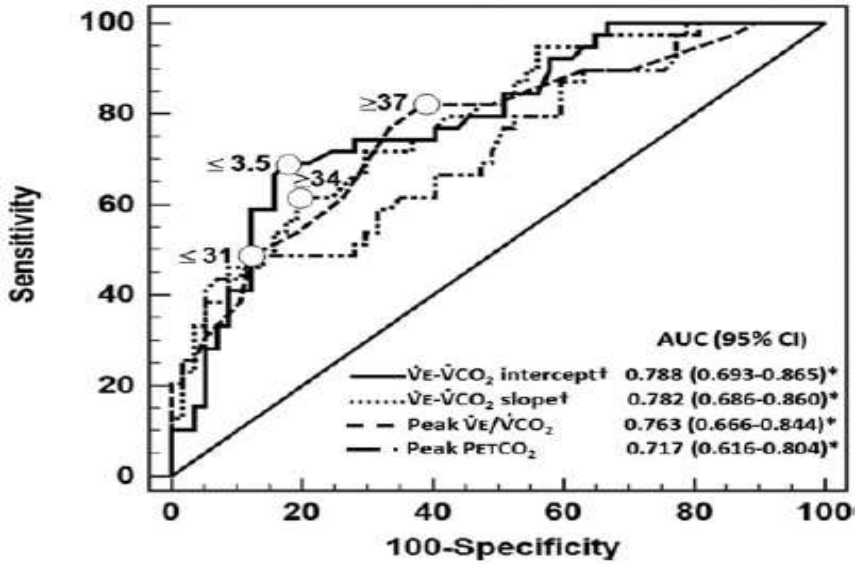
25 Pts with COPD, HF, LVF and PAH discriminated by **PETCO2**, **PECO2** and **PECO2/PETCO2**

Exercise Ventilation in COPD: Influence of Systolic Heart Failure

Flavio F. Arbex[a], Maria Clara Alencar[a], Aline Souza[a], Adriana Mazzuco[d], Priscila A. Sperandio[a], Alcides Rocha[a], Daniel M. Hirai[a,b], Frederico Mancuso[c], Danilo C. Berton[e], Audrey Borghi-Silva[d], Dirceu R. Almeida[c], Denis E. O'Donnell[b], and J. Alberto Neder[a,b]

Multivariate analysis

Model 1			31.1	102.1
$\dot{V}E$-$\dot{V}CO_2$ intercept ≤ 3.5 L/minute	7.69 (2.61–22.65)	0.0002		
$\dot{V}E$-$\dot{V}CO_2$ slope ≥ 34	2.18 (0.73–6.50)	0.14		
Peak SpO_2 ≤ 89%	—	0.42		
Model 2			29.6	103.5
$\dot{V}E/\dot{V}CO_2$ peak ≥ 37	5.35 (1.96–14.59)	0.0010		
Peak $PETCO_2$ ≤ 31 mmHg	5.73 (1.42–23.15)	0.0142		
Peak SpO_2 ≤ 89%	—	0.50		



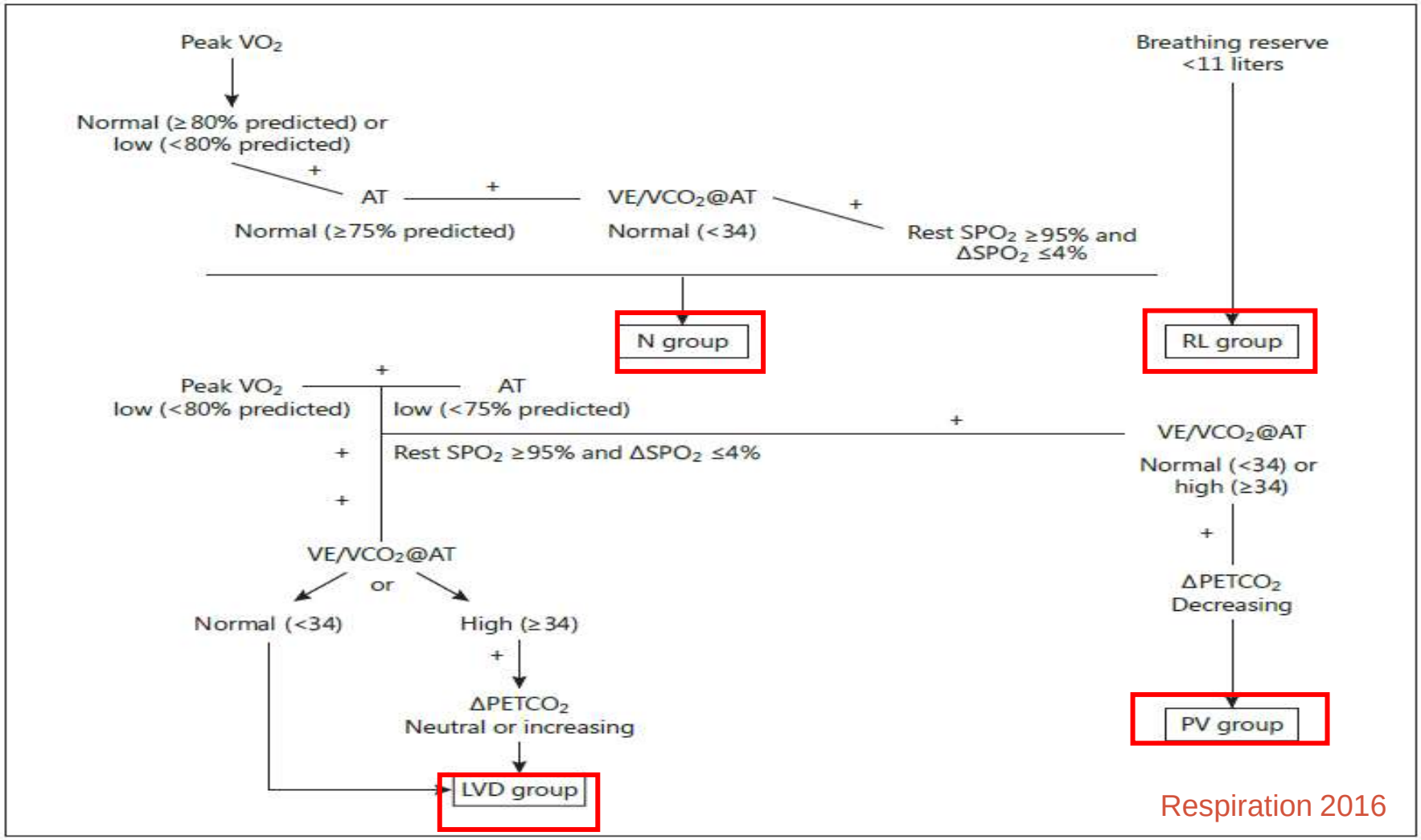
57 moderate to very severe COPD pts and **41 "overlap"** HF-COPD patients

COPD: JOURNAL OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE
2016, VOL. 0, NO. 0, 1–8
http://dx.doi.org/10.1080/15412555.2016.1174985

Phenotyping Exercise Limitation in Systemic Sclerosis: The Use of Cardiopulmonary Exercise Testing

Afroditi K. Boutou[a] Georgia G. Pitsiou[a] Panagiota Siakka[b]
Theodoros Dimitroulas[c, d] Asimina Paspala[a] Evdokia Sourla[a]
Nikolaos Chavouzis[a] Alexandros Garyfallos[b] Paraskevi Argyropoulou[a]
Ioannis Stanopoulos[a]

78 SSc patients with exertional dyspnea



Respiration 2016

Περιστατικό 2ο

Άντρας, μη καπνιστής με ήπιας βαρύτητας UIP και δύσπνοια στην κόπωση

2016

Σπιρομέτρηση

FEV1= 71,2%

FVC=76,3%

DLCO=63,1%

CPET

VO2=87%

AT=60%

RReserve >11 lit

VE/VCO2@AT: 39

Echo καρδιας

SPAP=37 mmHg

2017

Σπιρομέτρηση

FEV1=71,9%

FVC=73,2%

DLCO=55,2%

CPET

VO2=79%

AT=55%

RReserve > 11 lit

VE/VCO2@AT=47

Echo καρδιας

sPAP=45 mmHg

2018

Σπιρομέτρηση

FEV1=70,8

FVC=72,8%

DLCO=49,5%

CPET

VO2=73%

AT=51%

RReserve =10.8 lit

VE/VCO2@AT=54

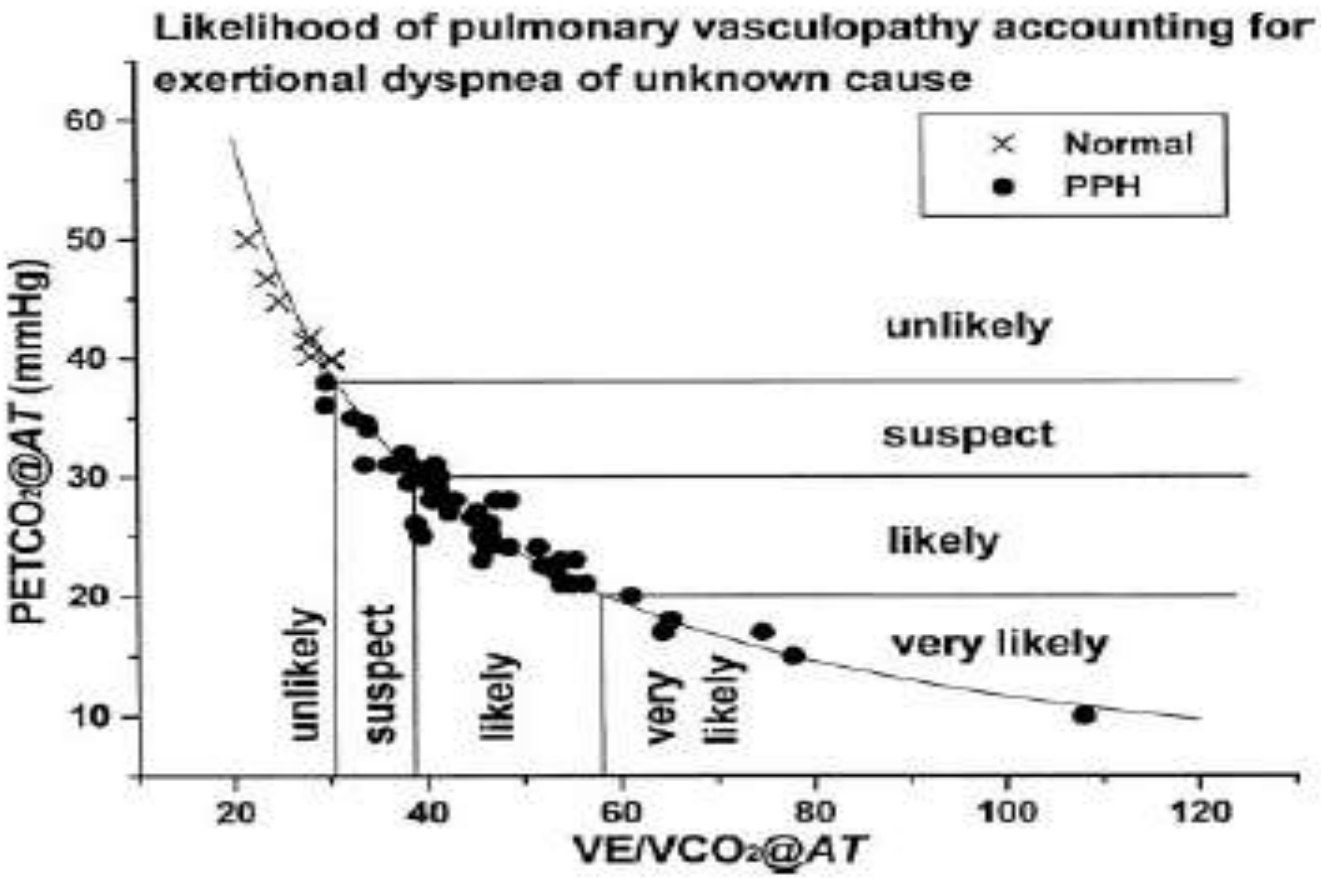
Echo καρδιας

sPAP=53mmHg

RHC

mPAP=48 mmHg

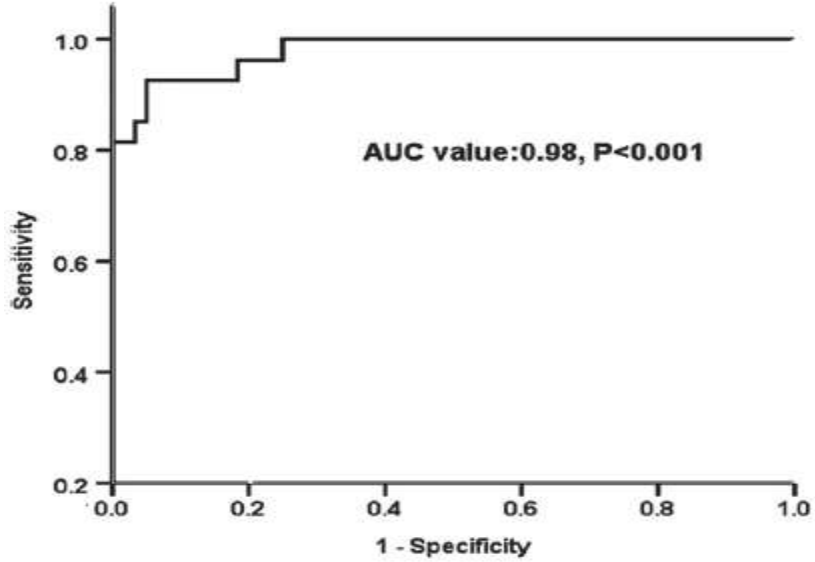
PETCO2 and VE/VCO2 for the diagnosis of pulmonary vasculopathy among patients with DUO



Yasunobu et al. CHEST 2005

Cardiopulmonary exercise testing improves diagnostic specificity in patients with echocardiography-suspected pulmonary hypertension

	OR (95% CI)	*P* Value	β-Coefficient	OR (95% CI)	*P* Value
Age	0.98 (0.95-1.00)	0.08	−0.09	0.92 (0.85-0.98)	0.012
Sex	2.15 (0.71-6.5)	0.17			
BMI	0.78 (0.66-0.93)	0.006	−0.75	0.47 (0.26-0.85)	0.012
CPET parameters					
VO_2 peak, mL/min/kg	0.86 (0.77-0.95)	0.005			
AT, mL/min/kg	0.75 (0.61-0.93)	0.008	−0.35	0.71 (0.52-0.96)	0.03
$P_{ET}CO_2$, mm Hg	0.72 (0.62-0.83)	<0.001			
Lowest VE/VCO_2	1.37 (1.17-1.61)	<0.001			
VE/VCO_2 slope	1.37 (1.17-1.59)	<0.001	0.56	1.76 (1.24-2.48)	0.001

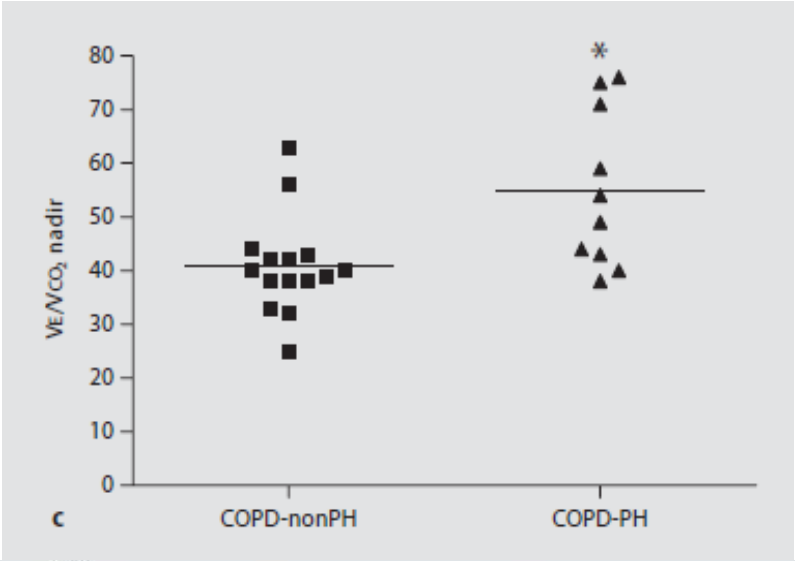


88 pts with potential PH based on Echo:
27 PH (PAH or CTEPH), **61 non-PH**

Zhao et al. Clin Cardiol 2016

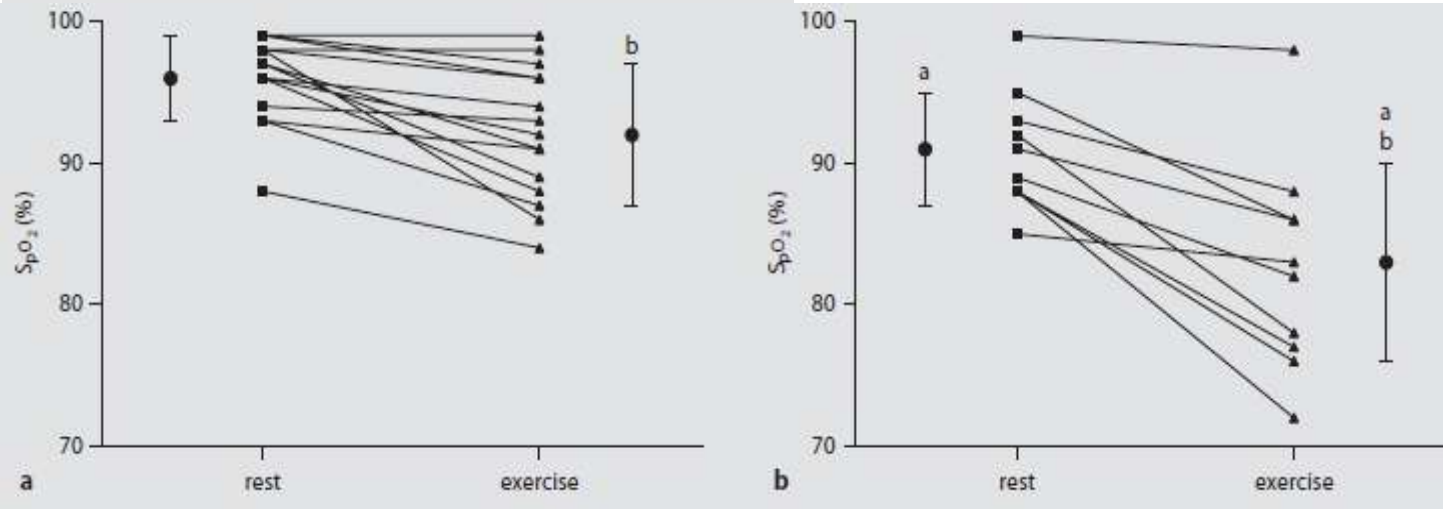
Cardiopulmonary Exercise Test Characteristics in Patients with Chronic Obstructive Pulmonary Disease and Associated Pulmonary Hypertension

Sebastiaan Holverda Harm J. Bogaard H. Groepenhoff Pieter E. Postmus
Anco Boonstra Anton Vonk-Noordegraaf



25 COPD patients with deteriorating symptoms (10 with PH and 15 without PH after RHC)

(peak VO2, VO2/HR, ΔVO2/ΔWR similar)



Respiration 2008;76:160–167
DOI: 10.1159/000110207

Exercise capacity in idiopathic pulmonary fibrosis: The effect of pulmonary hypertension

AFRODITI K. BOUTOU,[1] GEORGIA G. PITSIOU,[1] IOANNIS TRIGONIS,[1] DESPINA PAPAKOSTA,[2]
PASCHALINA K. KONTOU,[1] NIKOLAOS CHAVOUZIS,[1] CHRYSANTHI NAKOU,[1]
PARASKEVI ARGYROPOULOU,[1] KARLMAN WASSERMAN[3] AND IOANNIS STANOPOULOS[1]

	IPF patients		
	sPAP ≤ 35 mm Hg $n = 35$	sPAP 36–50 mm Hg $n = 30$	sPAP > 50 mm Hg $n = 16$
WR max	70.2 ± 19.4*	59.3 ± 15.6*	45.5 ± 14.3*
WR max, % predicted	61.6 ± 21.2*	56.5 ± 10.4*	42.8 ± 10.2*
VO_2 peak, % predicted	60.3 ± 18.2	61 ± 14.3	48.4 ± 12.6
VO_2 peak, mL/kg/min	12.9 ± 3.8*	13.2 ± 3.9*	10.5 ± 2*
AT, %	53.4 ± 19.2**	51.1 ± 13.2	37.9 ± 14.8**
AT, mL/kg/min	11.8 ± 2.3*	10.6 ± 3.1*	7.8 ± 2.1*
VO_2/HR peak, % predicted	65.2 ± 21.3	73.1 ± 14.8	53.9 ± 13.6
VO_2/HR peak, mL/beat	8.6 ± 1.8*	8.2 ± 2.3*	6.1 ± 1.6*
$PETCO_2$@AT	32.6 ± 4.2	32.4 ± 3.3	26.1 ± 4.6
$PETCO_2$@VO_2 peak	30.2 ± 3.1	31.7 ± 3.9	26 ± 4.2
VE/VCO_2@AT	43.3 ± 9.9**	48.1 ± 8.3	57.1 ± 9.3**
VE/VCO_2@VO_2 peak	46.3 ± 6.2**	49.2 ± 9.1	60.1 ± 14.7**
$\Delta VO_2/\Delta WR$	8.9 ± 2.9**	7.6 ± 2.7	5.9 ± 1.9**
V_E max, L	59 ± 13.2	54.9 ± 16.8	50.1 ± 11.9
Vt max, L	1.3 ± 0.5	1.2 ± 0.6	1.1 ± 0.7
V_E peak/MVV, %	87.5 ± 29.8	82.2 ± 24.1	83.9 ± 37.9
BR, L	22.1 ± 20.9	19 ± 14.2	17.9 ± 19.2
Vt/IC	0.97 ± 0.4	0.85 ± 0.8	0.83 ± 0.5
RR peak	45.2 ± 10.8	48.1 ± 9.4	50.4 ± 14
HR peak, % predicted	86.3 ± 11.9	87.1 ± 11.3	85.2 ± 12.4
SaO_2 at rest, %	95.2 ± 2.8**	93.5 ± 2.2	91 ± 3.4**
SaO_2 peak, %	87.2 ± 4.9**	82.9 ± 3.3	80.8 ± 1.3**

Respirology 2011

Σημαντικές παράμετροι για την βαρύτητα και την πρόγνωση της ΠΑΥ

Table 13 Risk assessment in pulmonary arterial hypertension

Determinants of prognosis[a] (estimated 1-year mortality)	Low risk <5%	Intermediate risk 5–10%	High risk >10%
Clinical signs of right heart failure	Absent	Absent	Present
Progression of symptoms	No	Slow	Rapid
Syncope	No	Occasional syncope[b]	Repeated syncope[c]
WHO functional class	I, II	III	IV
6MWD	>440 m	165–440 m	<165 m
Cardiopulmonary exercise testing	Peak VO_2 >15 ml/min/kg (>65% pred.) VE/VCO_2 slope <36	Peak VO_2 11–15 ml/min/kg (35–65% pred.) VE/VCO_2 slope 36–44.9	Peak VO_2 <11 ml/min/kg (<35% pred.) VE/VCO_2 slope ≥45
NT-proBNP plasma levels	BNP <50 ng/l NT-proBNP <300 ng/l	BNP 50–300 ng/l NT-proBNP 300–1400 ng/l	BNP >300 ng/l NT-proBNP >1400 ng/l
Imaging (echocardiography, CMR imaging)	RA area <18 cm^2 No pericardial effusion	RA area 18–26 cm^2 No or minimal, pericardial effusion	RA area >26 cm^2 Pericardial effusion
Haemodynamics	RAP <8 mmHg CI ≥2.5 l/min/m^2 SvO_2 >65%	RAP 8–14 mmHg CI 2.0–2.4 l/min/m^2 SvO_2 60–65%	RAP >14 mmHg CI <2.0 l/min/m^2 SvO_2 <60%

ESC/ERS guidelines for the diagnosis and treatment of PH, Eur Heart J 2015

Παρακολούθηση ασθενών με ΠΑΥ

Table 14 Suggested assessment and timing for the follow-up of patients with pulmonary arterial hypertension

	At baseline	Every 3–6 months[a]	Every 6–12 months[a]	3–6 months after changes in therapy[a]	In case of clinical worsening
Medical assessment and determination of functional class	+	+	+	+	+
ECG	+	+	+	+	+
6MWT/Borg dyspnoea score	+	+	+	+	+
CPET	+		+		+[e]
Echo	+		+	+	+
Basic lab[b]	+	+	+	+	+
Extended lab[c]	+		+		+
Blood gas analysis[d]	+		+	+	+
Right heart catheterization	+		+[f]	+[e]	+[e]

ESC/ERS guidelines for the diagnosis and treatment of PH, Eur Heart J 2015

Περιστατικό 3

Ασθενής 51 ετών με θρομβοεμβολική ΠΥ

Προ θεραπείας

Σπιρομέτρηση
FEV1: 109,8%
FVC: 112,6 %
DLCO: 47,6%

CPET
Peak VO2=49%
AT=36%
VE/VCO2@AT=57

Echo
sPAP=81 mmHg

Ενδαρτηρεκτομή και ελεγχόμενη άσκηση →

1 έτος αργότερα

Σπιρομέτρηση
FEV1: 107,6%
FVC: 110,9 %
DLCO: 69%

CPET
Peak VO2=71%
AT=43%
VE/VCO2@AT=39

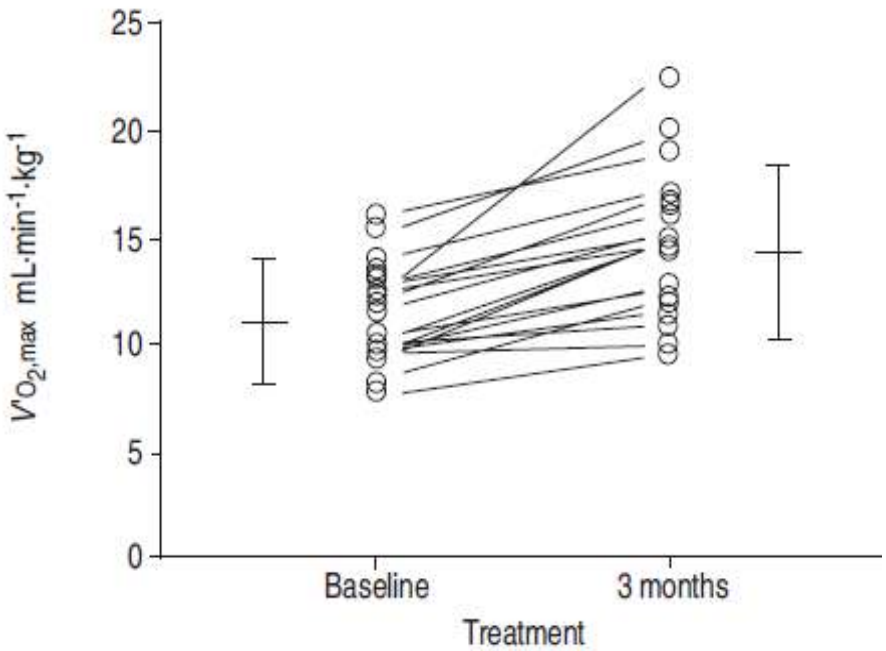
Echo
sPAP=36 mmHg

RHC
mPAP=27 mmHg

Bosentan treatment in patients with primary pulmonary hypertension receiving nonparenteral prostanoids

M.M. Hoeper, N. Taha, A. Bekjarova, R. Gatzke, E. Spiekerkoetter

	Baseline	3 months	p-value
Work rate W	43±20	63±17	<0.0001
$f_{c,max}$ beats·min^{-1}	133±16	139±16	0.03
$\dot{V}O_{2,max}$ mL·min^{-1}·kg^{-1}	11.0±2.3	13.8±3.6	<0.0001
AT mL·min^{-1}·kg^{-1}	10.2±2.2	11.7±2.9	0.007
Peak oxygen pulse mL·beat^{-1}	5.7±1.5	6.8±2.0	0.0004
$\dot{V}E_{,max}$ L·min^{-1}	45.8±14.5	57.6±15.0	<0.0001
$\dot{V}E/\dot{V}CO_2$ at AT#	52.3±14.9	44.9±10.3	0.004
Peak SBP mmHg¶	120±17	139±21	<0.0001



20 patients with PPH under inhaled iloprost or oral beraprost alone (baseline) and **3 months after bosentan add-on**.

Eur Respir J 2003

COPD treatment: the role of CWR CPET

Table 1. Effects of different types of interventions on CWR tests in COPD

Type of intervention	Tiotropium [28]	Oxygen ($FiO_2 = 0.5$) [29]	Heliox [30]	Oxygen and rehabilitation [32]
Exercise intensity, % max. predicted	75	75	80	75
FEV_1, % predicted	42	31	38	35
Change in endurance time, %	+21	+145	+115	+224
Change in inspiratory capacity (at isotime), %	+12	+24	+12	-
Change in dyspnea (at isotime), %	-14	-40	-25	-

Ferazza et al Respiration; 2009

COPD treatment: the role of ICPET

TABLE 2. EFFECT OF TRAINING ON THE PEAK RESPONSES IN INCREMENTAL EXERCISE TESTS IN WHICH AIR WAS RESPIRED

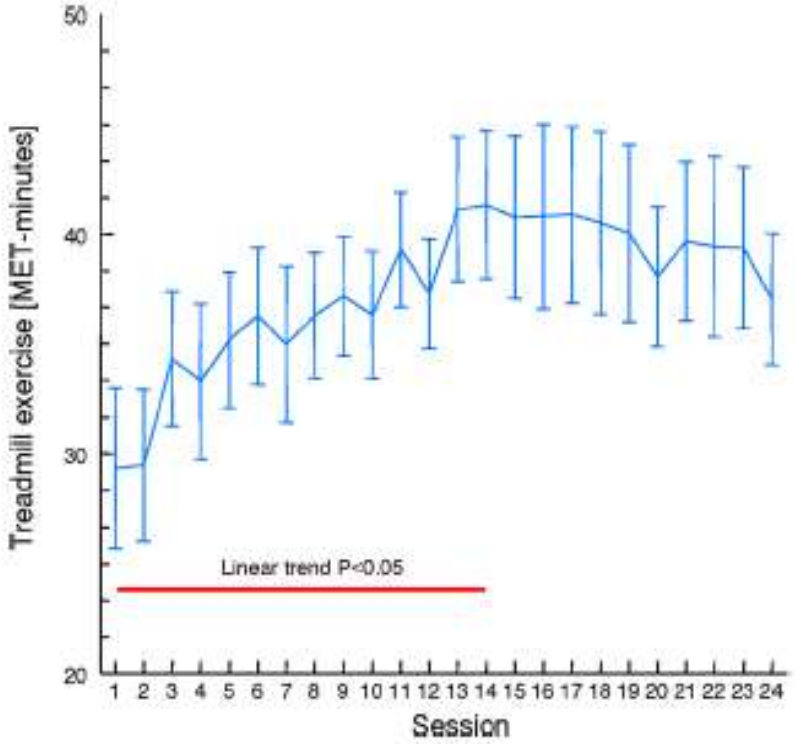
	Oxygen-training Group		Air-training Group	
	Before Training	After Training	Before Training	After Training
Work rate, W	54 (25)	67 (24)*	54 (27)	64 (29)*
SBP, torr	197 (23)	188 (26)*	187 (25)	187 (31)
DBP, torr	94 (10)	92 (8)*	92 (14)	87 (12)
Heart rate, beats/min	125 (22)	128 (22)	125 (16)	130 (19)
$\dot{V}O_2$, L/min	0.89 (0.22)	0.93 (0.27)	0.91 (0.36)	0.97 (0.32)
VCO_2, L/min	0.90 (0.28)	0.95 (0.30)	0.90 (0.39)	0.98 (0.32)
$\dot{V}E$, L/min	34 (8)	39 (10)*	36 (11)	39 (11)*
VT, L	1.06 (0.21)	1.21 (0.32)	1.11 (0.30)	1.18 (0.36)
f, breaths/min	30.9 (4.1)	32.6 (5.0)	32.2 (7.3)	33.8 (10.0)
Breathlessness	6.3 (2.5)	6.7 (2.1)	5.8 (1.8)	5.9 (1.5)
Leg fatigue	5.4 (2.4)	4.6 (2.7)	5.3 (2.2)	4.0 (2.4)
Lactate, mmol/L	4.2 (2.8)	4.8 (2.3)	3.8 (1.8)	4.6 (2.2)
SaO_2, %	94 (3)	93 (4)	93 (4)	93 (3)

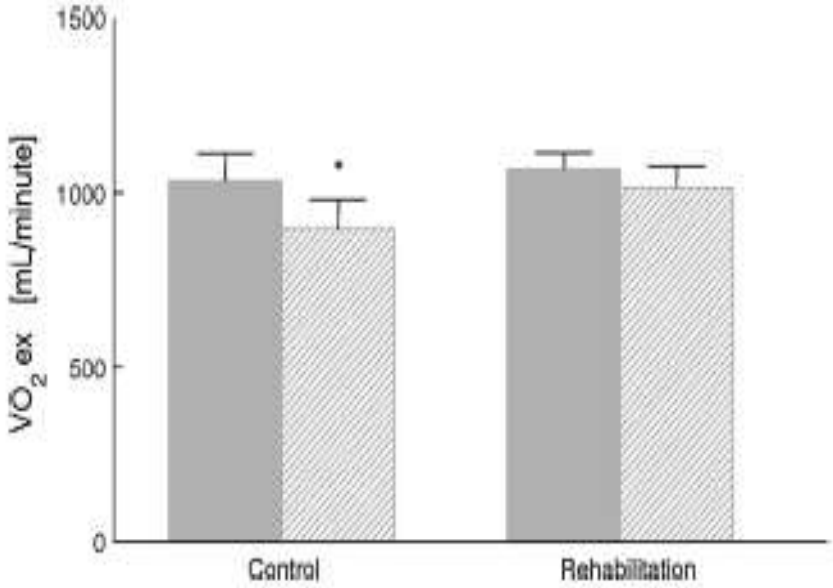
Emtner et al
AJRCCM; 2003

IPF treatment: the role of CPET

Exercise Limitation in IPF Patients: A Randomized Trial of Pulmonary Rehabilitation

Robert M. Jackson · Orlando W. Gómez-Marín · Carol F. Ramos · Constanza M. Sol · Meryl I. Cohen · Ignacio A. Gaunaurd · Lawrence P. Cahalin · Diana D. Cardenas





11 pts vs. **10 controls**, 3 months PR

Lung (2014) 192:367–376
DOI 10.1007/s00408-014-9566-9

TASK FORCE REPORT
ERS STATEMENT

Use of exercise testing in the evaluation of interventional efficacy: an official ERS statement

Luis Puente-Maestu[1,2,3], Paolo Palange[4], Richard Casaburi[5], Pierantonio Laveneziana[6,7], François Maltais[8], J. Alberto Neder[9,10], Denis E. O'Donnell[11], Paolo Onorati[4,12], Janos Porszasz[5], Roberto Rabinovich[13], Harry B. Rossiter[5,14], Sally Singh[15], Thierry Troosters[16,17] and Susan Ward[18]

Eur Respir J, 2016

TABLE 3 Responsiveness of the tests to rehabilitation

	Variable	COPD	PAH	ILD
IET	$\dot{V}O_{2peak}$	Mean ↑ of 11%	Mean ↑ of 1–1.5 $mL \cdot min^{-1} \cdot kg^{-1}$	Mean ↑ of 1.2 $mL \cdot min^{-1} \cdot kg^{-1}$
	WR_{peak}	Mean ↑ of 6.8 W	No	
	$\dot{V}E$-$\dot{V}CO_2$ indices			
CWRET	t_{LIM}	Yes; several studies; usually large effects Most studies show ↑ > MCID (105 s) Limited comparative evidence suggests that it is more responsive than other tests	Limited evidence suggests that it is responsive	Limited evidence suggests that it is responsive
	Isotime IC	Yes		Limited comparative evidence suggests that it is more responsive than other tests
	Isotime dyspnoea	Yes		

TABLE 4 Responsiveness of the different tests to bronchodilators for chronic obstructive pulmonary disease (COPD), vasodilators for pulmonary arterial hypertension (PAH) or pirfenidone for idiopathic pulmonary fibrosis (IPF)

	Variable	COPD	PAH	IPF
IET	$\dot{V}O_{2peak}$	Modest and inconsistent ↑; few studies	1.5–2 $mL \cdot min^{-1} \cdot kg^{-1}$ or ↑ 9–14%	
	$\dot{V}E$-$\dot{V}CO_2$ indices	Anecdotal evidence	↑ 3–6 units/10–30%	
CWRET	tLIM	14/26 (54%) and 3/11 (27%) of reviewed studies on long- and short-acting bronchodilators, respectively, showed ↑ >MCID (105 s) Limited comparative evidence suggest that it is more responsive than other tests		
	Isotime IC and dyspnoea	Most studies show ↑ >0.2 L and are associated with improvements in dyspnoea intensity of ≥1 unit on a Borg scale		

Περιστατικό 4ο

Άνδρας 62 ετών, καπνιστής (65 pack/years), με χειρουργήσιμο NSCLC υποβάλλεται σε προεγχειρητικό έλεγχο

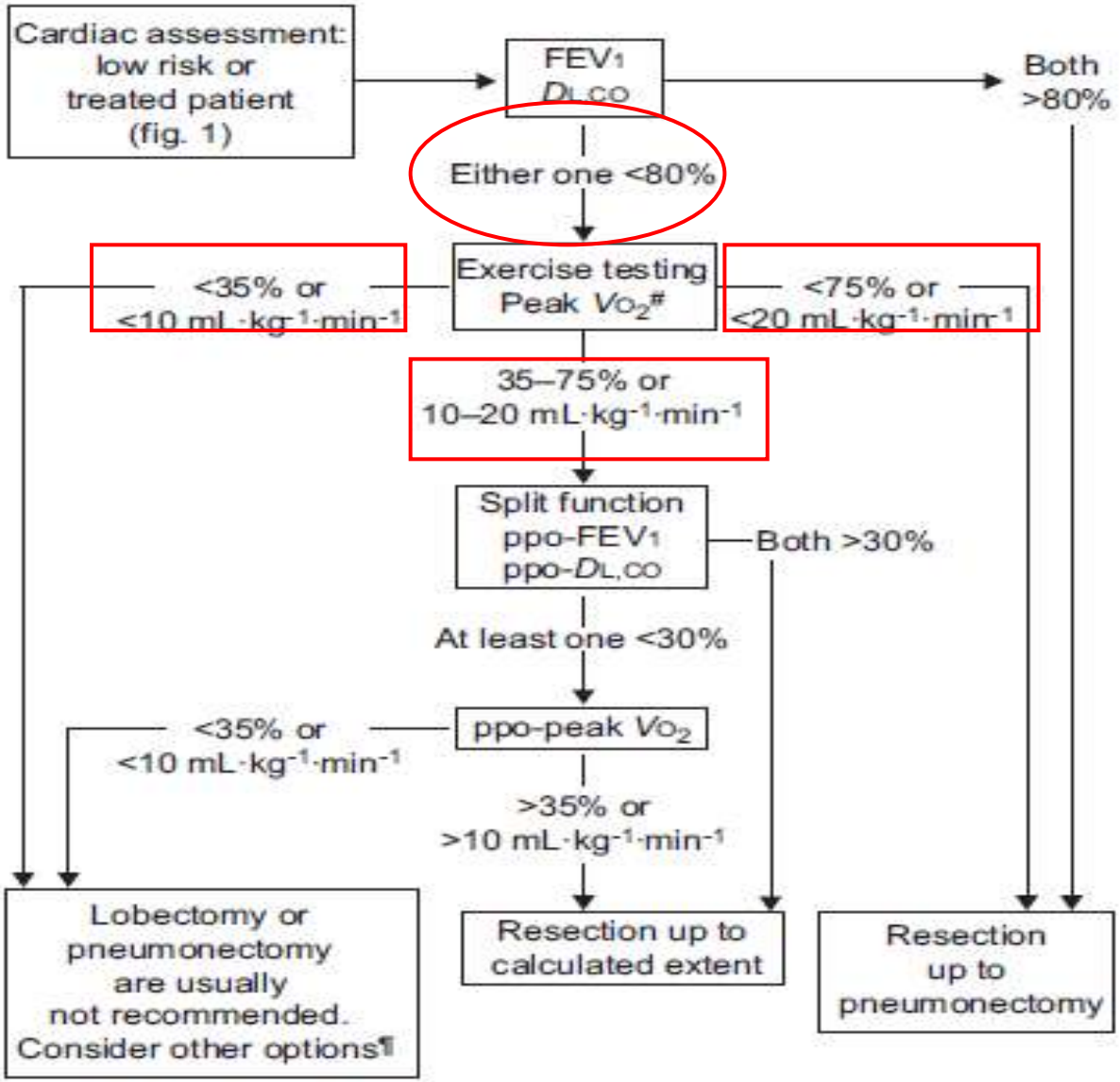
Σπιρομέτρηση

- FEV1: 63%
- FEV1/FVC: 67
- TLC: 81%
- DLCO: 46%
- KCO: 61%

- **ABGs**: pO2=71 mmHg, pCO2=48 mmHg, pH=7,41
- **ΗΕΓ**: RBBB
- **Echo καρδιάς**: EF=55-60%, sPAP=25 mmHg

ERS/ESTS clinical guidelines on fitness for radical therapy in lung cancer patients

Eur Respir J 2009; 34: 17–41



Role of cardiopulmonary exercise testing as a risk-assessment method in patients undergoing intra-abdominal surgery: a systematic review

British Journal of Anaesthesia, 116 (2): 177–91 (2016)

- Ανάλογα με το είδος της επέμβασης οι παράμετροι της προεγχειρητικής maximal CPET

-VO2@AT (κυριως) **(< 11 ml/kg/min)**

-VO2 peak

-VE/VCO2 (κατά περίπτωση)

Σχετίζονται στατιστικά σημαντικά με τα ακόλουθα outcomes:

-Είσοδος σε ICU

-Length of Hospital Stay

-Mortality (in hospital, 30-day, 60-day,90-day, 1 year, >2 years)

-Morbidity (7-day, 30-day, 90-day, >90-day)

Perioperative cardiopulmonary exercise testing (CPET): consensus clinical guidelines on indications, organization, conduct, and physiological interpretation

Baseline Observations:

Weight		Ideal Weight		BMI		Hb	

Exercise protocol and test conduct:

Incremental test gradient	Watts/min		Incremental phase duration: minutes
Test quality	good/poor and reasons		
Perceived exertion (Borg scale, range: 1-10)	Borg, rest:	Borg, peak exercise:	Observer description of effort
Reason exercise stopped	Patient reason and Investigators' observations		

Exercise Capacity: Anaerobic Threshold and $\dot{V}O_2peak$

$\dot{V}O_2peak$	Absolute ml/min	ml/kg/min	% of predicted	
Anaerobic threshold	Absolute ml/min	ml/kg/min	% of $\dot{V}O_2peak$	
WR	At AT	Watts	At $\dot{V}O_2peak$	Watts
RER at peak exercise				

Cardiovascular Function:

Resting ECG		
Exercise ECG	Ischaemia or arrhythmia or conduction defect – when this occurred during test	
Predicted maximum HR	(normal approximately 220 – age bpm)	
BP	Rest: mm Hg	Peak exercise: mm Hg
Peak HR	Absolute and % of maximum predicted value	
Heart rate reserve	Absolute and %	
O_2 pulse	Absolute and % of predicted peak exercise value; **comment on profile of response**	
$\dot{V}O_2$/WR	ml/min/watt (normal range 10 ml/min/watt; standard deviation +/- 1)	

Respiratory Function:

Breathing Reserve	Absolute and percentage (normal > 15% or greater than 11 l/min)	
$\dot{V}E/\dot{V}CO_2$ at Anaerobic threshold	(normal < 32)	
$\dot{V}E/\dot{V}CO_2$ gradient	(normal < 32)	
Oxygen saturation	Rest %	Peak exercise %
Spirometry	FEV_1 absolute and % predicted, FEV_1/FVC, MVV calculated (e.g. FEV_1 x 40)	

ACCEPTED MANUSCRIPT

Levett BZH, et al. BJA 2018

CPET στην προεγχειρητική εκτίμηση

CPET (13/07/2015)

- VO2peak: 14.9 ml/kg/min (59.8%)
- AT: 10.1 ml/kg/min (41%)
- RER: 1.18
- VE/MVV: 87%
- VE/VCO2@AT: 31
- BP, ECG: normal

Severe deconditioning, υψηλός κίνδυνος επιπλοκών

CPET (20/09/2015)
(μετά από πρόγραμμα άσκησης)

- VO2peak: 17.6 ml/kg/min (71%)
- AT: 11.9 ml/kg/min (48%)
- RER: 1.14
- VE/MVV: 93%
- VE/VCO2@AT: 31
- BP, ECG: normal

Δυνατή η εκτομή, χαμηλός ο κίνδυνος επιπλοκών

Cardiopulmonary exercise testing, prehabilitation, and Enhanced Recovery After Surgery (ERAS)

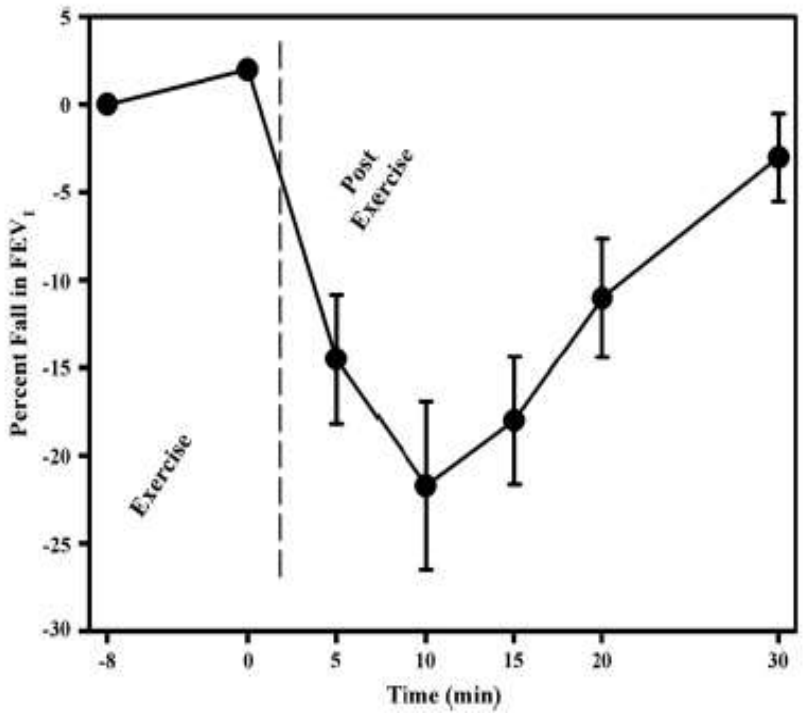
Denny Z. H. Levett, PhD · Michael P. W. Grocott, MBBS, MD

Can J Anesth/J Can Anesth (2015) 62:131–142

-Prehabilitation: Exercise training before surgery in order to improve functional capacity

-There is some evidence that CPET-guided structured training program is feasible and could be effective for prehabilitation

CPET and exercise-induced bronchoconstriction



Test protocol:

- High intensity exercise (totally 8 minutes)
- >90% HR for at least 6 minutes → >85%MVV
- Spirometry pre and post (2 manouvers)
- Spirometry at 5, 10, 15 and 30 minutes post
- FEV1 drop >10%: EIB diagnosis (gold standard)
- If FEV1drop >50% use SAMA
- Stay at lab until FEV1 >95% of baseline

Rundell et al. J Allergy Clin Immunol 2008;122:238-46.)

Συμπεράσματα

- Η CPET αποτελεί ένα σημαντικό εργαλείο για τη **διαφορική διάγνωση της δύσπνοιας** κατά κόπωση, μέσα από τη αξιολόγηση του μοντέλου άσκησης που εμφανίζει ο ασθενής
- Η CPET αποτελεί gold standard για τη διάγνωση της **δύσπνοιας αγνώστου αιτιολογίας** καθώς και για τη διάγνωση του **βρογχόσπασμου** επαγόμενου με την άσκηση
- Η CPET συμβάλλει σημαντικά στην διάγνωση **συννοσηρότητας** σε αναπνευστικούς ασθενείς και πόσο αυτή συμμετέχει στη χαμηλή ανοχή στην κόπωση
- η CPET βοηθά στην αντικειμενική παρακολούθηση του **θεραπευτικού** αποτελέσματος καθώς και στην **πρόγνωση** των ασθενών με αναπνευστικά νοσήματα
- Η CPET είναι απαραίτητη για την **προεγχειρητική εκτίμηση** των ασθενών με καρκίνο του πνεύμονα, καθώς καθοριζει το **βαθμό εκτομής** καθώς και την μετεγχειρητική τους **πρόγνωση**

ΕΥΧΑΡΙΣΤΩ ΠΟΛΥ

"What fits your busy schedule better, exercising one hour a day or being dead 24 hours a day?"