Les épreuves d'effort :
Les équivalents respiratoires

Michel Lamotte, PhD

HU Bruxelles - Belgique

Conflits d'intérêts

Aucun lié à cette présentation

Equivalents respiratoires

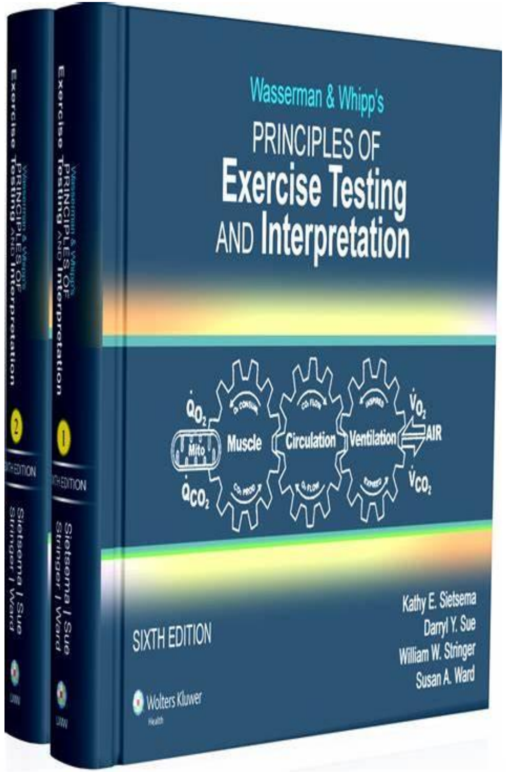
Qu’est ce que c’est ?

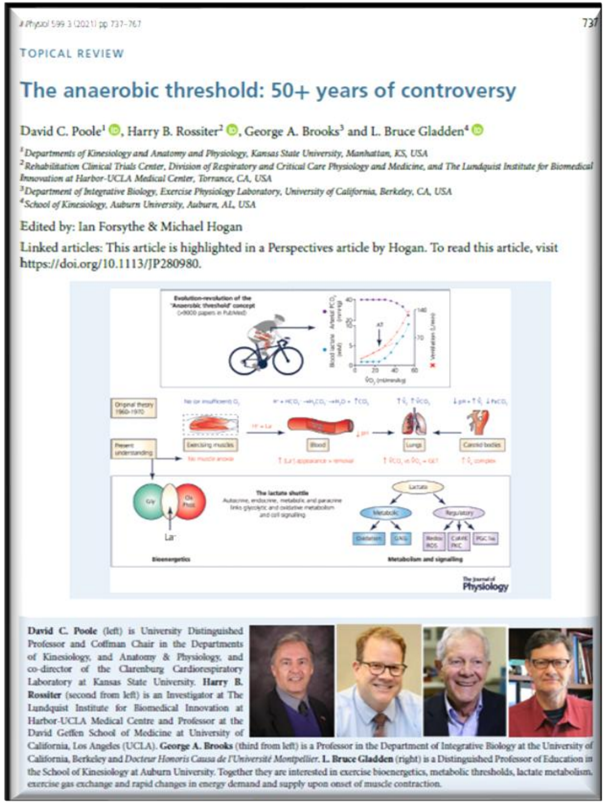
A quoi ça sert ?

Précautions d’interprétations

Facteurs liés

Notions théoriques, cliniques … et pratiques





J Physiol 599.3 (2021) pp 737–767 737

TOPICAL REVIEW

The anaerobic threshold: 50+ years of controversy

David C. Poole[1], Harry B. Rossiter[2], George A. Brooks[3] and L. Bruce Gladden[4]

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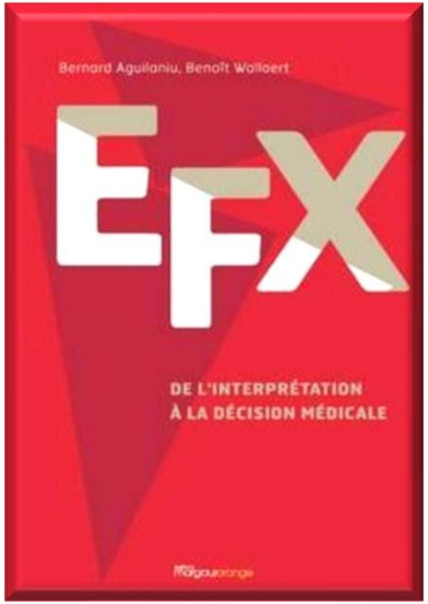
[2]Rehabilitation Clinical Trials Center, Division of Respiratory and Critical Care Physiology and Medicine, and The Lundquist Institute for Biomedical Innovation at Harbor-UCLA Medical Center, Torrance, CA, USA
[3]Department of Integrative Biology, Exercise Physiology Laboratory, University of California, Berkeley, CA, USA
[4]School of Kinesiology, Auburn University, Auburn, AL, USA

Edited by: Ian Forsythe & Michael Hogan

Linked articles: This article is highlighted in a Perspectives article by Hogan. To read this article, visit https://doi.org/10.1113/JP280980.

The Journal of Physiology

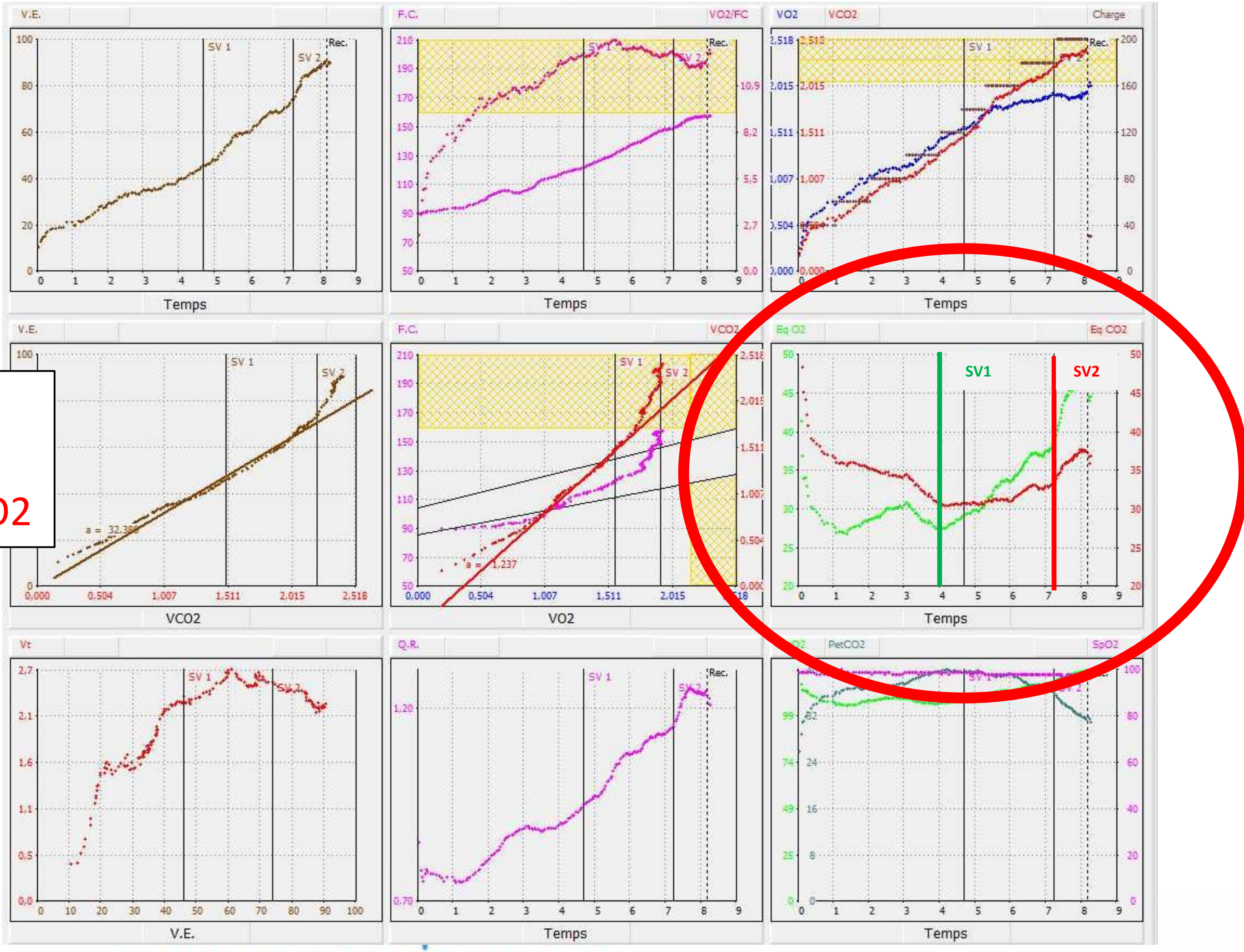
David C. Poole (left) is University Distinguished Professor and Coffman Chair in the Departments of Kinesiology, and Anatomy & Physiology, and co-director of the Clarenburg Cardiorespiratory Laboratory at Kansas State University. **Harry B. Rossiter** (second from left) is an Investigator at The Lundquist Institute for Biomedical Innovation at Harbor-UCLA Medical Centre and Professor at the David Geffen School of Medicine at University of California, Los Angeles (UCLA). **George A. Brooks** (third from left) is a Professor in the Department of Integrative Biology at the University of California, Berkeley and *Docteur Honoris Causa de l'Université Montpellier*. **L. Bruce Gladden** (right) is a Distinguished Professor of Education in the School of Kinesiology at Auburn University. Together they are interested in exercise bioenergetics, metabolic thresholds, lactate metabolism, exercise gas exchange and rapid changes in energy demand and supply upon onset of muscle contraction.



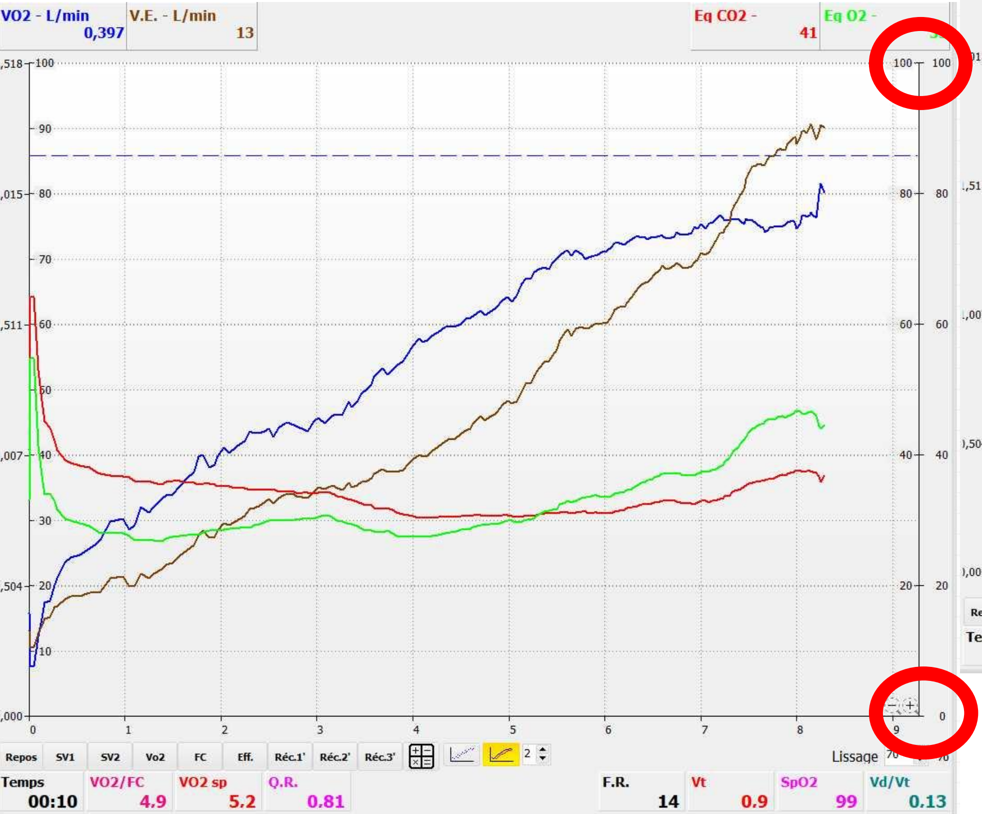
www.forumeuropeen.com

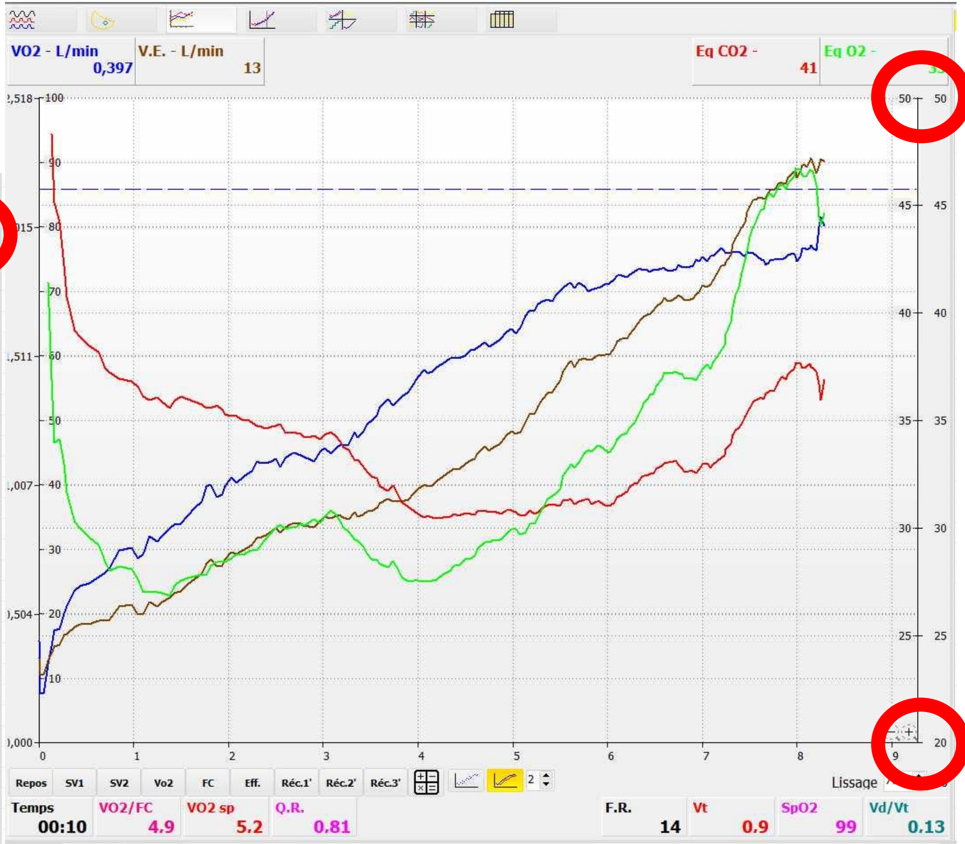
$ERO_2 = EqO_2 = Ve/VO_2$

$ERCO_2 = EqCO_2 = Ve/VCO_2$

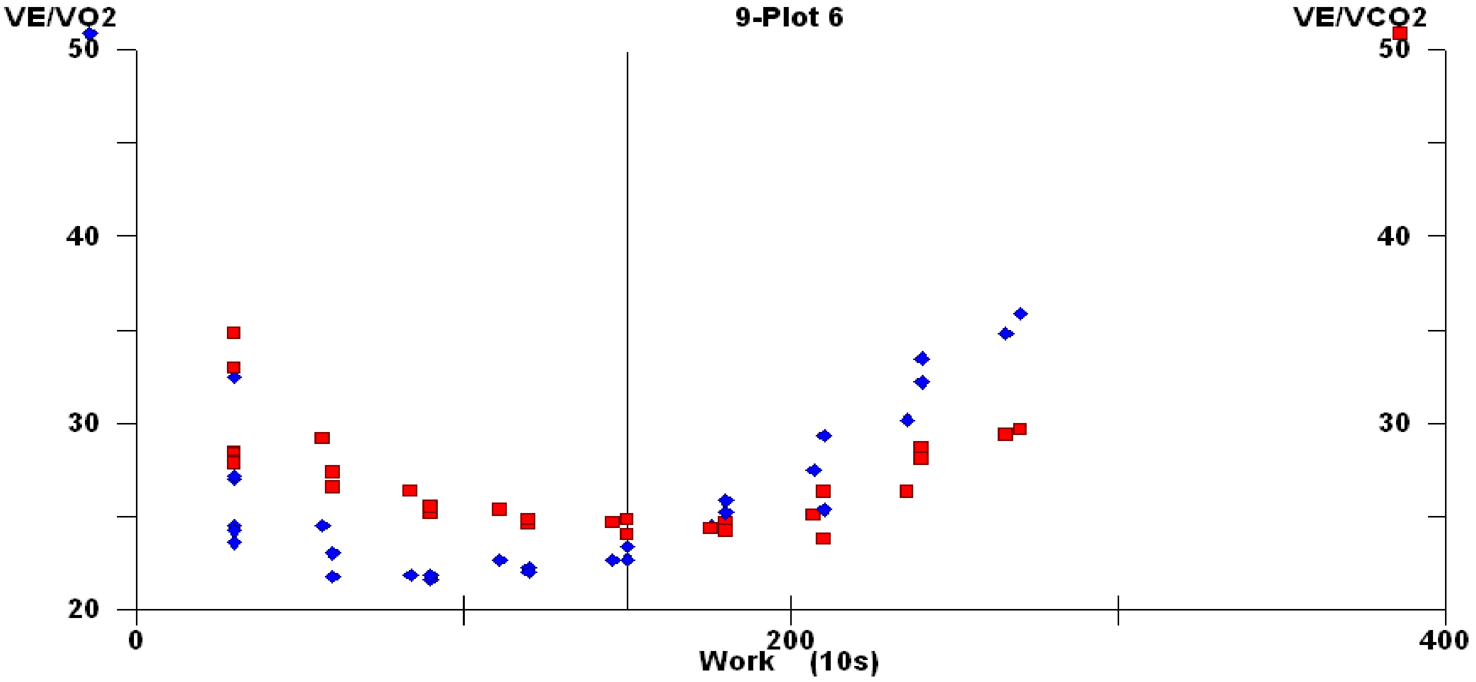


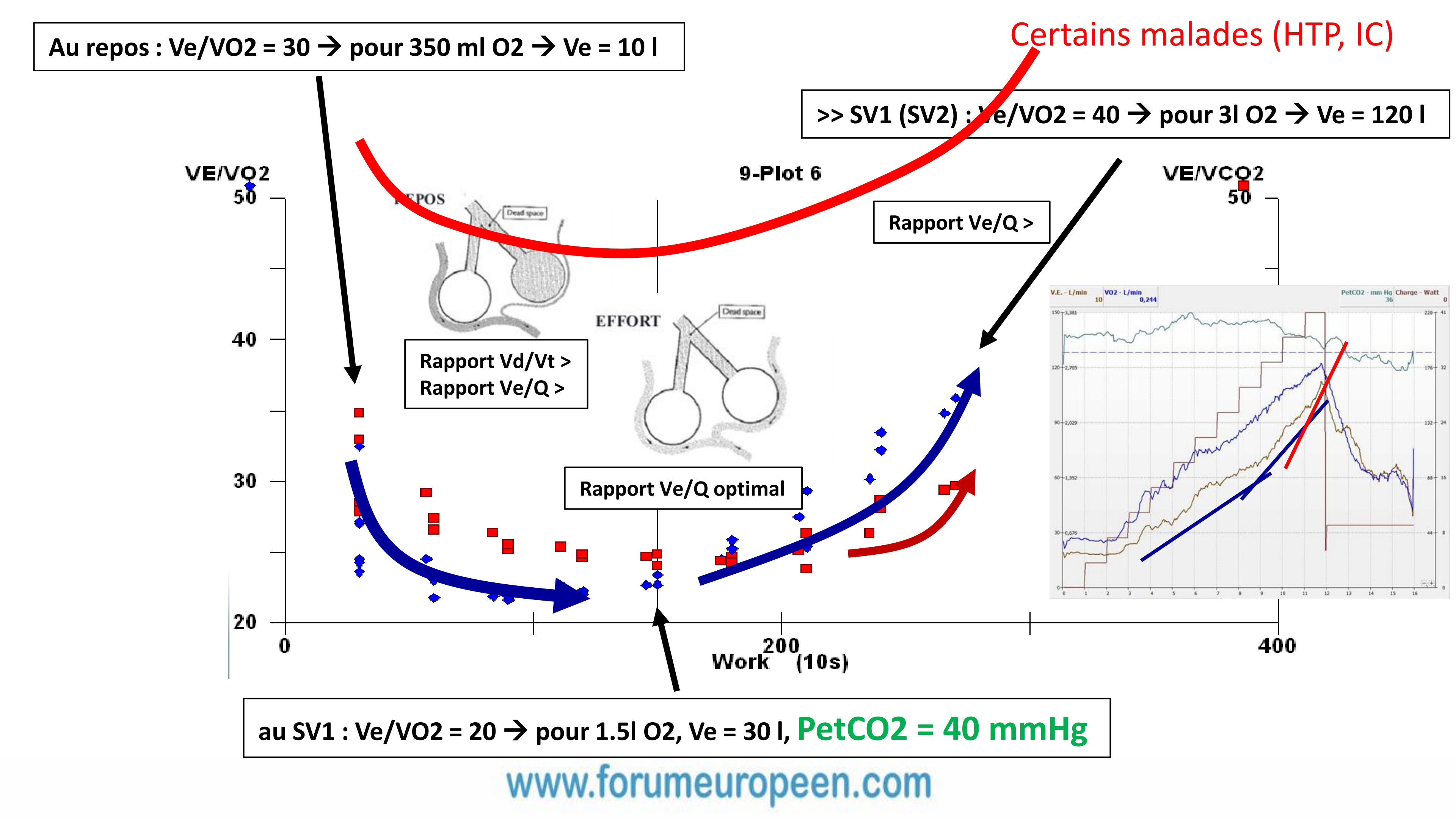
Ajuster les échelles !



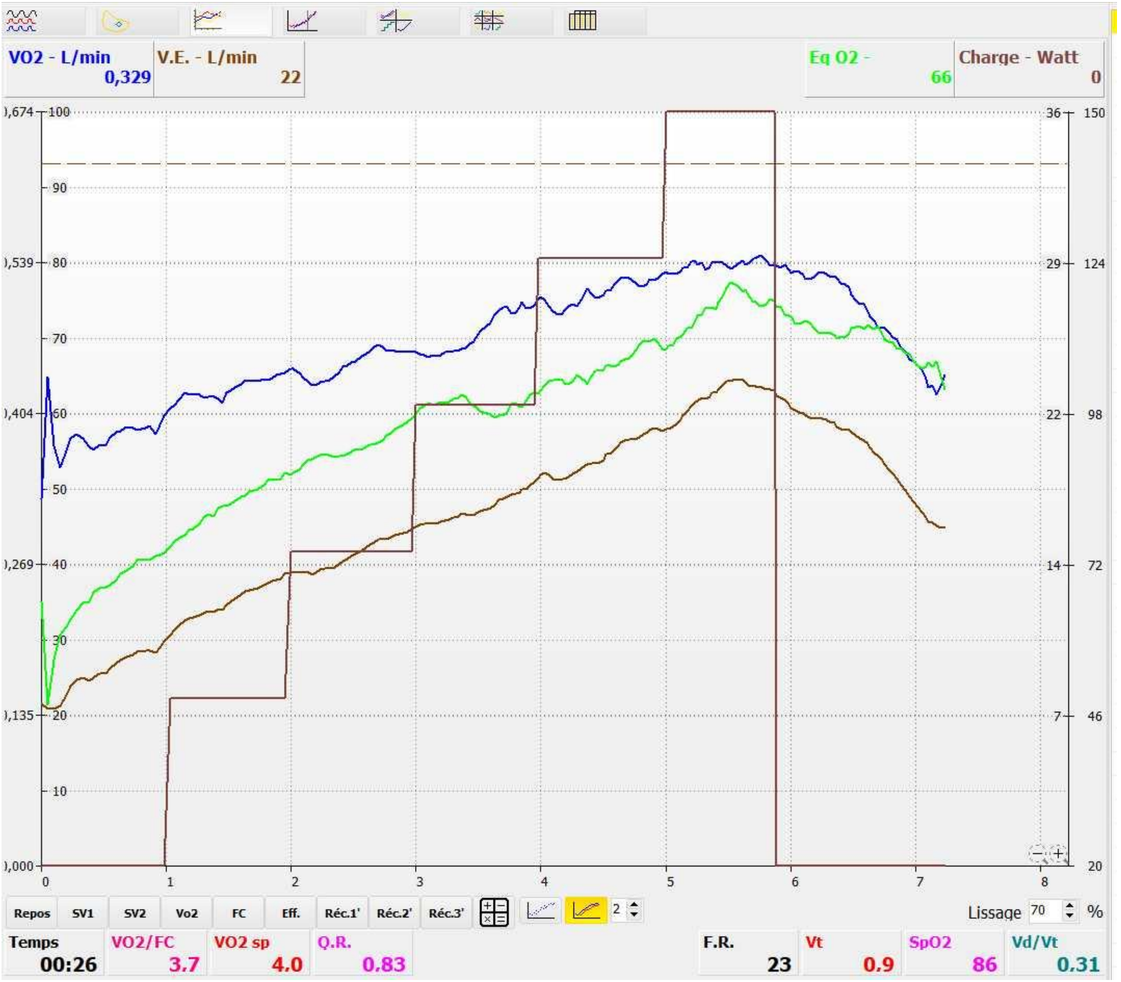


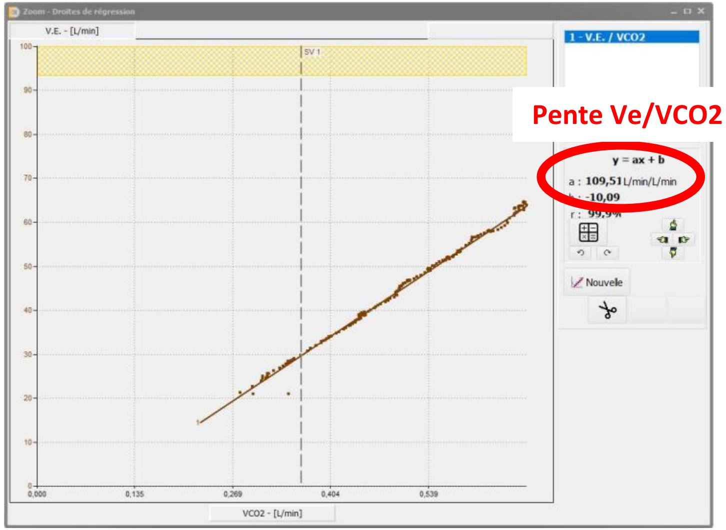
Ve/VO2 & Ve/VCO2 à l'exercice (**efficacité**)





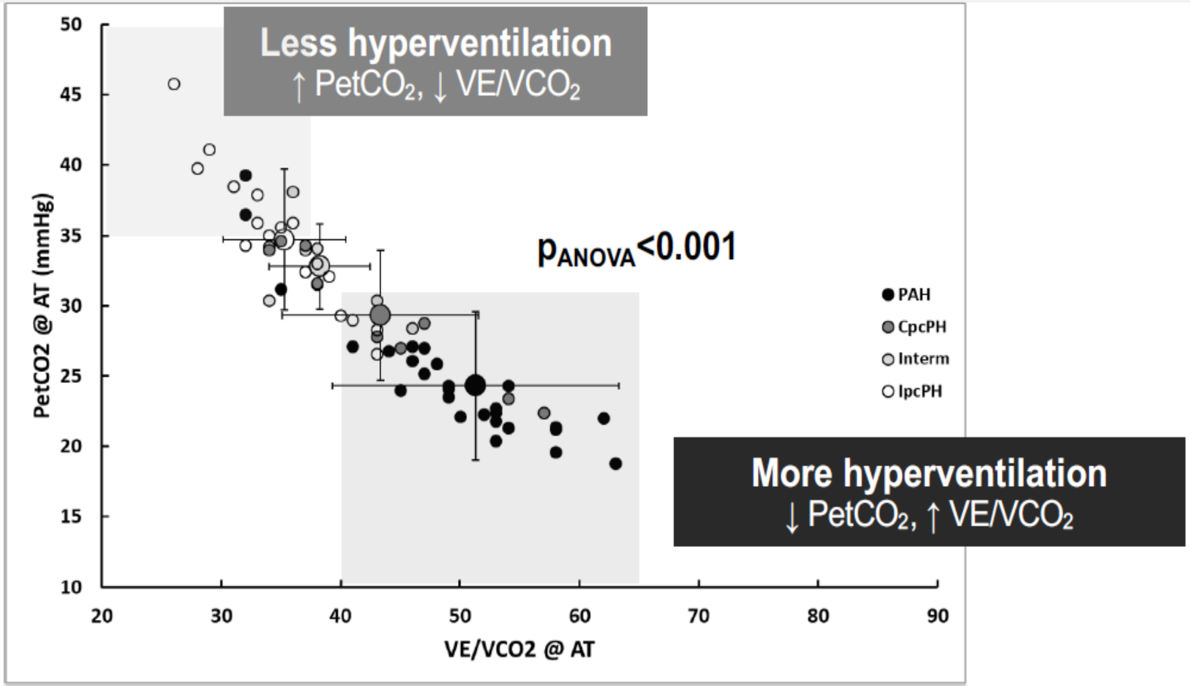
Au repos : Ve/VO2 = 30 → pour 350 ml O2 → Ve = 10 l
Certains malades (HTP, IC)
>> SV1 (SV2) : Ve/VO2 = 40 → pour 3l O2 → Ve = 120 l
VE/VO2
9-Plot 6
VE/VCO2
50
40
30
20
Dead space
EFFORT
Dead space
Rapport Ve/Q >
Rapport Vd/Vt >
Rapport Ve/Q >
Rapport Ve/Q optimal
0
200
400
Work (10s)
au SV1 : Ve/VO2 = 20 → pour 1.5l O2, Ve = 30 l, PetCO2 = 40 mmHg
www.forumeuropeen.com





HTP sévère(issime)

Ve/VCO2@|SV1 ou PetCO2@SV1 ?



Exercise hyperventilation:
PAH >> CpcPH >> Intermediate PH-LHD > IpcPH

PAH: pulmonary arterial hypertension; CpcPH: combined post-capillary pulmonary hypertension; isolated post-capillary pulmonary hypertension

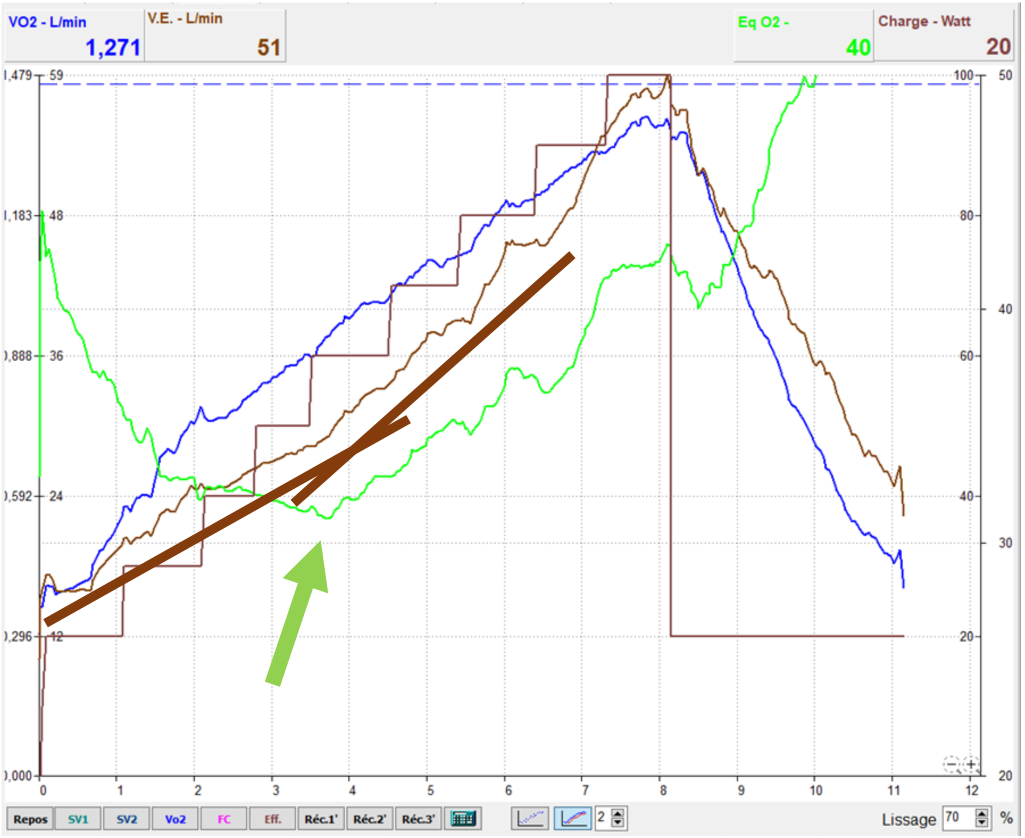
Caravita S et al. J Heart Lung Transpl 2017

A quoi ça sert ?

→ Détermination du SV1

V slope

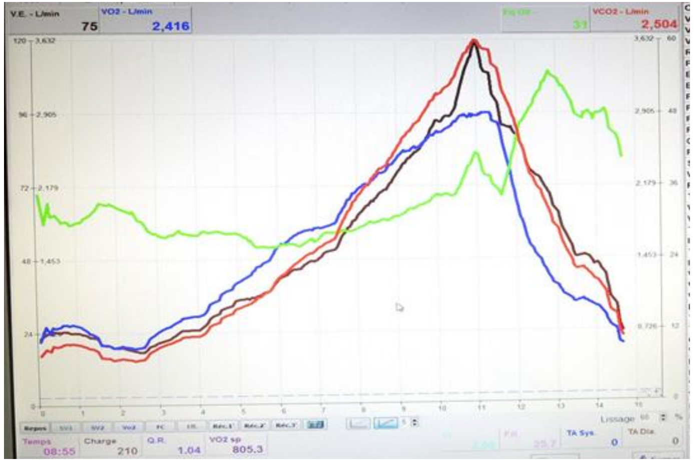
ERO2



VO2 - L/min
1,271
V.E. - L/min
51
Eq O2 -
40
Charge - Watt
20
Repos
SV1
SV2
Vo2
FC
Eff.
Réc.1'
Réc.2'
Réc.3'
Lissage
70
%

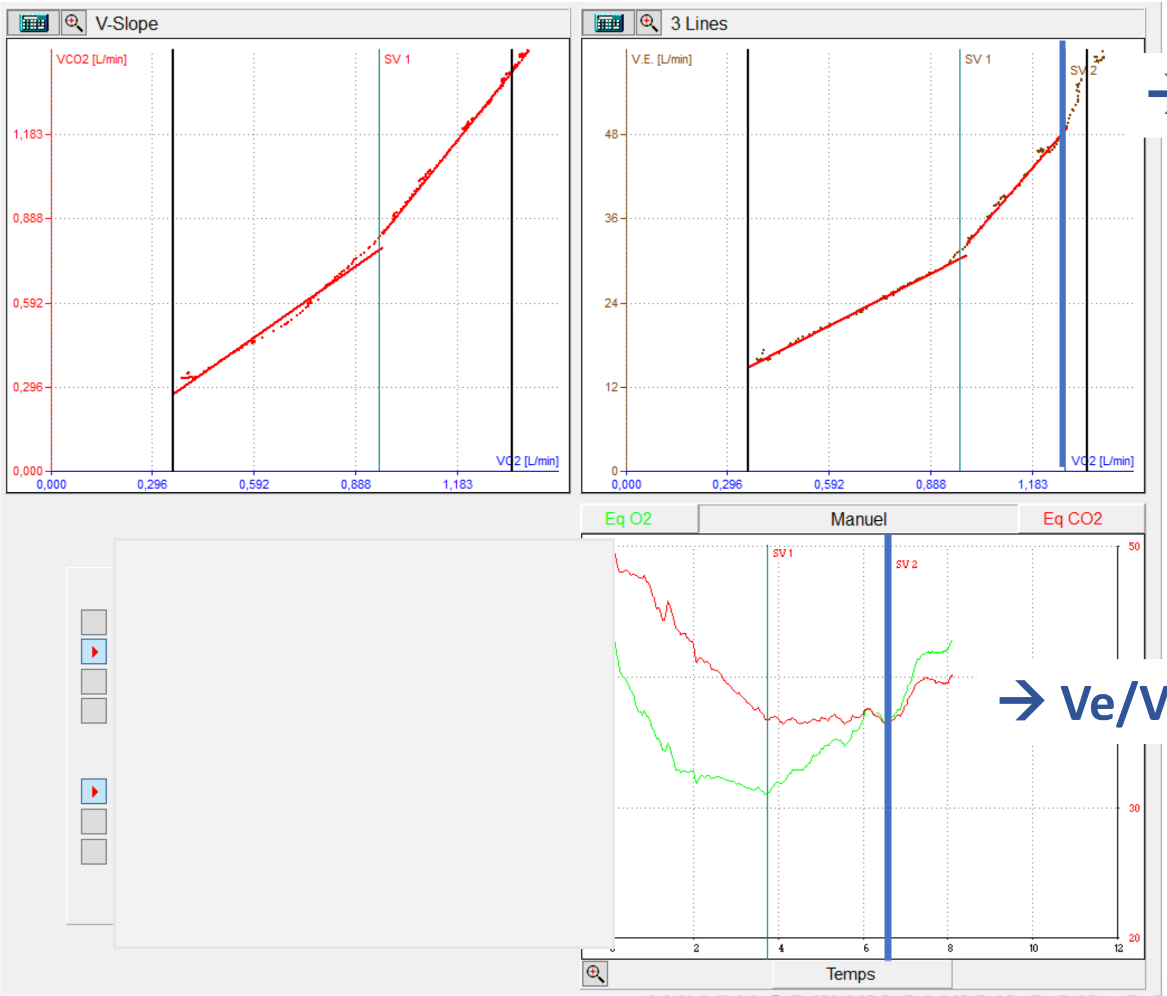
ERO2 : A quoi ça sert ?

- → Détermination du SV1
  - → Déterminer les niveaux d'entraînements
  - → Quantifier l'efficacité ventilatoire (ERO2 @SV1 ou PetCO2@SV1)
    - → @SV1 : PetCO2 = 40 mmHg / 35 / 30 / 25 / < 20)
    - → = « hyperventilation » mais pas au pic de l'effort !
  - → Indice de qualité de vie
  - → (Facteur pronostique si EFX sous max)



ERCO2 : A quoi ça sert ?

→ Détermination du SV2 (ERO2=Ve/VCO2)



→ Ve >> / VO2 (VCO2, W, Temps)

→ Ve/VCO2 >>

ERCO2 : A quoi ça sert ?

- → Détermination du SV2
  - → Mis en évidence chez 30 à 50 % des patients
  - → Déterminer les niveaux d'entraînements

ESC European Society of Cardiology
European Journal of Preventive Cardiology
doi:10.1093/eurjpc/zwab007

POSITION PAPER
Cardiac rehabilitation

Exercise intensity assessment and prescription in cardiovascular rehabilitation and beyond: why and how: a position statement from the Secondary Prevention and Rehabilitation Section of the European Association of Preventive Cardiology

2021

Dominique Hansen[1,2]*, Ana Abreu[3], Marco Ambrosetti [4], Veronique Cornelissen[5], Andreas Gevaert[6,7], Hareld Kemps[8,10], Jari A. Laukkanen[11,12], Roberto Pedretti[13], Maria Simonenko [14], and Matthias Wilhelm[15]
Reviewers: Constantinos H. Davos [16], Wolfram Doehner[17,19], Marie-Christine Iliou[18], Nicolle Kränkel[19,20], Heinz Völler[21,22], and Massimo Piepoli[23]

→ **Utilisation des seuils ventilatoires ….**
extrapolés à la FC / W

ERCO2 : A quoi ça sert ?

→ Détermination du SV2

  → Mis en évidence chez 30 à 50 % des patients

  → Déterminer les niveaux d'entraînements

  → Être plus précis pour l'estimation de la pente Ve/VCO2

European Heart Journal (2012) 33, 2917–2927
doi:10.1093/eurheartj/ehs221

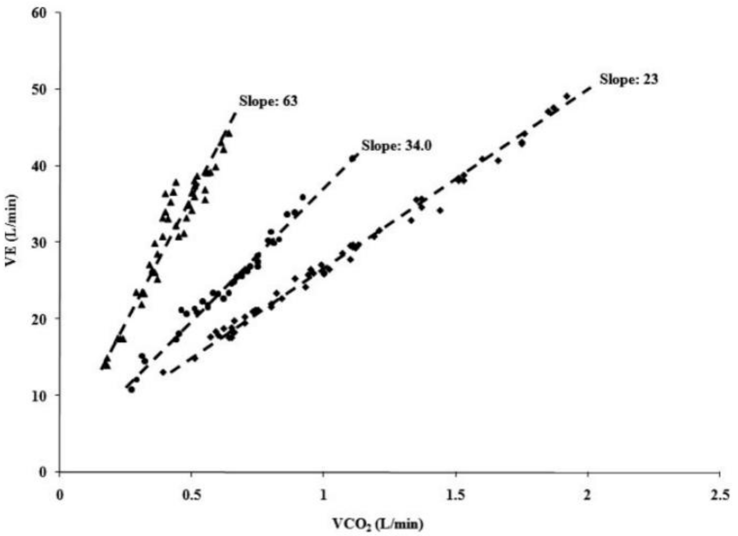
POSITION STATEMENT

EACPR/AHA Joint Scientific Statement

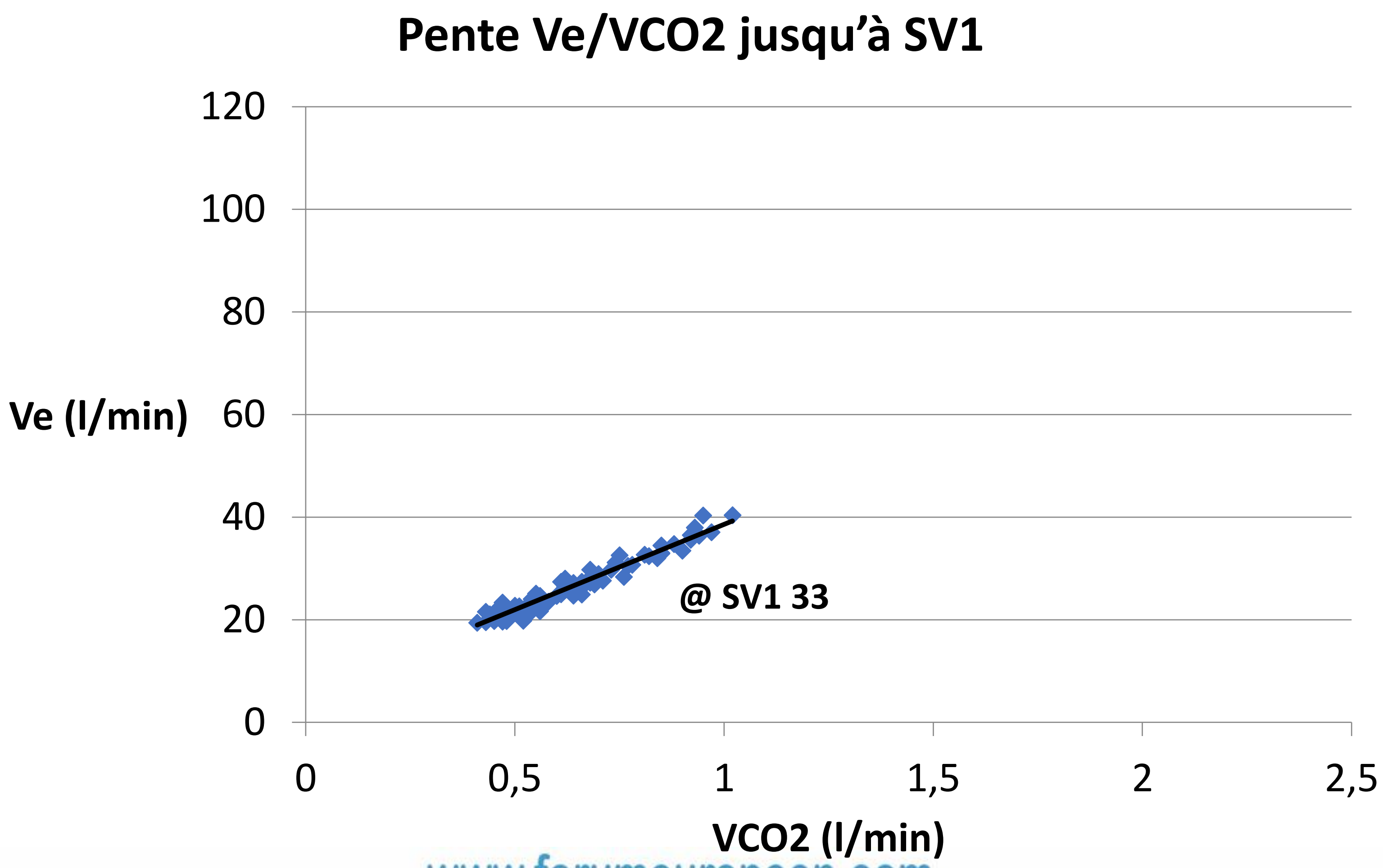
Clinical recommendations for cardiopulmonary exercise testing data assessment in specific patient populations

- Relationship between VE, plotted on the *y*-axis, and V_{CO_2} plotted on the *x*-axis; both variables in L min^{-1}
- Most commonly calculated using all ET data[7]
- Represents matching of ventilation and perfusion within the pulmonary system
- Broadly reflects disease severity as well as prognosis in a number of patient populations including HF, HCM, PAH/secondary PH, COPD, ILD

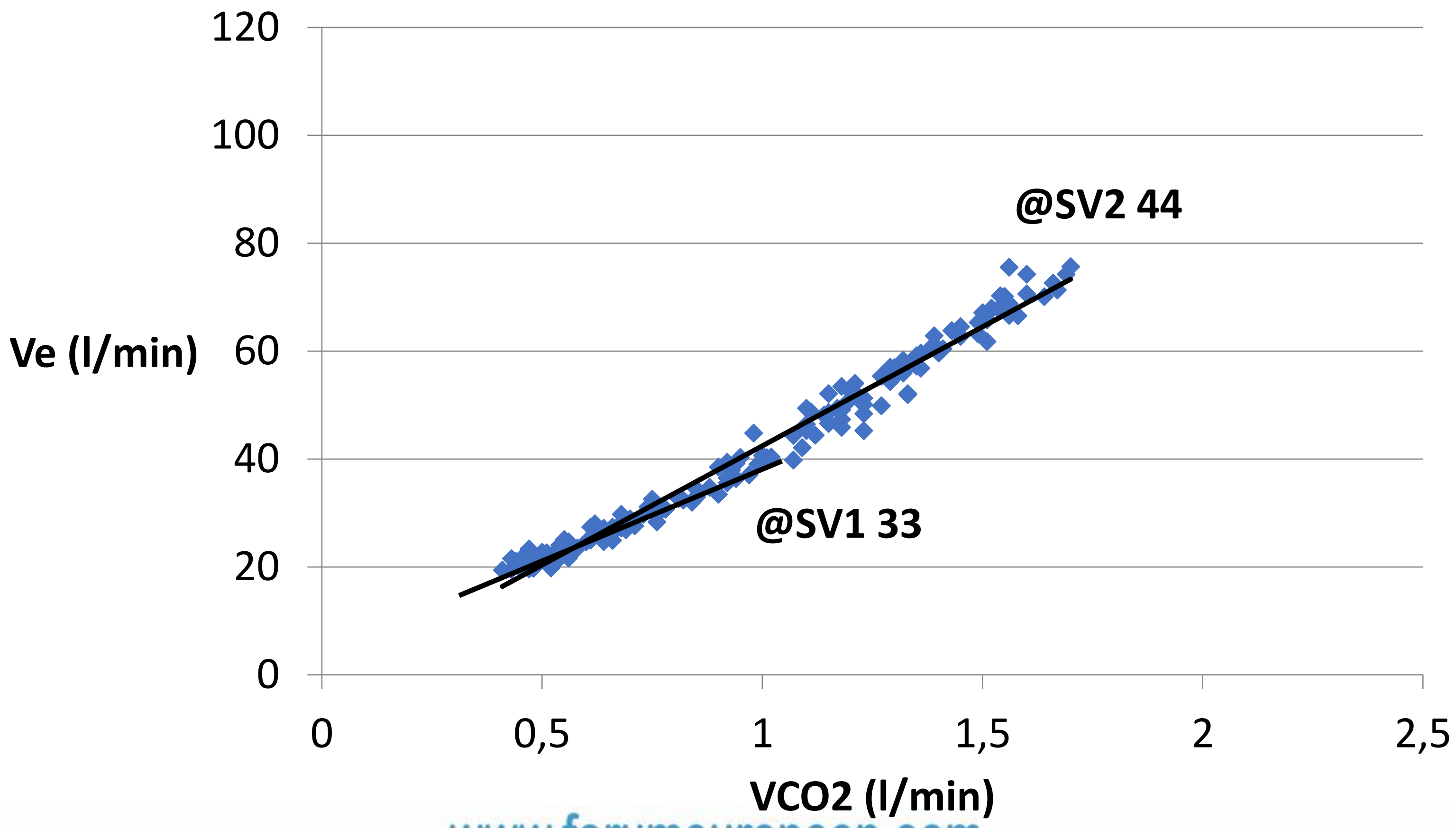
<30 considered normal with slight increase with advanced age possible



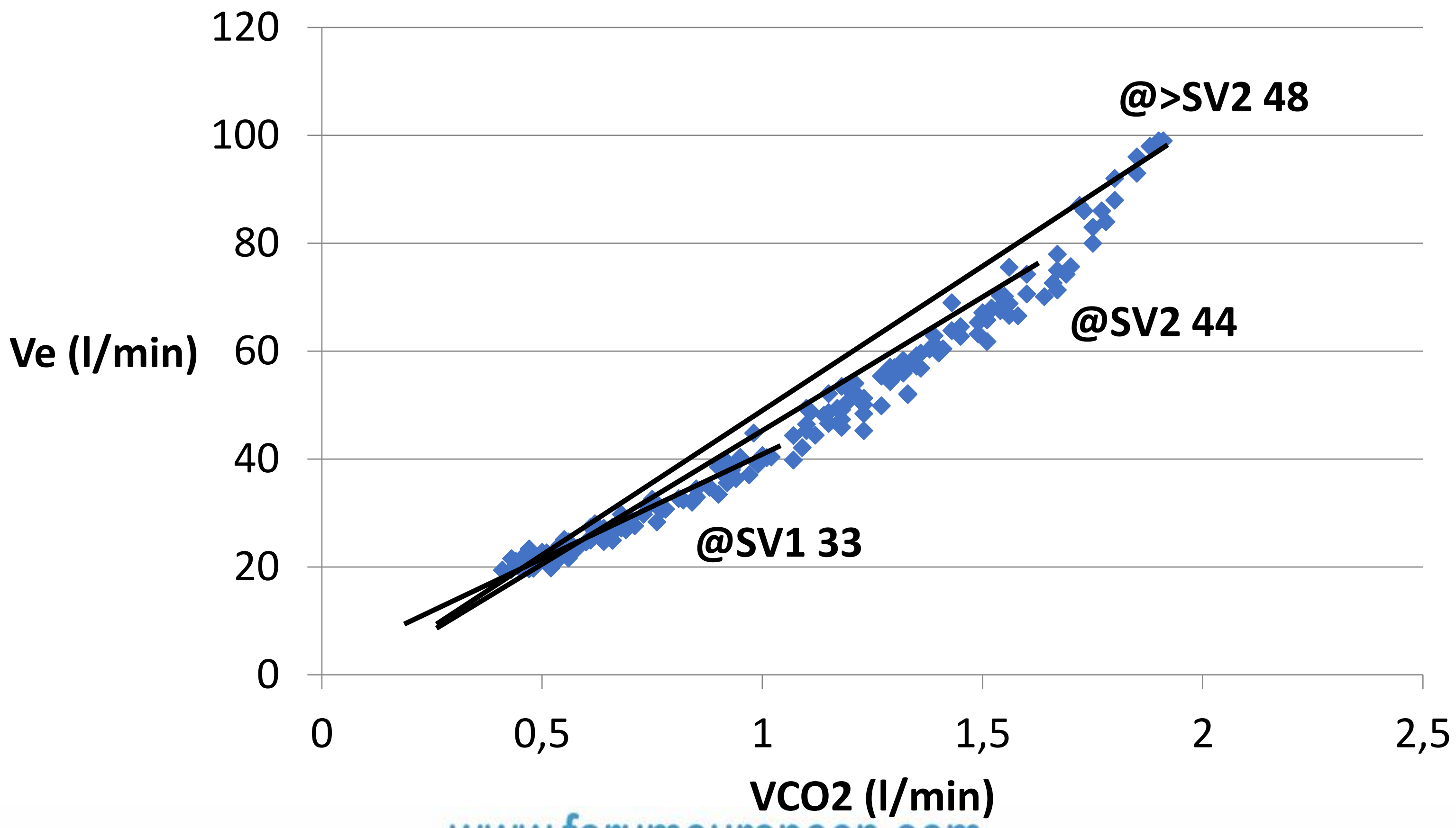
NB :
Très reproductible
Pas influencé par le type d'effort
Pas influencé par l'incrément de charge utilisé

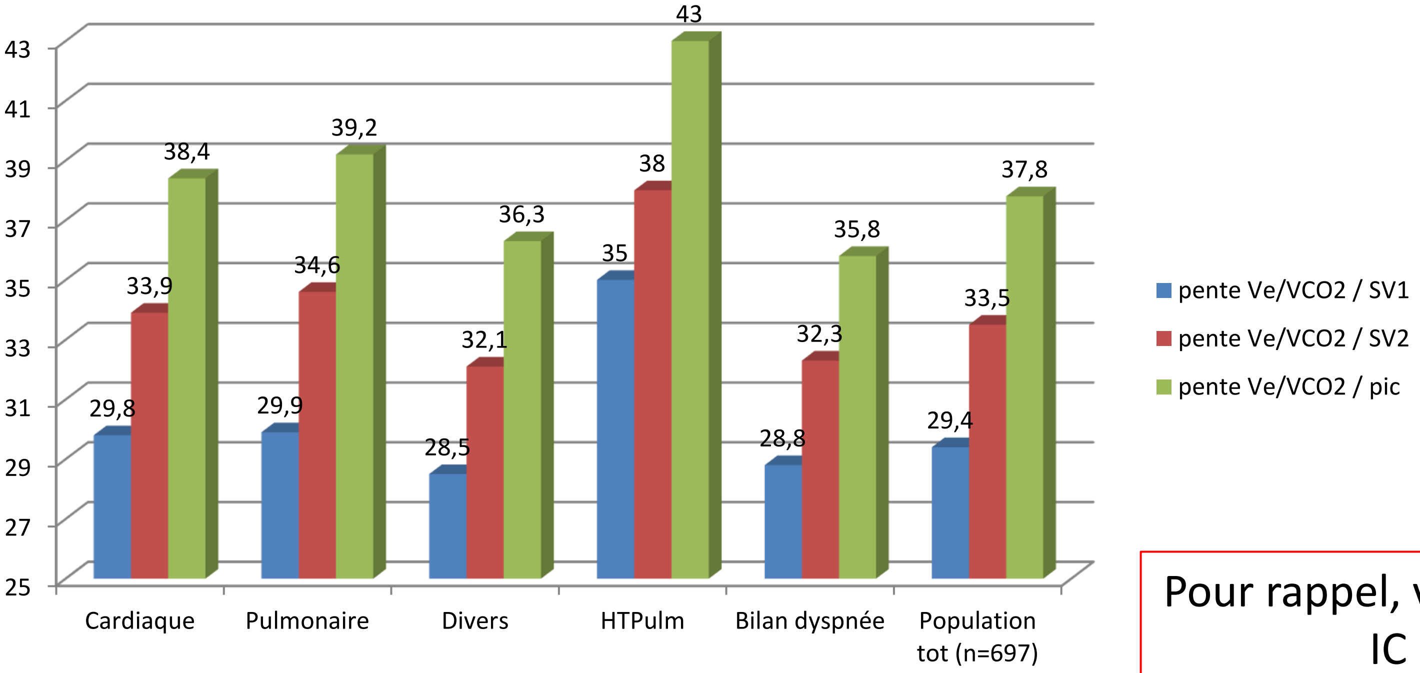

Pente Ve/VCO2 jusqu'à SV1
120
100
80
60
40
20
0
Ve (l/min)
@ SV1 33
0
0,5
1
1,5
2
2,5
VCO2 (l/min)

Pente Ve/VCO2 jusqu'à SV2



Pente Ve/VCO2 sur tous les points





Pour rappel, valeurs « cut off :

IC : 34-35

« HTP » : 54-55

healthcare

MDPI

Article

How Does the Method Used to Measure the VE/VCO_2 Slope Affect Its Value? A Cross-Sectional and Retrospective Cohort Study

Martin Chaumont *,†, Kevin Forton †, Alexis Gillet, Daryl Tcheutchoua Nzokou and Michel Lamotte

Différences importantes en fonction de la méthode de mesure

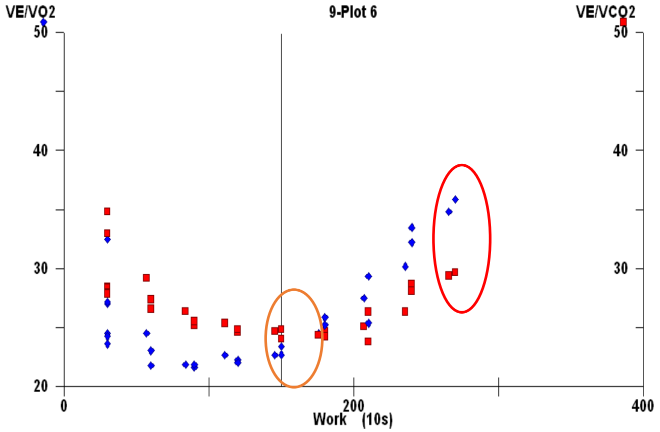
→ 1 : Obtenir un test « réellement » maximum

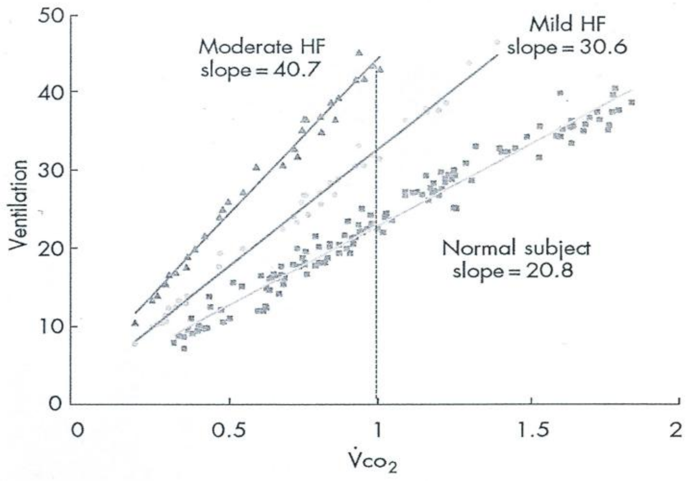
→ 2 : expliciter comment est faite la mesure :

- → pente Ve/VCO2 mesurée jusqu'à SV2
- → Pente Ve/VCO2 mesurée sur l'entièreté de l'effort (SV2 dépassé)

→ 3 : exprimer la valeur en « % de valeur prédite » (âge, sexe ?)

! Ve/VCO2 (ERCO2) ←→ pente Ve/VCO2





= point isolé

@ SV1 = efficacité du système

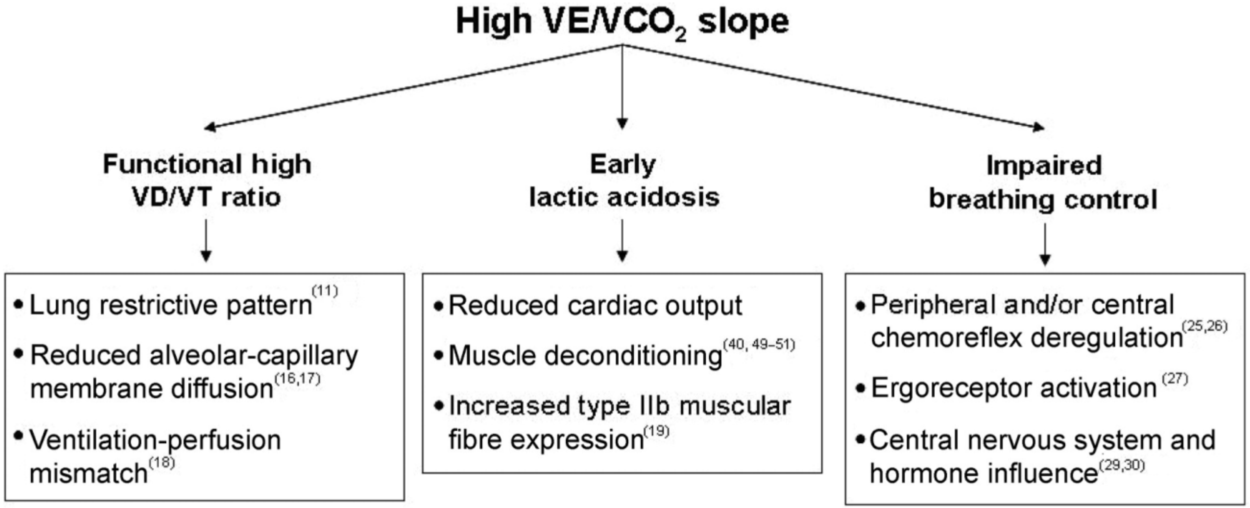
Pet CO2 = 40 mmHg = 5,3 KPa

@ max : Hyperventilation en fin d'effort ?

→ Tributaire du patient / investigateur

= réponse ventilatoire globale, sur l'ensemble du test (peu sensible à la motivation)

→ Témoin pronostique



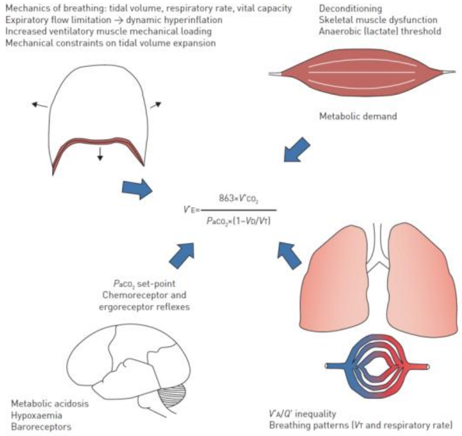
pronostic

Pulmonaire

Périphérique
Central (cardiaque)

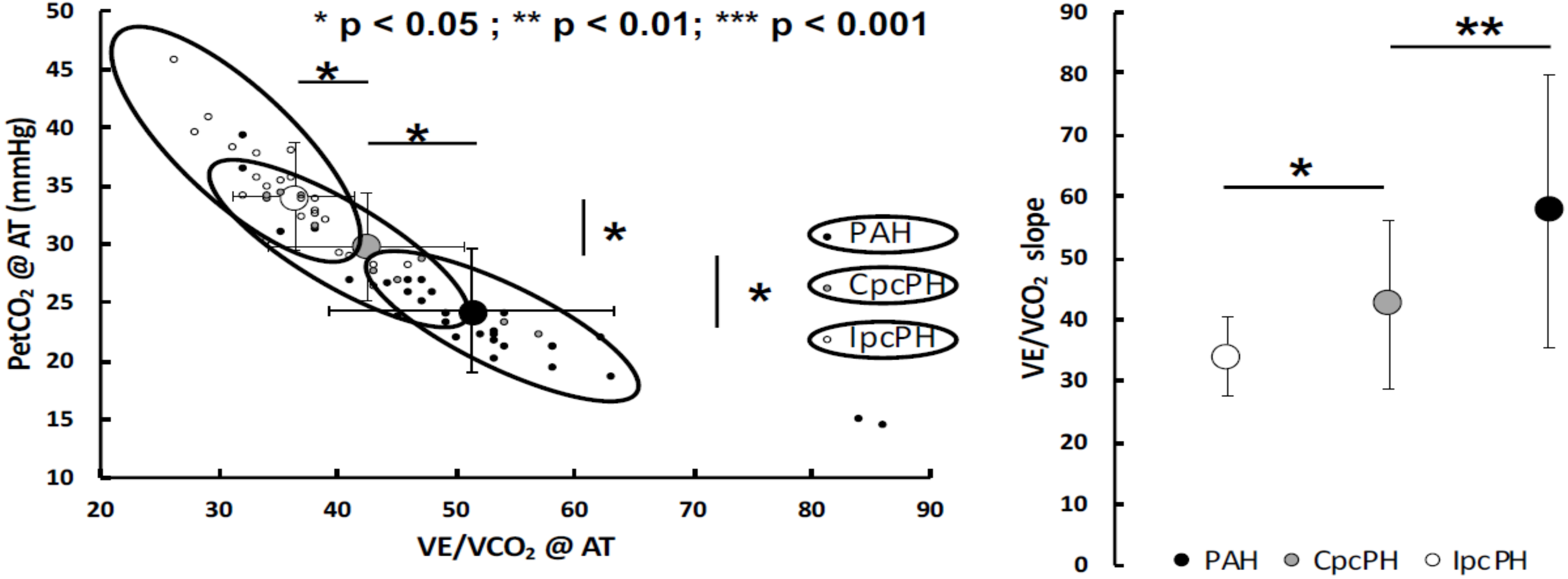
Central (cérébral)

Tumminello Eur Heart J 2007



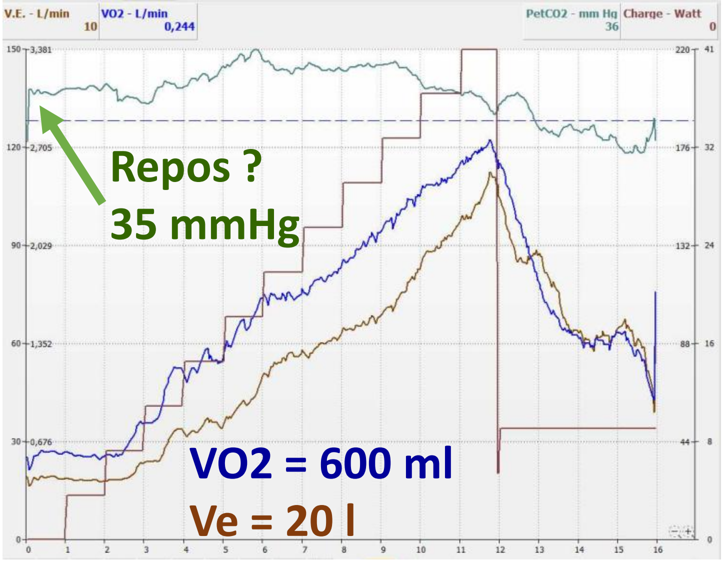
Weatherald, Eur Resp J, 2018

Lien PetCO2@SV1, ERCO2@SV1 et pente Ve/VCO2



Caravita S et al. J Heart Lung Transplant 2016; 36: 754-762

- Hyperventilation au repos ? (ERO2 ou PetCO2 ?)
- Valeurs au pic de l'effort ? (ERO2, ERCO2) ?
  - Plutôt critère de maximalité ?
  - Tributaire du patient (motivation) ou de l'investigateur (motivation)



ERCO2@SV1 et « maladies pulmonaires »

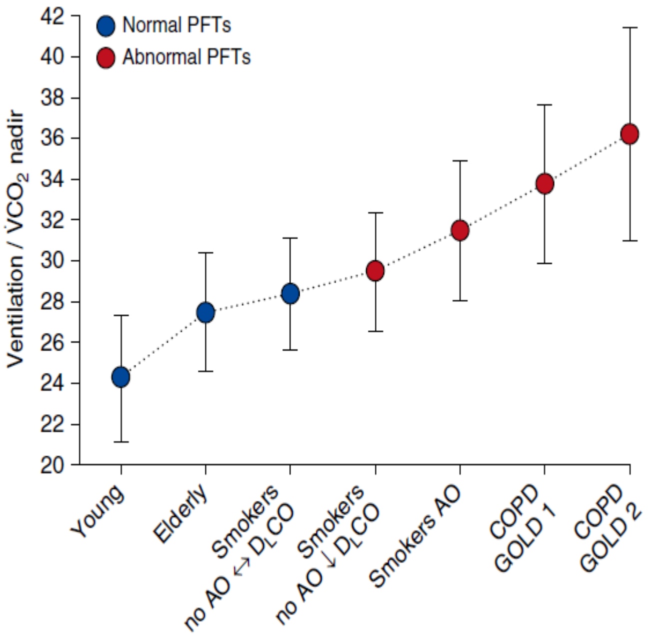


Figure 1. Average effect of senescence (19–21), chronic smoking (34–37), mild chronic obstructive pulmonary disease (COPD) (38–44), and moderate COPD (45–47) on $\dot{V}_E/\dot{V}_{CO_2}$, a metric of exercise ventilatory inefficiency. The modulating influence of airflow obstruction (AO) (35, 36) and decrements (*downward arrow*) in lung diffusing capacity for carbon monoxide (D_{LCO}) (37) in smokers are also shown. Values are mean ± SD as obtained from each data source. GOLD = Global Initiative for Chronic Obstructive Lung Disease; PFT = resting pulmonary function test.

MAIS

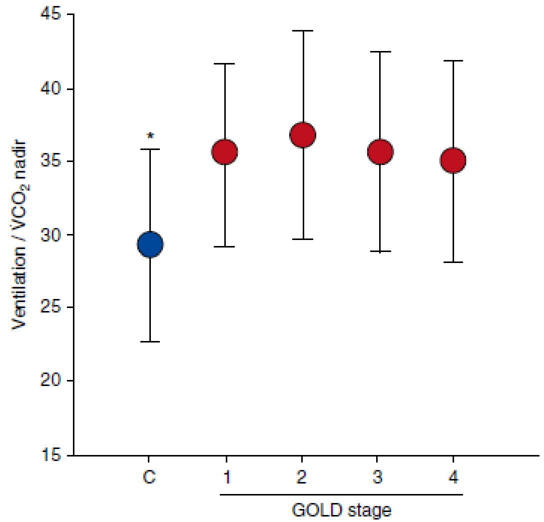


Figure 5. Increased ventilation/$\dot{V}_{CO_2}$ nadir (a metric of ventilatory inefficiency) across the stages of chronic obstructive pulmonary disease severity according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) spirometry stages. *C* represents age- and sex-matched healthy control subjects. $^*P < 0.05$: control subjects versus patients (all stages). Adapted by permission from Reference 45.

Neder, annals ATS 2017

Conclusion

- A quoi ça sert ?
  - Efficacité ventilatoire, détermination SV1 / SV2
- Précautions d'interprétations
  - Repos, @SV1 (ERO2), @SV2 (ERCO2), Max
- Facteurs liés
  - PetCO2@SV1, pente Ve/VCO2
  - Valeurs très spécifiques aux populations

Merci pour votre attention

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Détermination des seuils : SV1-SV2

V-slope

ERO2 / ERCO2

PetO2, PetCO2

QR