Ergospirometri vid pulmonell hypertension

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Innehåll

- Ergospirometriska fynd vid PH/PAH
- Ergospirometri för prognostik vid PAH (enligt guidelines)
- Vidare läsning

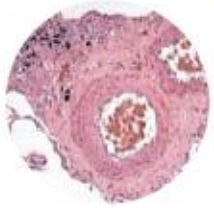
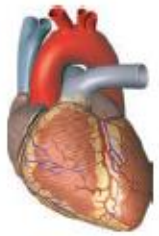
Pulmonell hypertension (PH)
Pulmonell arteriell hypertension (PAH)

Pulmonell hypertension (PH) definieras som:

medeltryck i a pulmonalis (mPAP) >20 mmHg

Pulmonell arteriell hypertension (grupp 1 PH),
vid PH med förändringar i lungans små artärer.

CLINICAL CLASSIFICATION

Pulmonary arterial hypertension (PAH)	PH associated with left heart disease	PH associated with lung disease	PH associated with pulmonary artery obstructions	PH with unclear and/or multifactorial mechanisms
				?
• Idiopathic/heritable • Associated conditions	• IpcPH • CpcPH	• Non-severe PH • Severe PH	• CTEPH • Other pulmonary obstructions	• Haematological disorders • Systemic disorders

PREVALENCE

Rare	Very common	Common	Rare	Rare
				

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Humbert m.fl. European Heart Journal (2022) 43, 3618–3731, sid 3657.

Ergospirometriska fynd vid PH/PAH

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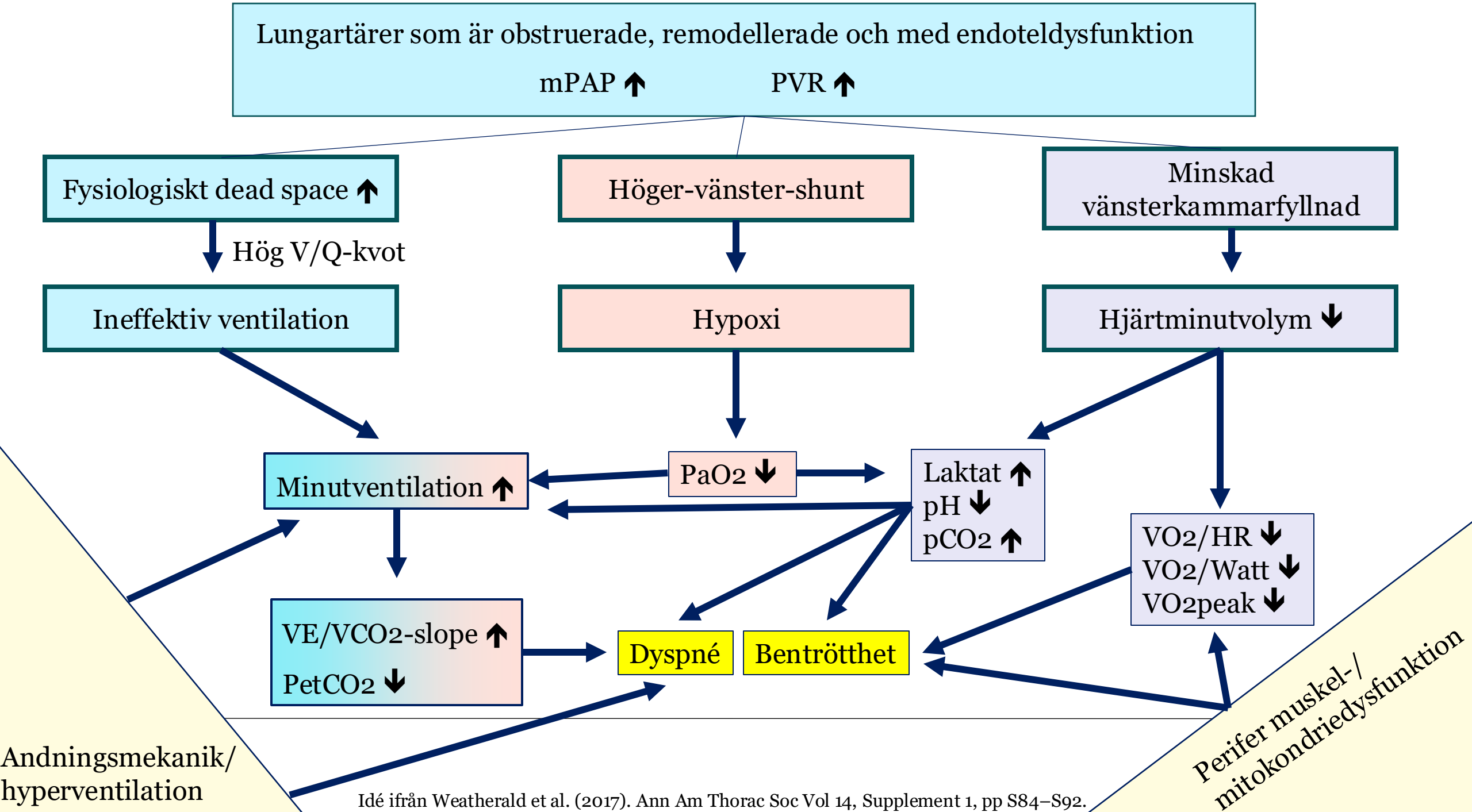
Varför ergospirometri vid PH?

1. **Utredning av oklar dyspné** → differentialdiagnostik/diagnostik

2. **Vid etablerad sjukdom**:
    1. Prognosvärdering
    2. Uppföljning
    3. Utvärdera behandlingseffekt



Idé ifrån Weatherald et al. (2017). Ann Am Thorac Soc Vol 14, Supplement 1, pp S84–S92.

Således vid PH/PAH:

- Bild som vid **cirkulatorisk begränsning** av arbetsförmågan:
  - Sänkt VO2peak
  - Låg/flack VO2/HR (syrepuls)
  - Låg anaerob/ventilatorisk tröskel
  - Normal ventilationsreserv

- Jämfört med en typisk vänstersidig hjärtsvikt:
  - Vid PH - vanligare med (kraftig) desaturation
  - Vid PH – oftast högre VE/VCO2-slope
  - Vid PH – oftast lägre PetCO2

Således vid PH/PAH:

ESC European Society of Cardiology
European Heart Journal (2022) 43, 3618–3731
https://doi.org/10.1093/eurheartj/ehac237
ESC/ERS GUIDELINES

2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension

5.1.11. Cardiopulmonary exercise testing

…

Patients with PAH show a typical pattern, with

- a low end-tidal partial pressure of carbon dioxide (PETCO2),
- high ventilatory equivalent for carbon dioxide (VE/VCO2),
- low oxygen pulse (VO2/HR), and
- low peak oxygen uptake (VO2).

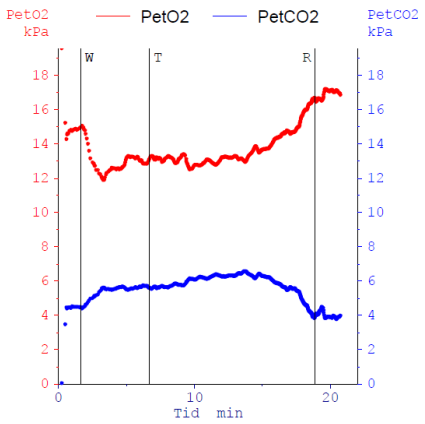
These findings should prompt consideration of pulmonary vascular disease. In patients with left-sided heart disease or COPD, such a pattern may indicate an additional pulmonary vascular limitation.

In populations at risk of PAH, such as those with systemic sclerosis, a normal peak VO2 seems to exclude the diagnosis of PAH.

Humbert m.fl. European Heart Journal (2022) 43, 3618–3731, sid 3657.

PetCO2

PetCO2



N=52 CPET
”Primary PH”

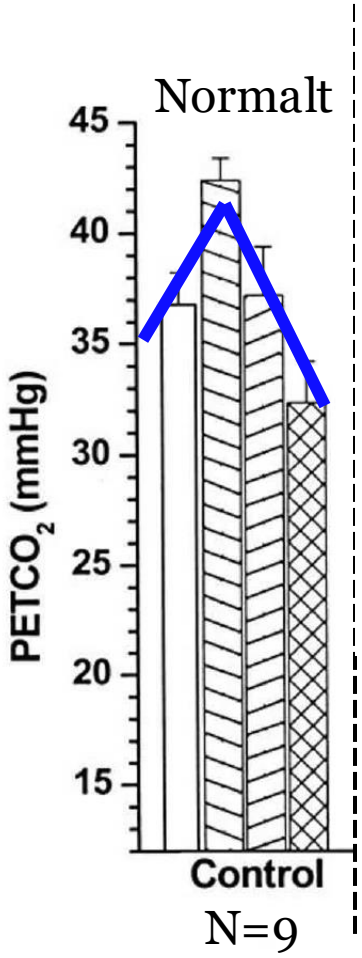


FIGURE 2. $PETCO_2$ at rest, AT, peak $\dot{V}O_2$, and recovery in relation to physiologic severity in 52 patients with PPH (4 mild, 17 moderate, 21 severe, and 10 very severe) and 9 normal control subjects. $PETCO_2$ was significantly reduced as related to severity at all stages of exercise compared to control. $PETCO_2$ increased in control subjects, but decreased in PPH patients except for the mild group at AT. In

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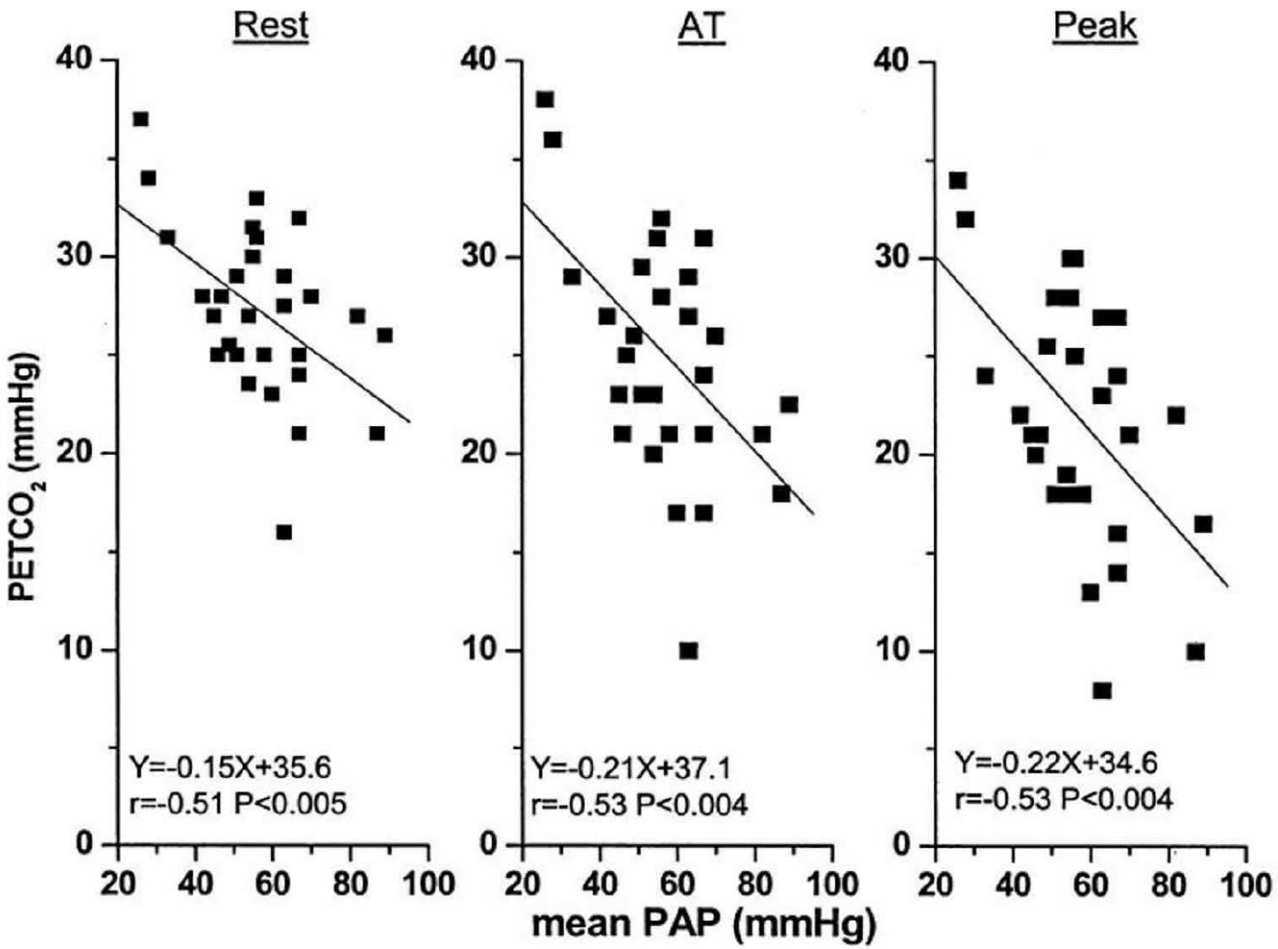
Yasonubo m.fl. CHEST 2005; 127:1637–1646

PetCO2 korrelerar (negativt) med mPAP



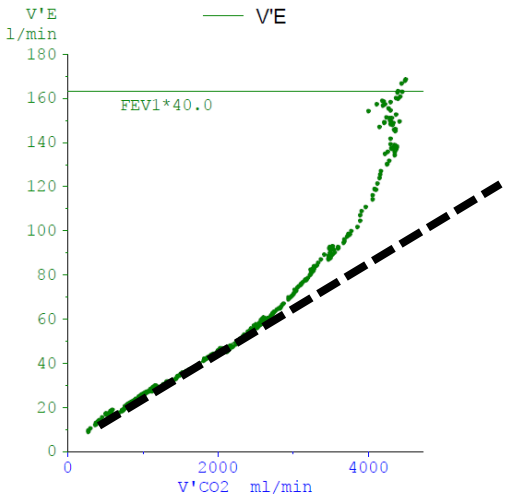
N=29 CPET+
hö hjärtkat

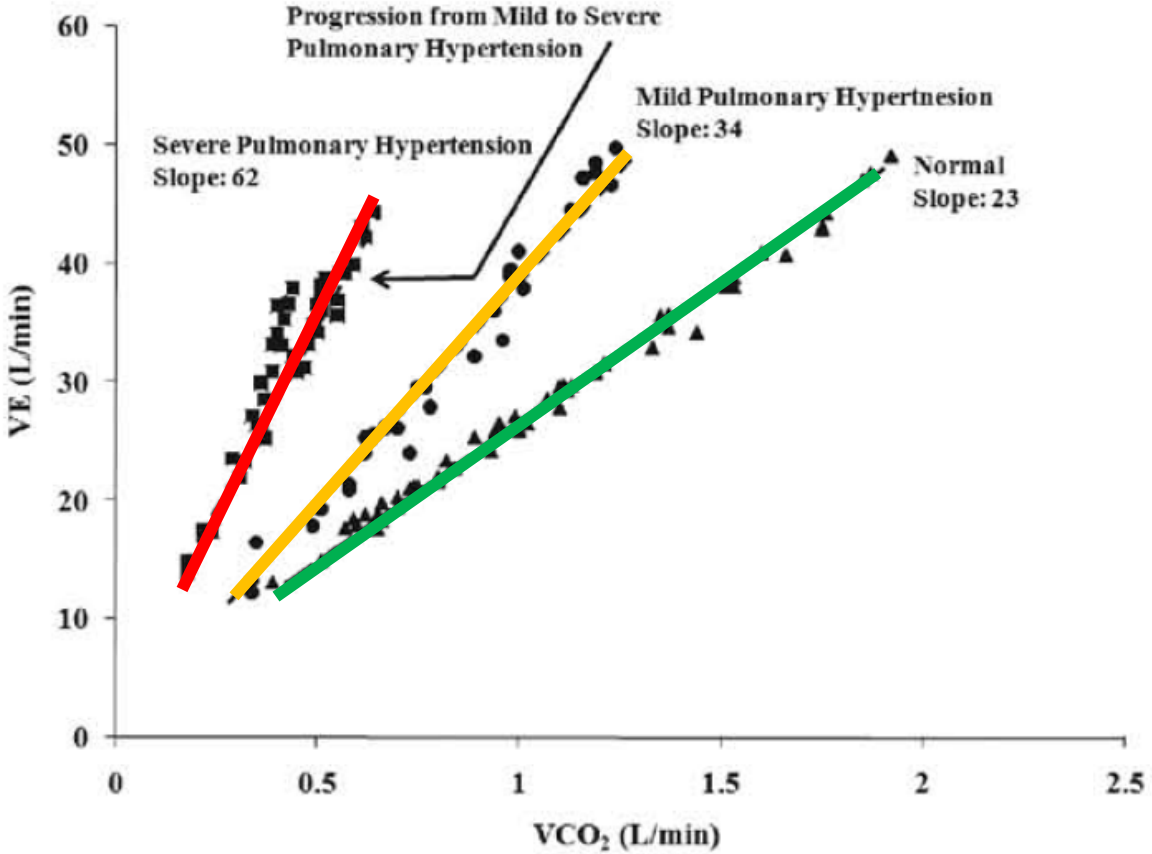
FIGURE 7. Correlation of P_{ETCO_2} at rest, AT, and peak exercise with mPAP in the 29 PPH patients who underwent diagnostic right-heart catheterization within 50 days of the CPET. See Figure 6 legend for expansion of abbreviation.

Yasonubo m.fl. CHEST 2005; 127:1637–1646

VE/VCO2-slope

VE/VCO2-slope stiger med allvarligare PH





Arena m.fl. J Heart Lung Transplant 2010;29:159–73 (Review)

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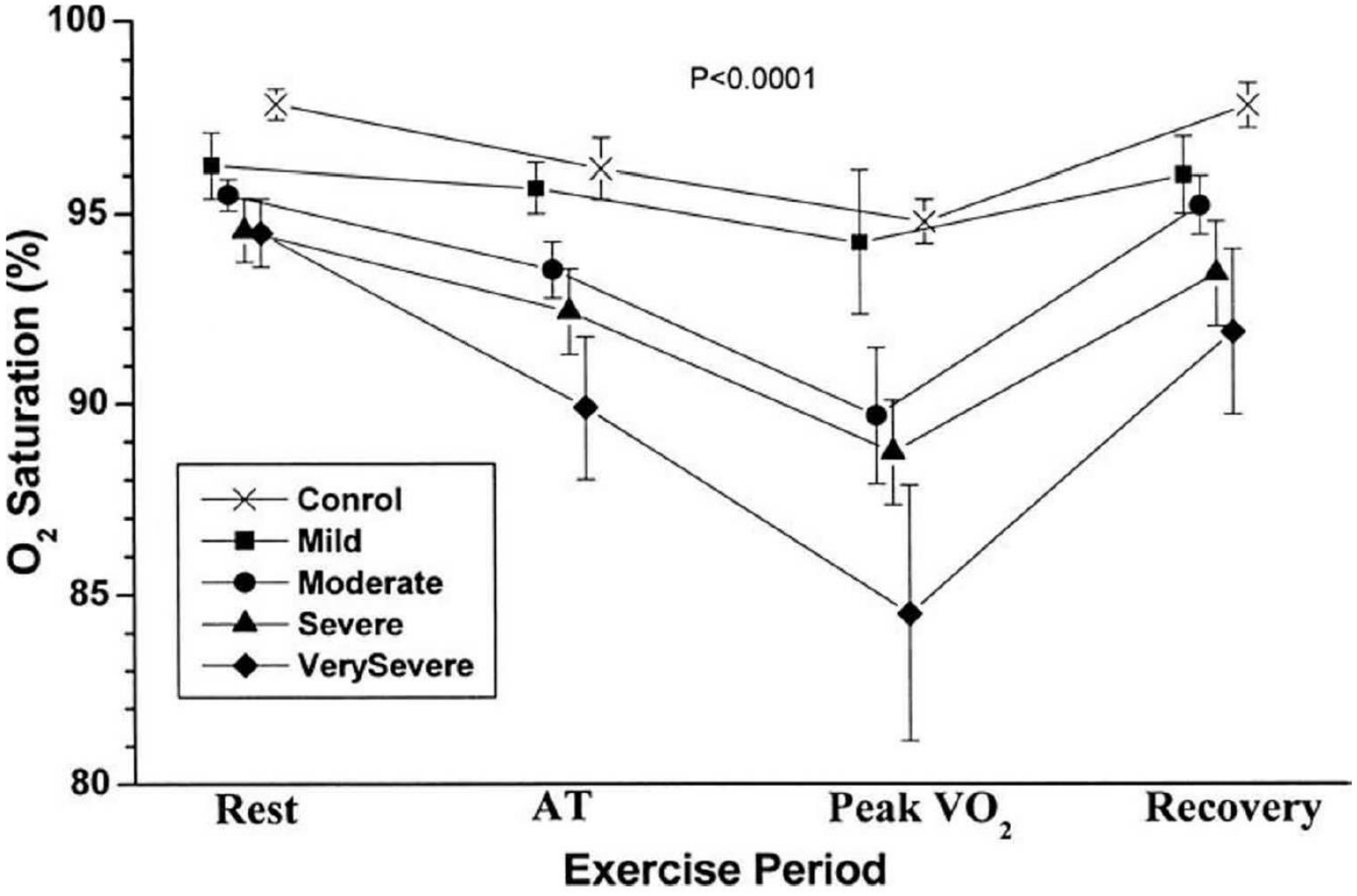
Desaturation

Desaturation / hypoxi

- Dels ev. höger → vänster-shunt

- Men förstås kanske framför allt:
  - Minskad funktionell pulmonell kapillärryta (destruktion, ocklusion)
  - Visar sig under arbete p.g.a. ökad hjärtminutvolym
    → kortare transittid för röda blodkroppar i lungkärlbädden
    → dessa hinner ej mättas med O2



Yasonubo m.fl. CHEST 2005; 127:1637–1646

Ergospirometri och prognostik vid PAH

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ESC European Society of Cardiology European Heart Journal (2022) 43, 3618–3731 https://doi.org/10.1093/eurheartj/ehac237

ESC/ERS GUIDELINES

Nuvarande guidelines

2022 ESC/ERS Guidelines for the diagnosis and treatment of pulmonary hypertension

Table 16 Comprehensive risk assessment in pulmonary arterial hypertension (three-strata model)

Determinants of prognosis (estimated 1-year mortality)	Low risk (<5%)	Intermediate risk (5–20%)	High risk (>20%)
Clinical observations and modifiable variables			
Signs of right HF	Absent	Absent	Present
Progression of symptoms and clinical manifestations	No	Slow	Rapid
Syncope	No	Occasional syncope[a]	Repeated syncope[b]
WHO-FC	I, II	III	IV
6MWD[c]	>440 m	165–440 m	<165 m
CPET	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	Peak VO_2 <11 mL/min/kg (<35% pred.) VE/VCO_2 slope >44

VO2peak

VE/VCO2-slope →

Humbert m.fl. European Heart Journal (2022) 43, 3618–3731, sid 3657.

Nuvarande guidelines

- Sid 3658: ”Robust prognostic evidence for peak VO2 and VE/VCO2 has been found in three studies, all powered for multivariable analysis.[261–263]

261. **Badagliacca** R, Papa S, Poscia R, Valli G, Pezzuto B, Manzi G, et al. The added value of cardiopulmonary exercise testing in the follow-up of pulmonary arterial hypertension. J Heart Lung Transpl 2019;38:306–314.

262. **Deboeck** G, Scoditti C, Huez S, Vachiery JL, Lamotte M, Sharples L, et al. Exercise testing to predict outcome in idiopathic versus associated pulmonary arterial hypertension. Eur Respir J 2012;40:1410–1419.

263. **Wensel** R, Francis DP, Meyer FJ, Opitz CF, Bruch L, Halank M, et al. Incremental prognostic value of cardiopulmonary exercise testing and resting haemodynamics in pulmonary arterial hypertension. Int J Cardiol 2013;167:1193–1198.

Humbert m.fl. European Heart Journal (2022) 43, 3618–3731.

ELSEVIER

The Journal of Heart and Lung Transplantation

http://www.jhltonline.org

The added value of cardiopulmonary exercise testing in the follow-up of pulmonary arterial hypertension

Roberto Badagliacca, MD, PhD,[a,1] Silvia Papa, MD,[a,1] Roberto Poscia, MD,[a] Gabriele Valli, MD,[a] Beatrice Pezzuto, MD,[a] Giovanna Manzi, MD,[a] Roberto Torre, RN, MSN,[a] Daniele Gianfrilli, MD,[b] Susanna Sciomer, MD,[a] Paolo Palange, MD,[c] Robert Naeije, MD,[d] Francesco Fedele, MD,[a] and Carmine Dario Vizza, MD[a]

"We therefore investigated the prognostic relevance of CPET variables added to clinical and hemodynamic assessment in the follow-up of stable PAH patients with satisfactory clinical and hemodynamic responses to targeted therapies."

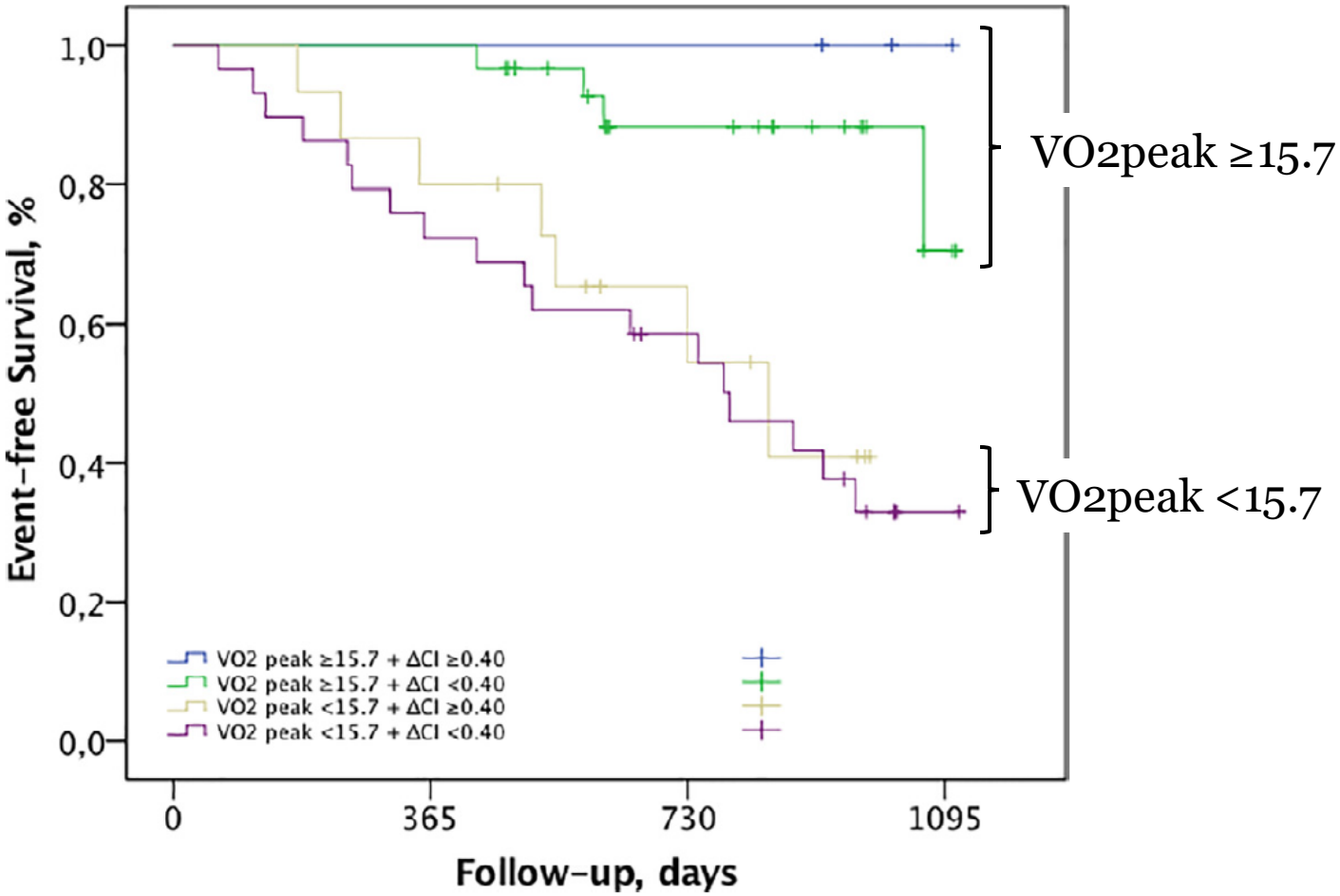

Figure 3 Kaplan–Meier event-free survival curves of the 4 groups of patients, based on the combination of cut-off values of peak VO_2 and ΔCI. Group 1 and 2 patients had a significantly better prognosis compared with Group 3 and 4 patients (Group 1 vs Group 2, p = not statistically significant [NS]; Group 1 vs Group 3, $p = 0.01$; Group 1 vs Group 4, $p = 0.005$; Group 2 vs Group 3, $p = 0.01$; Group 2 vs Group 4, $p = 0.005$; Group 3 vs Group 4, p = NS). ΔCI, change in cardiac index from diagnosis.

N=80 derivation cohort
N=80 validation cohort

Outcome: Clinical worsening or death
- 6MWD ↓ by 15% (confirmed by 2 tests within 2 weeks) plus worsening of WHO FC
- non-elective hospitalization for PAH
- all-cause mortality

Kombinationer av VO2peak + ΔCI
(ΔCI = förändring i cardiac index under uppföljning)

Ingen med VO2peak >19 ml/kg/min dog under uppföljningen.

Badagliacca R m.fl. J Heart Lung Transpl 2019;38:306–314.

Eur Respir J 2012; 40: 1410–1419
DOI: 10.1183/09031936.00217911

Exercise testing to predict outcome in idiopathic *versus* associated pulmonary arterial hypertension

Gaël Deboeck*, Cristina Scoditti#, Sandrine Huez*, Jean-Luc Vachiéry*, Michel Lamotte*, Linda Sharples¶, Christian Melot+ and Robert Naeije§

"The purpose of the present study is to evaluate the prognostic value of CPET variables and 6MWT in IPAH versus APAH, and to determine their ability not only to predict survival, but also TTCW".

- 6MWD
- VO2peak
- VE/VCO2-slope

- VO2 vid anaerob tröskel
- VE/VCO2 vid anaerob tröskel

N=136 (85 idiopatisk, 51 associerad)

Outcome: Clinical worsening or death

- 6MWD ↓ by 15% (confirmed by 2 tests within 2 weeks) plus worsening of WHO FC
- non-elective hospitalization for PAH
- lung transplantation
- all-cause mortality

Deboeck m.fl. Eur Respir J 2012;40:1410–1419.

TABLE 4 Receiver operating characteristics for death at 4 yrs for pulmonary arterial hypertension (PAH) cohort and idiopathic PAH (IPAH) and PAH with associated conditions (APAH) subgroups

Variables	PAH		IPAH		APAH#	
	AUC % (95% CI)	p-value	AUC % (95% CI)	p-value	AUC % (95% CI)	p-value
Subjects n	136		70		66	
Peak V'_{O_2} mL·kg^{-1}·min^{-1}	73.2 (63.8–82.6)	<0.001	71.9 (58.0–85.9)	0.007		
$V'_{O_2,at}$ mL·kg^{-1}·min^{-1}	69.0 (58.6–79.3)	0.001	71.8 (57.9–85.7)	0.007		
$V'_E/V'_{CO_2,at}$	69.8 (59.7–80.0)	0.001	69.5 (54.6–84.4)	0.017	Not calculated	
V'_E/V'_{CO_2} slope	63.9 (51.3–76.5)	0.033	65.7 (49.3–82.0)	0.054		
6MWD m	73.1 (62.2–84.0)	<0.001	78.0 (63.6–92.4)	0.001		

AUC: area under the curve; V'_{O_2}: oxygen consumption; $V'_{O_2,at}$: V'_{O_2} at anaerobic threshold; V'_E: minute ventilation; V'_{CO_2}: carbon dioxide production; $V'_E/V'_{CO_2,at}$: ventilatory equivalent for carbon dioxide at the anaerobic threshold; 6MWD: 6-min walk distance. #: no receiver operating characteristic curve was calculated in the APAH subgroup.

TABLE 6 Receiver-operating characteristics at 2 yrs for clinical worsening for pulmonary arterial hypertension (PAH) cohort and idiopathic PAH (IPAH) and PAH with associated conditions (APAH) subgroups

Variables	PAH		IPAH		APAH#	
	AUC % (95% CI)	p-value	AUC % (95% CI)	p-value	AUC % (95% CI)	p-value
Subjects n	136		70		66	
Peak V'_{O_2} mL·kg^{-1}·min^{-1}	73.9 (65.6–82.2)	<0.001	77.8 (66.9–88.7)	<0.001		
$V'_{O_2,at}$ mL·kg^{-1}·min^{-1}	71.0 (62.2–79.8)	<0.001	72.0 (59.9–84.2)	0.001		
$V'_E/V'_{CO_2,at}$	70.3 (61.5–79.1)	<0.001	69.3 (56.9–81.6)	0.005		
V'_E/V'_{CO_2} slope	65.5 (55.5–75.6)	0.003	69.0 (57.5–81.5)	0.005	Not calculated	
$P_{ET,CO_2,at}$	67.4 (57.8–77.1)	0.001	69.0 (56.4–81.5)	0.007		
O_{2pulse} mL·beat^{-1}	62.8 (53.3–72.3)	0.010	59.5 (46.6–72.3)	0.168		
ΔO_{2pulse} mL·beat^{-1}	66.3 (57.1–75.4)	0.001	67.0 (54.9–79.1)	0.013		
6MWD m	69.6 (60.8–78.5)	<0.001	73.0 (61.9–84.2)	0.001		

AUC: area under the curve; peak V'_{O_2}: peak oxygen consumption; $V'_{O_2,at}$: V'_{O_2} at anaerobic threshold; V'_E: minute ventilation; V'_{CO_2}: carbon dioxide production; $V'_E/V'_{CO_2,at}$: ventilatory equivalent for carbon dioxide at the anaerobic threshold; $P_{ET,CO_2,at}$: end-tidal carbon dioxide tension measured at the anaerobic threshold; $\Delta P_{ET,CO_2}$: change in end-tidal carbon dioxide tension between rest and peak exercise; O_{2pulse}: oxygen pulse; ΔO_{2pulse}: change in the $O_{2,pulse}$ between rest and peak exercise; 6MWD: 6-min walk distance. #: no receiver operating characteristic curve was calculated in the APAH subgroup.

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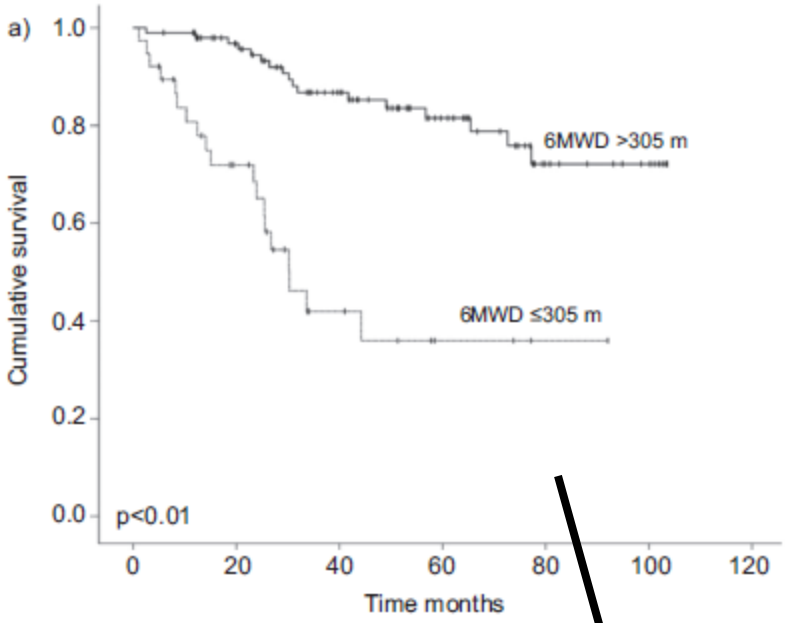
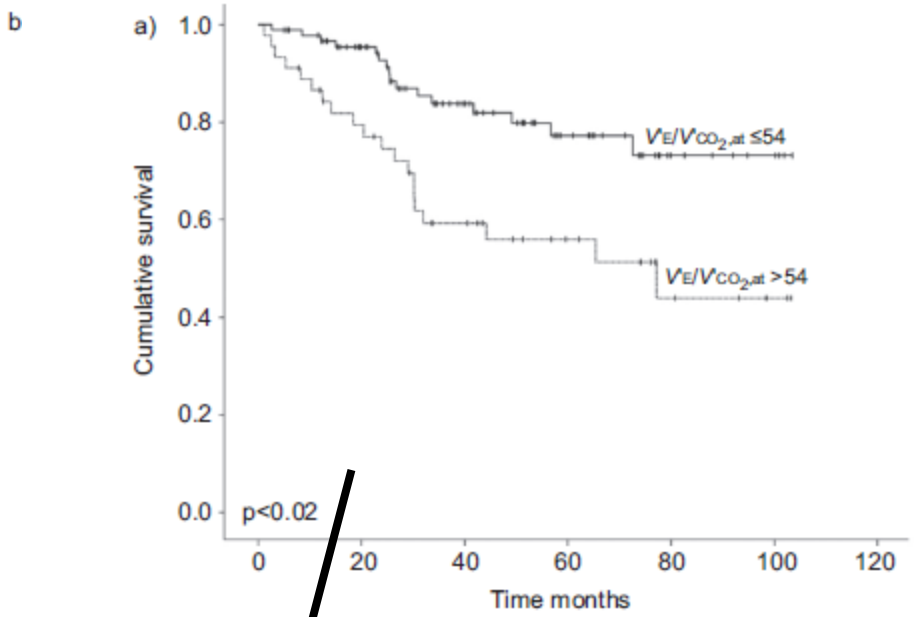
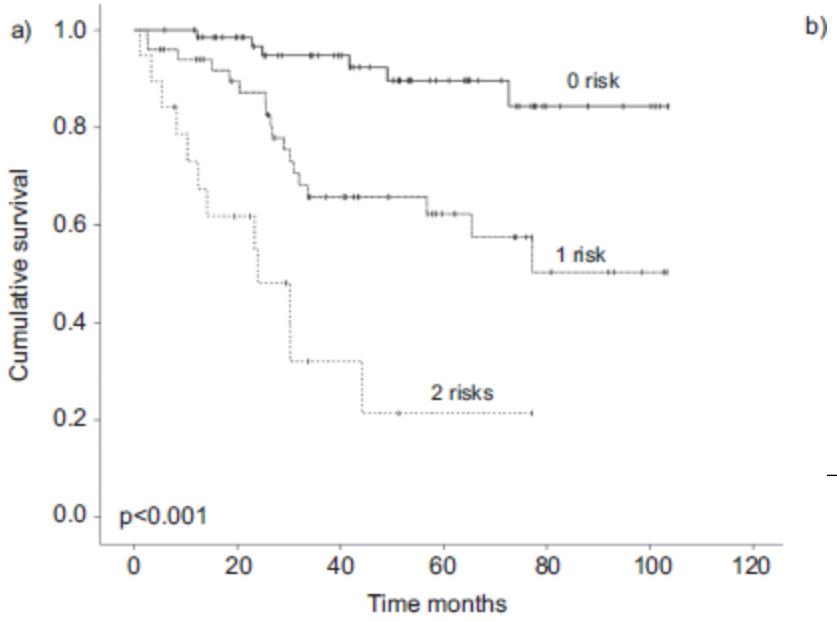
Deboeck m.fl. Eur Respir J 2012;40:1410–1419.



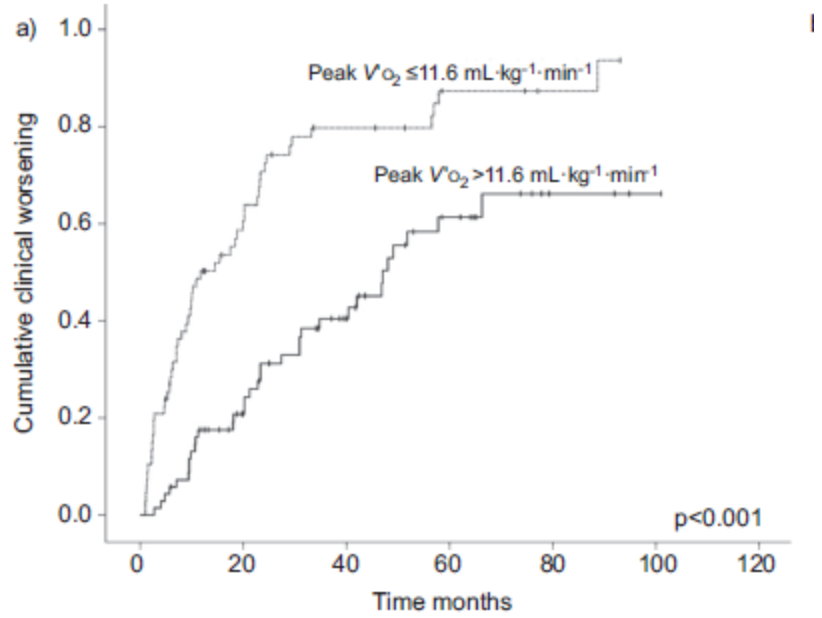




b)

Överlevnad
(för alla 136 patienter)

Deboeck m.fl. Eur Respir J 2012;40:1410–1419.



Clinical worsening
(för alla 136 patienter)

Tröskelvärde VO2peak: 11.6 ml/kg/min

Deboeck m.fl. Eur Respir J 2012;40:1410–1419.

"…**clinical stability is better predicted in IPAH than in APAH**
and that, for this purpose, **peak VO2 may be superior to the 6MWT**."

"…our study documents the importance of **VE/VCO2** as an outcome predictor **independently associated with survival** and also **able to predict TTCW in PAH and IPAH**."

Deboeck m.fl. Eur Respir J 2012;40:1410–1419.

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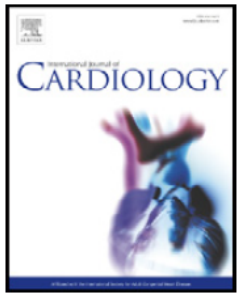


Incremental prognostic value of cardiopulmonary exercise testing and resting haemodynamics in pulmonary arterial hypertension

Roland Wensel [a,b,*], Darrel P. Francis [a], F. Joachim Meyer [c], Christian F. Opitz [d], Leonhard Bruch [e], Michael Halank [f], Jörg Winkler [g], Hans-Jürgen Seyfarth [h], Sven Gläser [i], Friedrich Blumberg [j], Anne Obst [i], Michael Dandel [k], Roland Hetzer [k], Ralf Ewert [i]

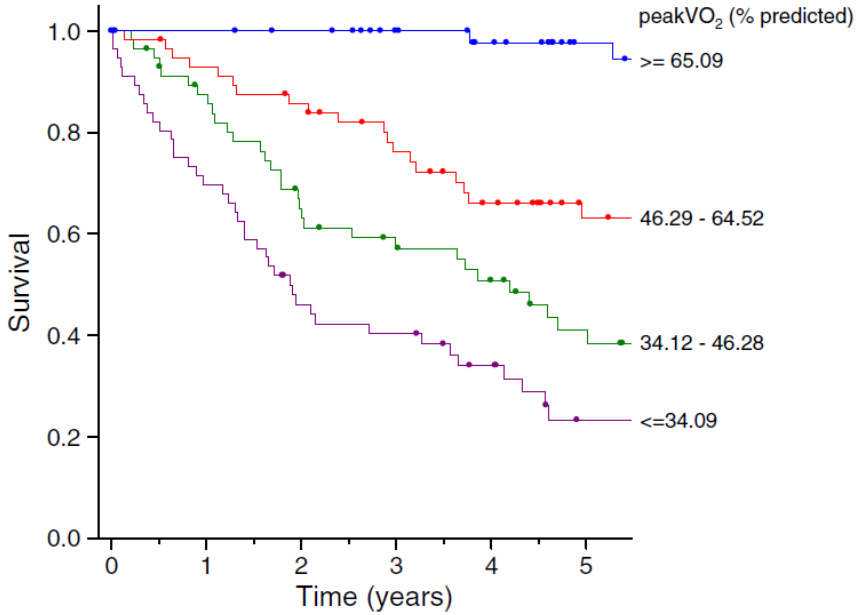
"The aim of the current study was to investigate the potential incremental prognostic value of the combined use of CPET derived parameters and resting haemodynamic parameters in a large cohort of patients with idiopathic or familial PAH in a multicentre setting".

- PVR
- VO2peak (% av fv)
- Hjärtfrekvensökning

N=226 (IPAH or familiar PAH)

Outcome: all-cause mortality or urgent transplantation

Wensel m.fl. Int J Card 2013;167:1193-1198



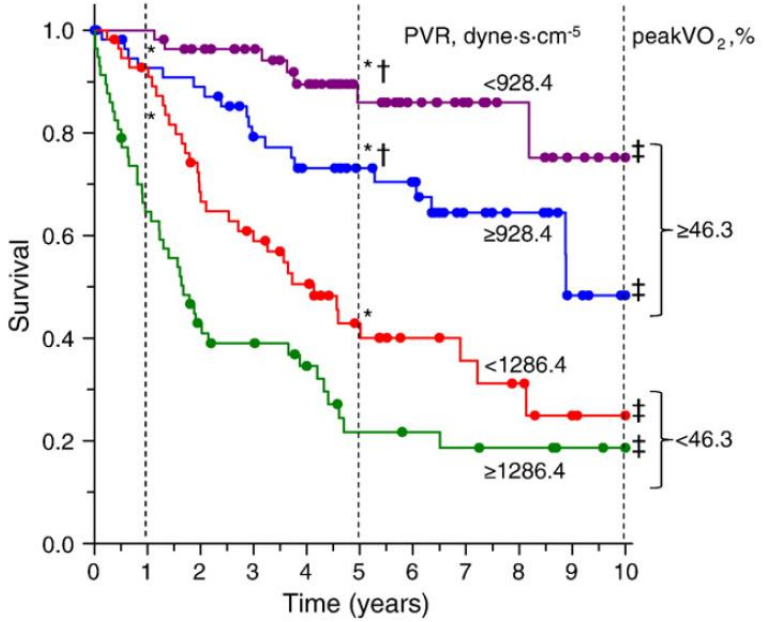


Fig. 5. Cumulative survival according to peak VO_2 and PVR. *Adjusted p-value<0.001 vs. low (<46.3%) peak VO_2 and high (≥928.4 dyn·s·cm^{-5}) PVR subgroup. †Adjusted p-value<0.01 vs. low (<46.3%) peak VO_2 and low (<928.4 dyn·s·cm^{-5}) PVR subgroup. ‡Adjusted p-value<0.05 for all pairwise comparison.

% av förväntat VO2peak + PVR

Wensel m.fl. Int J Card 2013;167:1193-1198

Nuvarande PH-guidelines

Table 16 Comprehensive risk assessment in pulmonary arterial hypertension (three-strata model)

Determinants of prognosis (estimated 1-year mortality)	Low risk (<5%)	Intermediate risk (5–20%)	High risk (>20%)
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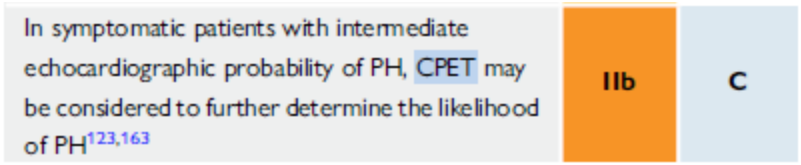
Humbert m.fl. European Heart Journal (2022) 43, 3618–3731.

Sammanfattningsvis

Misstänka / överväga / utreda avseende PH:

- Cirkulatorisk begränsning (inkl. sänkt VO2peak)
- Hög VE/VCO2-slope och låg PetCO2
- Desaturation



Class IIb: ”May be considered”
Level C: ”Consensus of opinion of the experts and/or small studies, retrospective studies, registries.”

Obs! CPET ingår tidigt i utredning av **oklar dyspné**, där PH endast är en av många potentiella orsaker.

Humbert m.fl. European Heart Journal (2022) 43, 3618–3731.

Sammanfattningsvis

Vid etablerad PH, prognostiskt visat värde av:

- VO2peak
- VE/VCO2-slope
- (6MWT, hjärtfrekvensreserv)

”May be considered” →

Table 17 Suggested assessment and timing for the follow-up of patients with pulmonary arterial hypertension

	At baseline	3–6 months after changes in therapy[a]	Every 3–6 months in stable patients[a]	In case of clinical worsening
Medical assessment (including WHO-FC)				
6MWT				
Blood test (including NT-proBNP)[b,c]				
ECG				
Echocardiography or cMRI				
ABG or pulse oximetry[d]				
Disease-specific HR-QoL				
CPET				
RHC				

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Humbert m.fl. European Heart Journal (2022) 43, 3618–3731.

Sammanfattningsvis

14. Gaps in evidence

14.1. Pulmonary arterial hypertension

- The role of CPET in the **early diagnosis of PAH in populations at risk** of developing PAH, and in **assessing prognosis in PAH on top of clinical and haemodynamic data**, needs further investigation.

- The role of exercise echocardiography and exercise RHC in patients at risk of developing PAH, with **abnormal CPET but normal rest echocardiogram**, also needs further evaluation.

Mitt tillägg: Andra variabler än VO2peak och VE/VCO2 bör studeras vidare. Lovande resultat i både retrospektiva och prospektiva material för bl.a. PetCO2.

Humbert m.fl. European Heart Journal (2022) 43, 3618–3731.

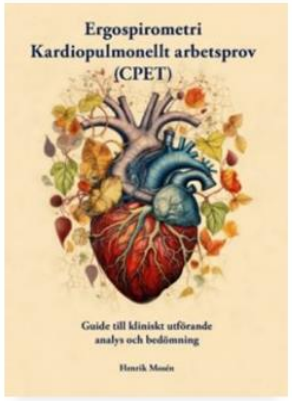
Vidare läsning

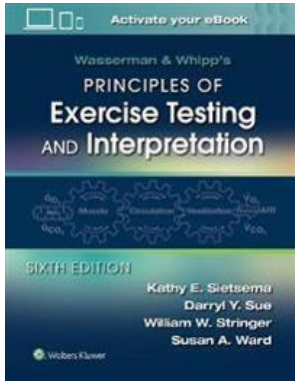
Arbetsfysiologi och ergospirometri

1. www.arbetsfysiologi.nu

2. Ergospirometri / kardiopulmonellt arbetsprov
   Henrik Mosén, 2024 (https://vifolka.se/ergospirometri-cpet/)

3. Wasserman & Whipp's Principles of
   Exercise Testing and Interpretation. 2020.





PAH och ergospirometri

Arena m.fl. Cardiopulmonary exercise testing in patients with pulmonary arterial hypertension: An evidence-based review. J Heart Lung Transplant 2010;29:159–73
Pezzuto & Agostoni. The Current Role of Cardiopulmonary Exercise Test in the Diagnosis and Management of Pulmonary Hypertension. J. Clin. Med. 2023, 12, 5465.

Ergospirometri vid preoperativ utredning inför kirurgi

Kristofer Hedman

ST-läkare Fysiologiska kliniken, US/Linköping

Biträdande professor, Inst. för Hälsa, Medicin och Vård, Linköpings universitet

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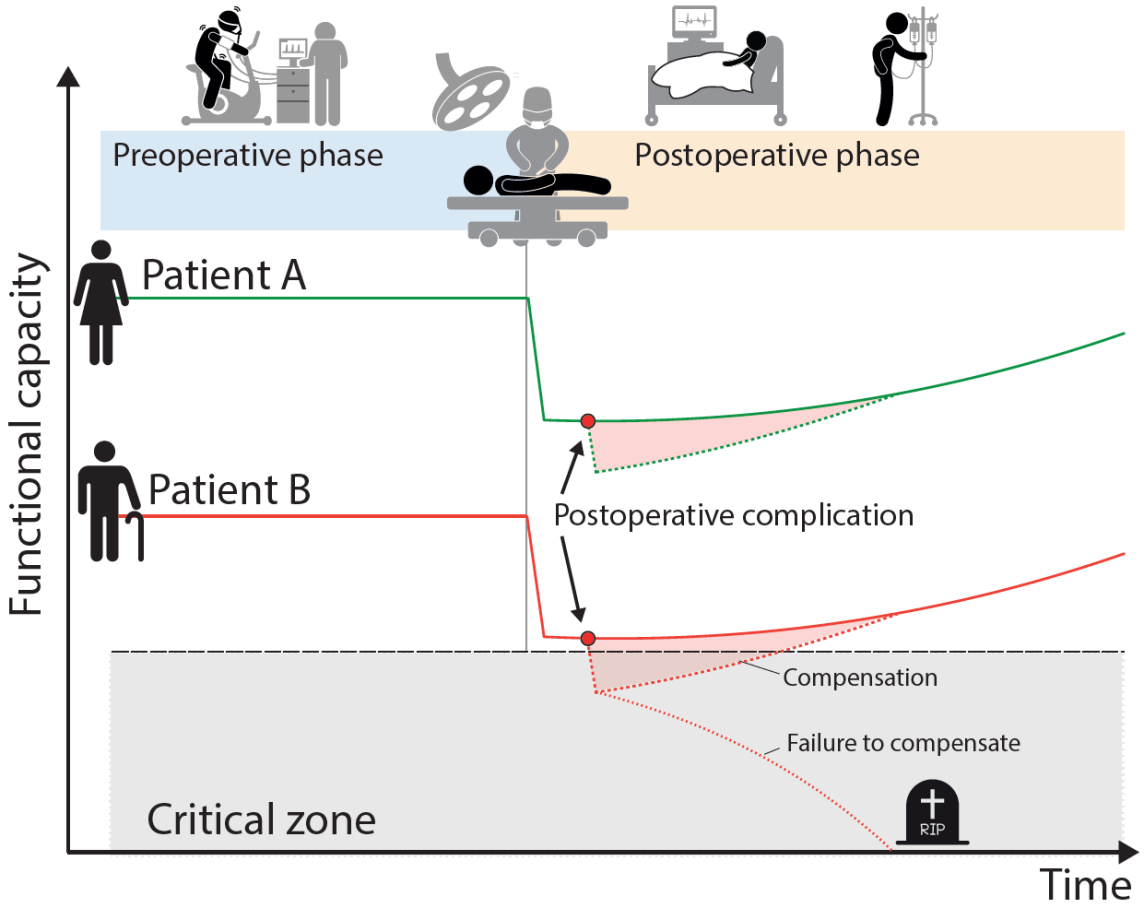
Innehåll

- Thoraxkirurgi vid Lungcancer

- Annan större kirurgi

Tanken med ergospirometri inför kirurgi



Förutsäga risk för allvarliga och potentiellt livshotande komplikationer.

- Risk vs. nytta med kirurgi
- Alternativa behandlingar?
- Optimera förutsättningar vid kirurgin

Figuren modifierad från Roxburgh et al. (2023) British Journal of Anaesthesia, 130 (2): 122e132

Definition av allvarliga komplikationer

Pneumoni
Lungemboli
Empyem
Acute respiratory distress syndrome
Andningssvikt
Lungödem

Försenad extubation (man kan inte extubera på operationssalen)
Reintubation
Reoperation

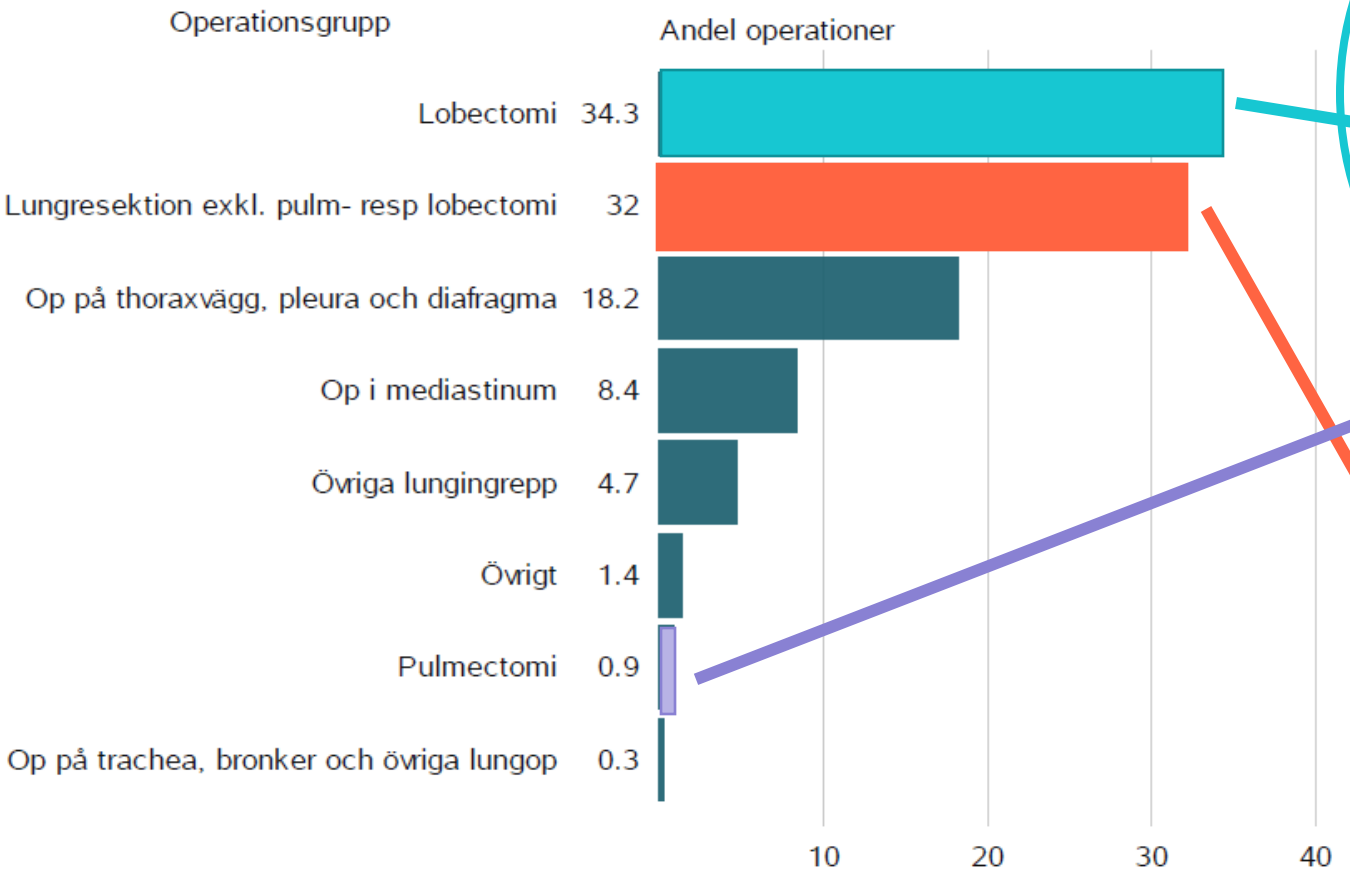
Cerebrovaskulär händelse (stroke, TIA)
Hjärtinfarkt
Akut njursvikt

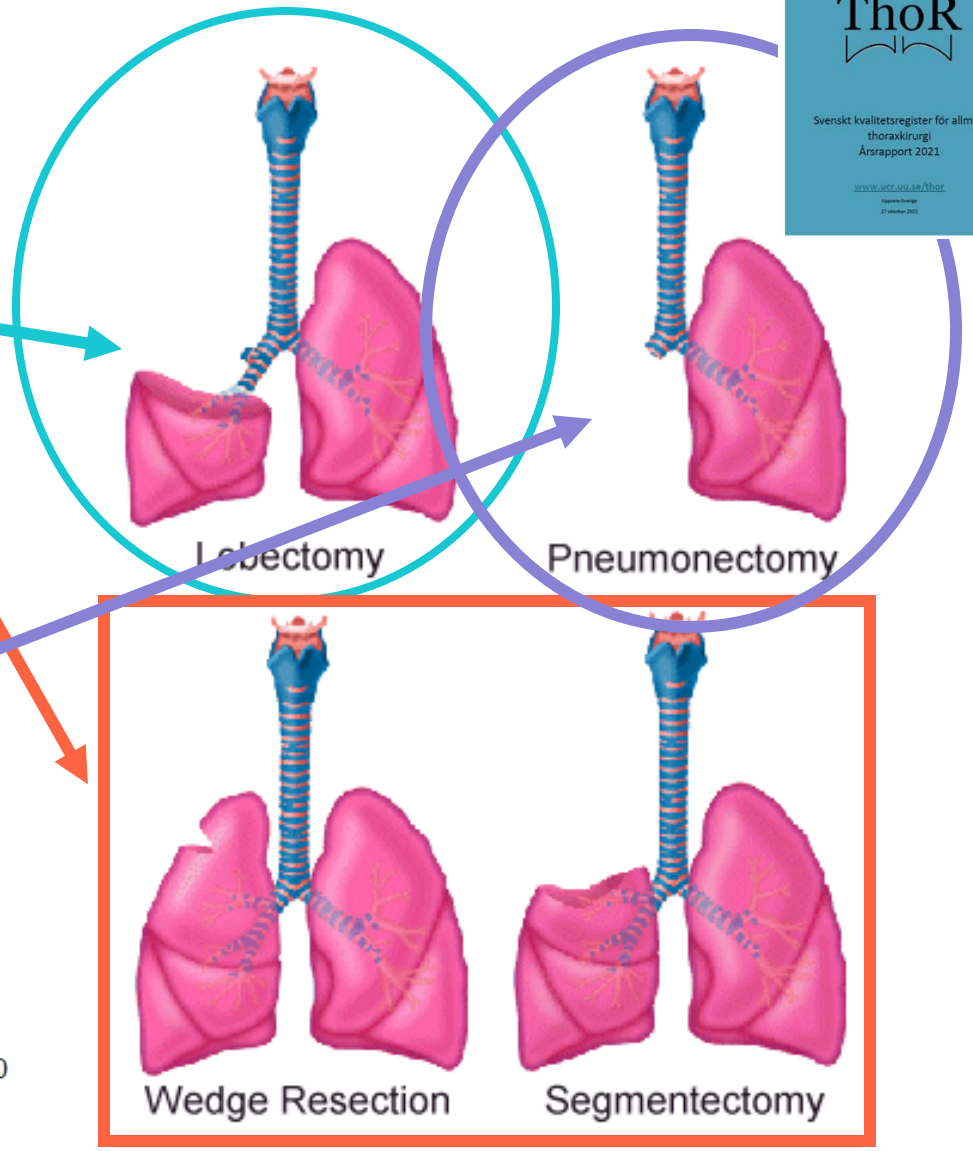
Död (oavsett orsak)

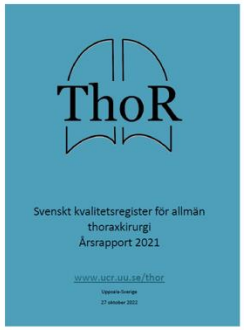
Fernandez et al. (2015) Annals of Thoracic Surgery; 99(1):368-376

Lungcancer

Lungcancerkirurgi i Sverige







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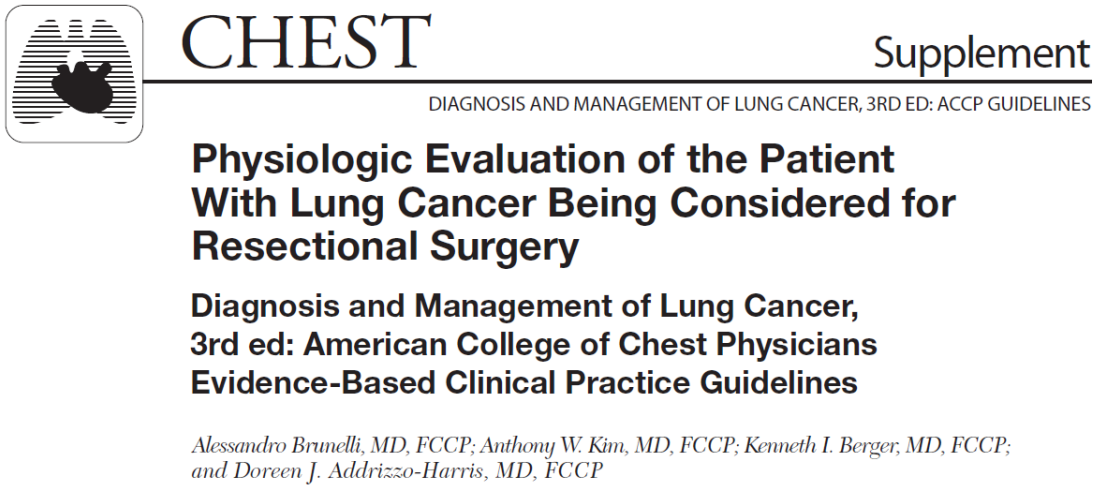
ThoR: Svensk kvalitetsregister för thoraxkirurgi. Årsrapport 2021. https://www.ucr.uu.se/thor/arsrapporter [Internet]. 2021.

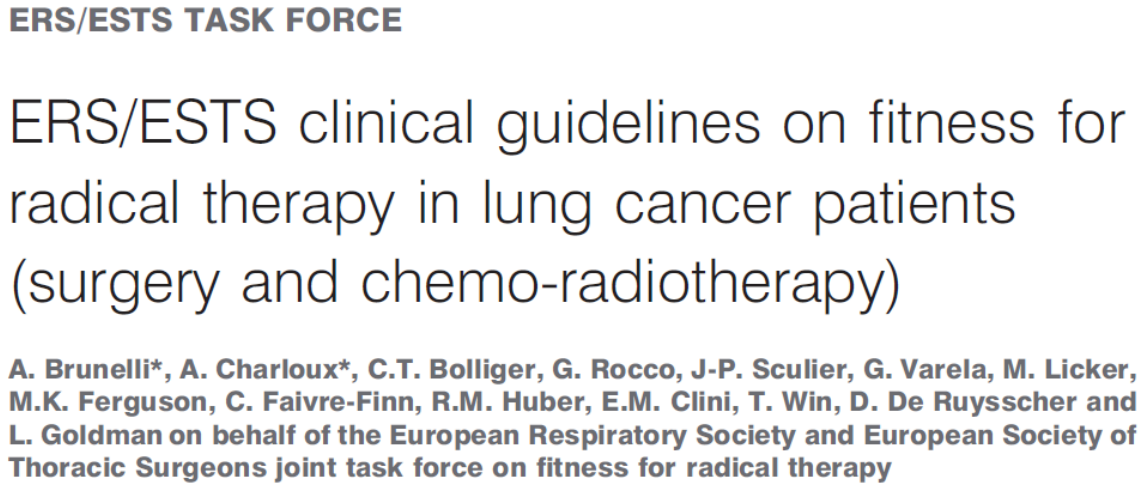
Bild från http://www.aboutcancer.com/lung_surgery.htm [Internet]. 2022.

Internationella riktlinjer



Brunelli et al. (2013)
CHEST 143(5)(Suppl):e166S–e190S

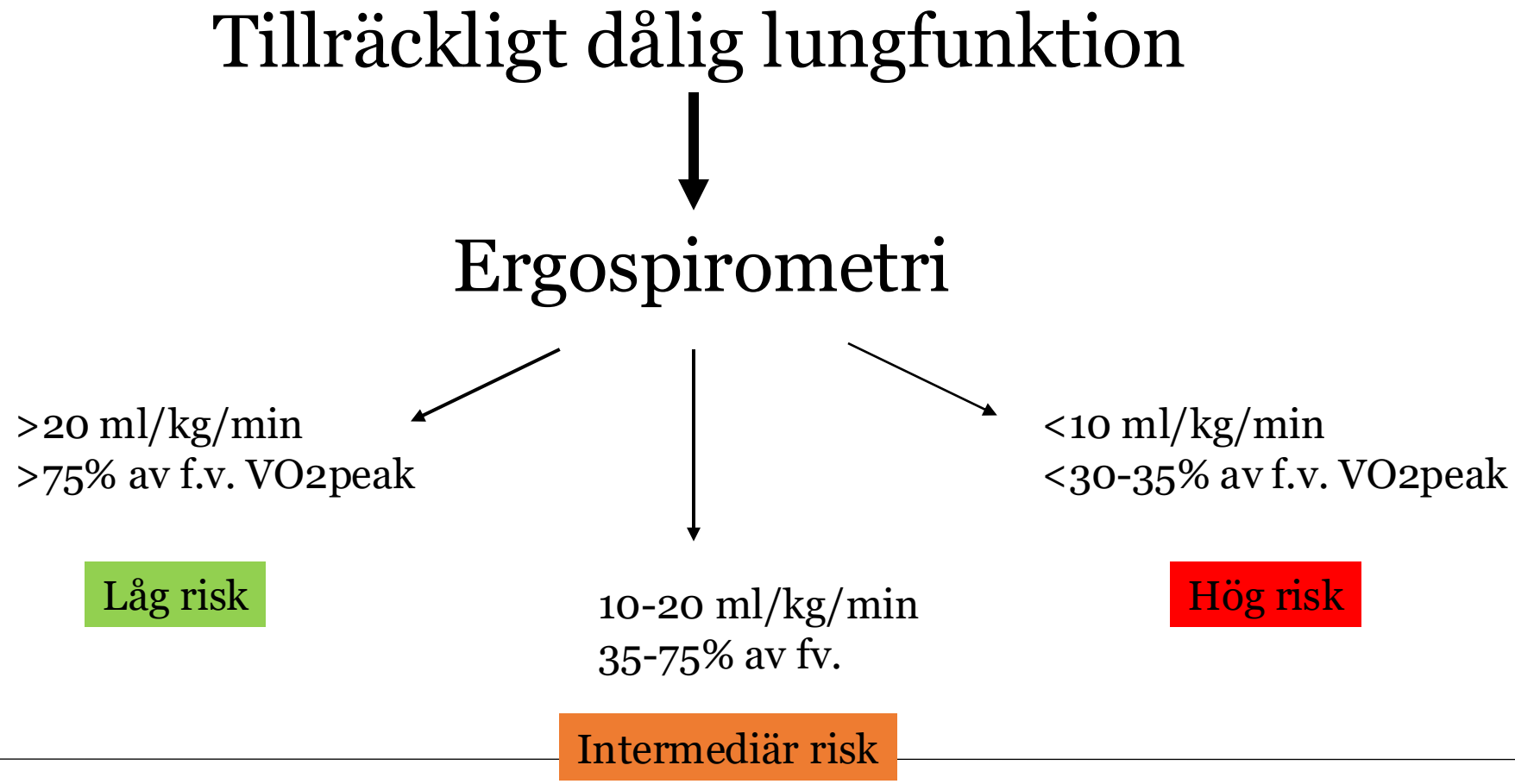
ACCP



Brunelli et al. (2009)
Eur Respir J; 34: 17–41

ERS/ESTS

Grundprincipen i riktlinjerna 2009, 2013



Grundprincipen i riktlinjerna 2009, 2013

Tillräckligt dålig lungfunktion

↓

Ergospirometri

>20 ml/kg/min
>75% av f.v. VO2peak

Låg risk

10-20 ml/kg/min
35-75% av fv.

Intermediär risk

<20 ml/kg/min
<30-35% av f.v. VO2peak

Hög risk

I kölvattnet av riktlinjerna…

Curr Surg Rep (2016) 4:37
DOI 10.1007/s40137-016-0158-x

THORACIC SURGERY (G. ROCCO AND M. SCARCI, SECTION EDITORS)

Risk Stratification in Lung Resection

Michele Salati[1] · Alessandro Brunelli[2]

Mellangruppen avseende VO2peak
(10-20 ml/kg/min / 30 – 75% av predicerat)

fortsatt svårbedömd ang. risk.

I kölvattnet av riktlinjerna…

Förslag; använd även **VE/VCO2-slope**!

Curr Surg Rep (2016) 4:37
DOI 10.1007/s40137-016-0158-x

THORACIC SURGERY (G. ROCCO AND M. SCARCI, SECTION EDITORS)

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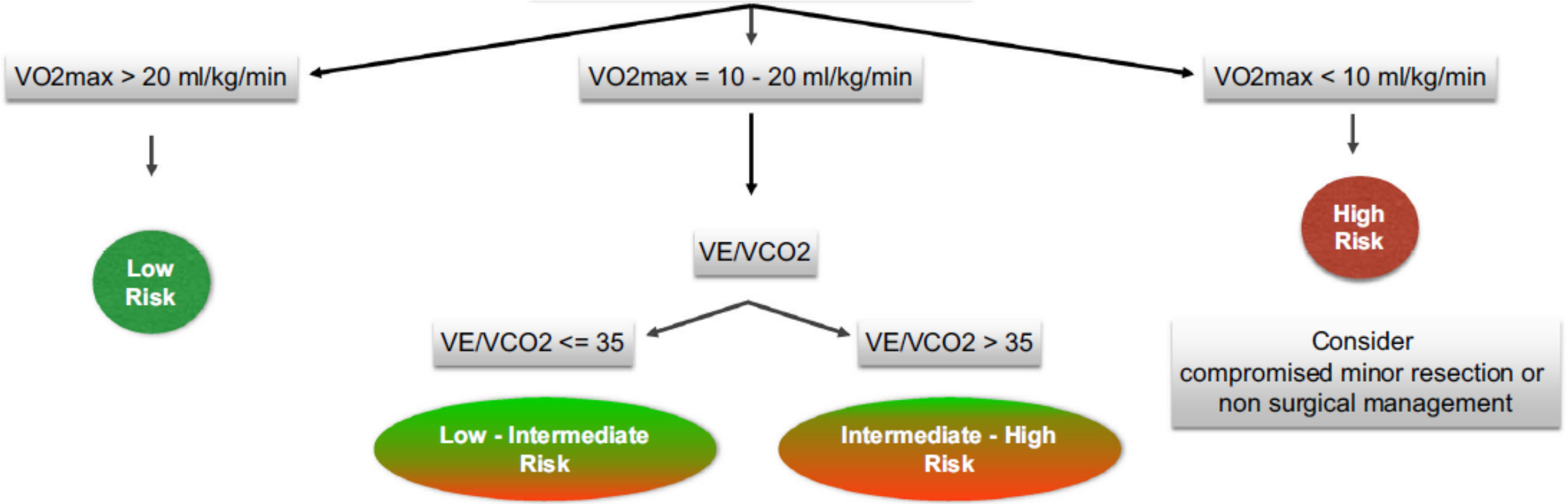
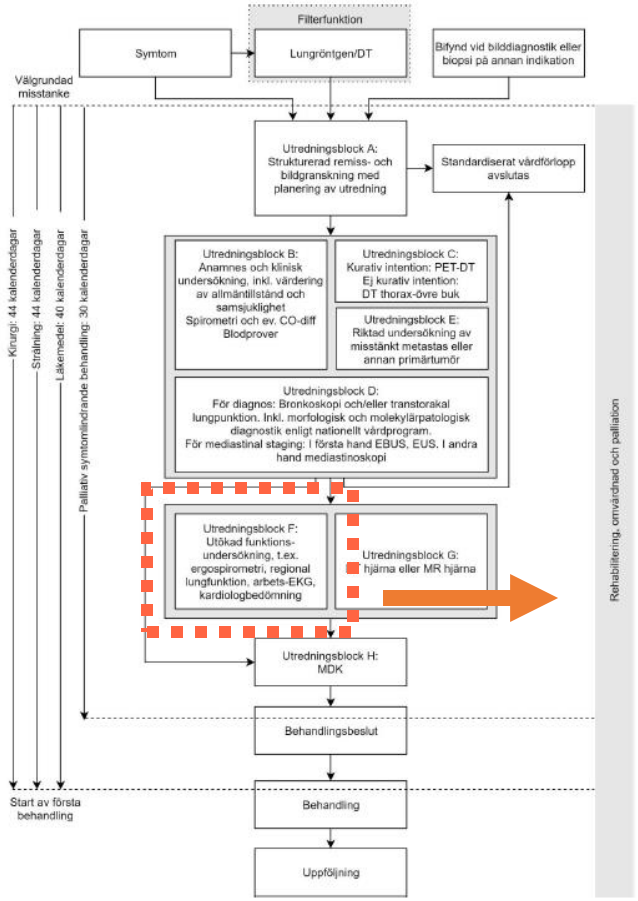
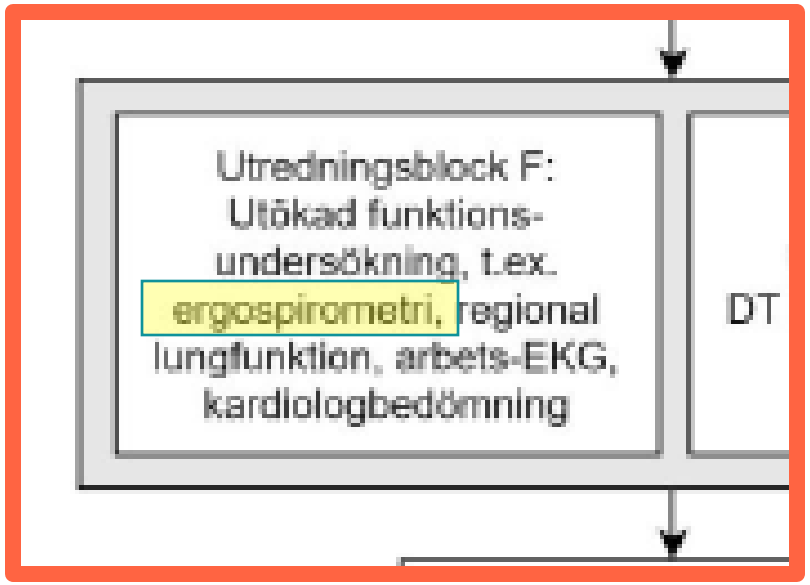


Svenska riktlinjer, SVF lungcancer

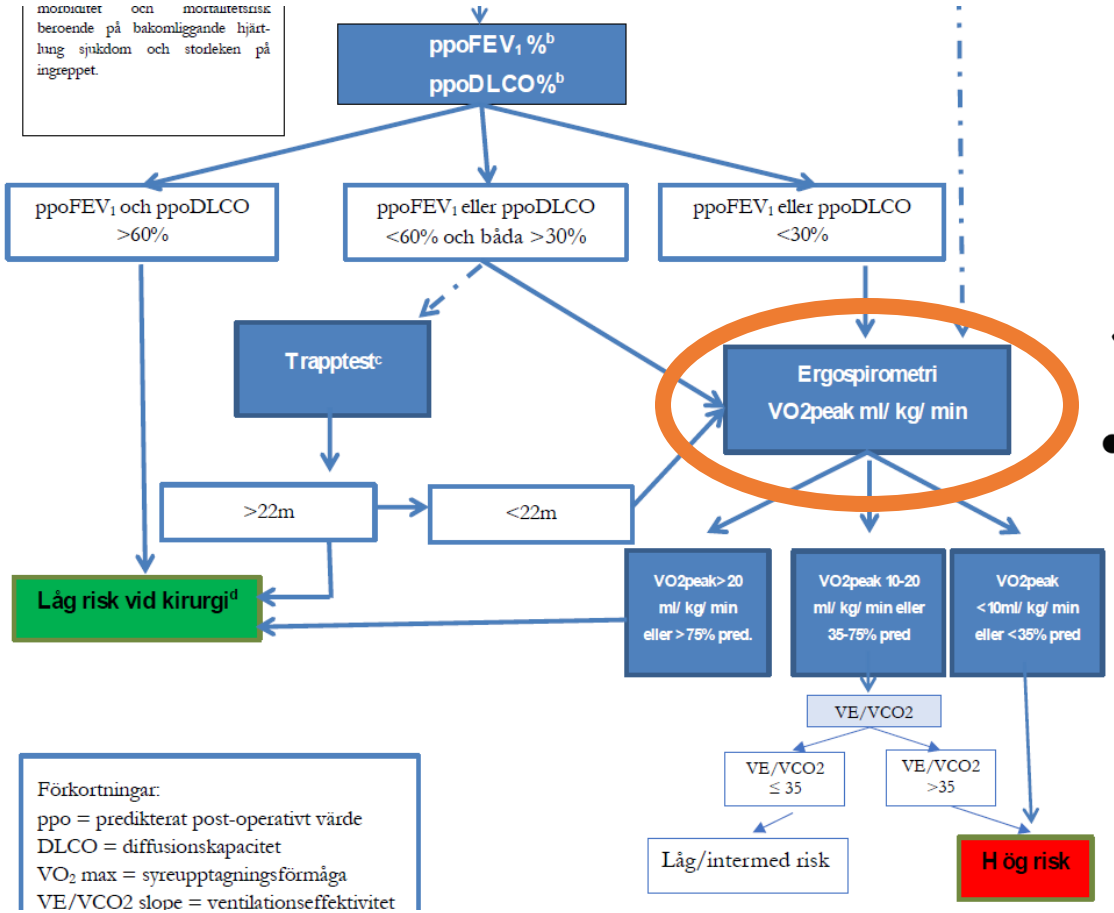
Lungcancer: standardiserat vårdförlopp

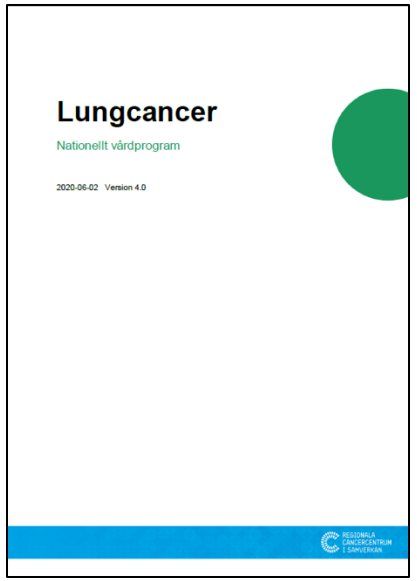




Regionalt Cancercentrum, kunskapsbanken. Lungcancer, regionalt vårdprogram [Internet]. 2024-06-25.
https://kunskapsbanken.cancercentrum.se/globalassets/cancerdiagnoser/lunga-och-lungsack/vardprogram/nationellt-vardprogram-lungcancer.pdf

Svenska riktlinjer: Nationella vårdprogrammet



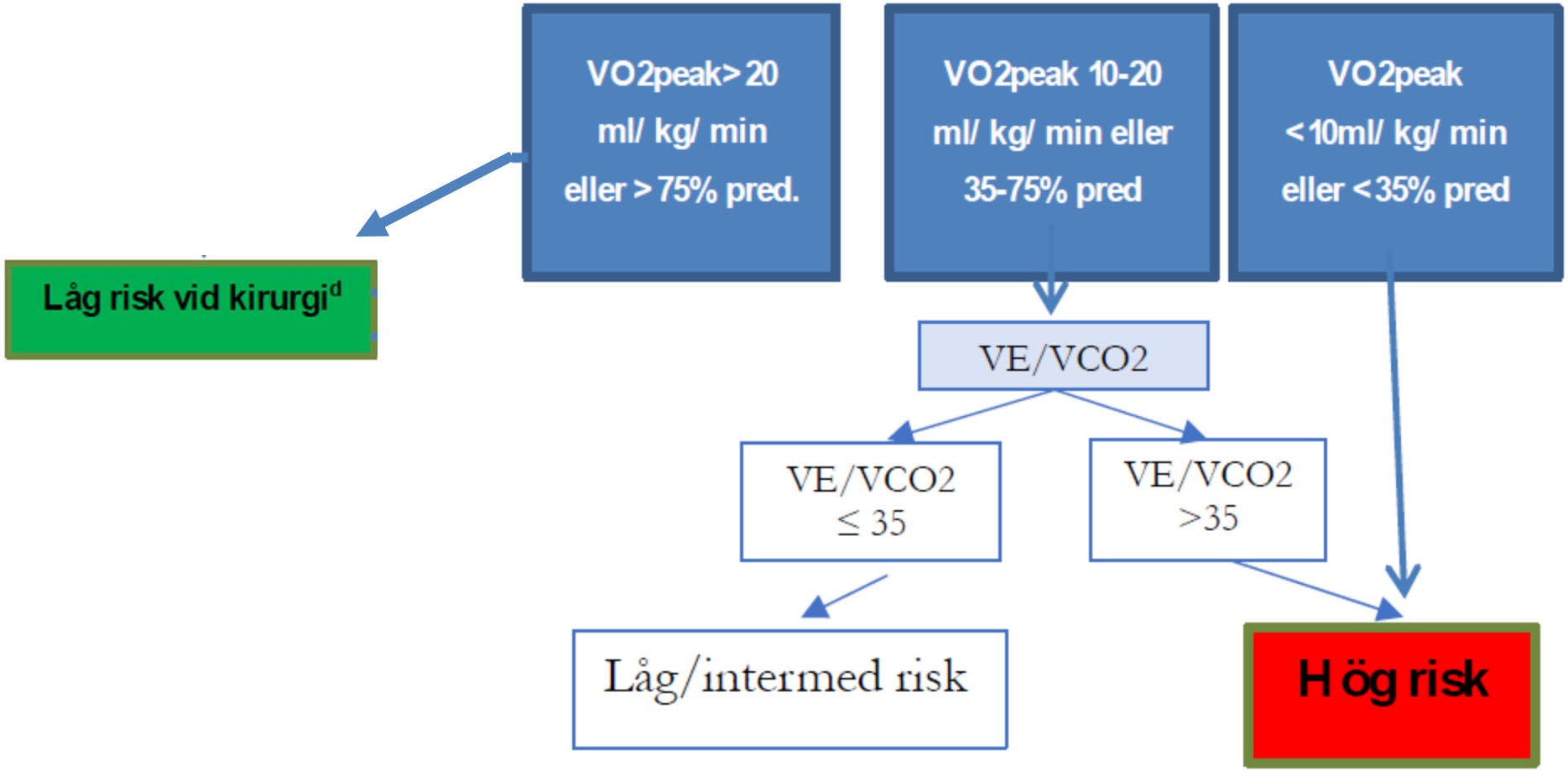


Ergospirometri om:

- Uttalat sänkt lungfunktion
- Måttligt sänkt lungfunktion och ej optimalt resultat trapptest
- (eller hög risk hjärtsjukdom)

Regionalt Cancercentrum, kunskapsbanken. Lungcancer, regionalt vårdprogram [Internet]. 2024-06-25.
https://kunskapsbanken.cancercentrum.se/globalassets/cancerdiagnoser/lunga-och-lungsack/vardprogram/nationellt-vardprogram-lungcancer.pdf

Syfte: att definiera risk för postoperativa komplikationer



Regionalt Cancercentrum, kunskapsbanken. Lungcancer, regionalt vårdprogram [Internet]. 2024-06-25.
https://kunskapsbanken.cancercentrum.se/globalassets/cancerdiagnoser/lunga-och-lungsack/vardprogram/nationellt-vardprogram-lungcancer.pdf

Utvärdering av ergospirometri-algoritmen i Linköpingskohort

Ventilatory efficiency in combination with peak oxygen uptake improves risk stratification in patients undergoing lobectomy

Karolina Kristenson, MD, PhD,[a] Johan Hylander, MD,[a] Miklos Boros, MD,[b] Anna Fyrenius, MD, PhD,[c] and Kristofer Hedman, MD, PhD[d]

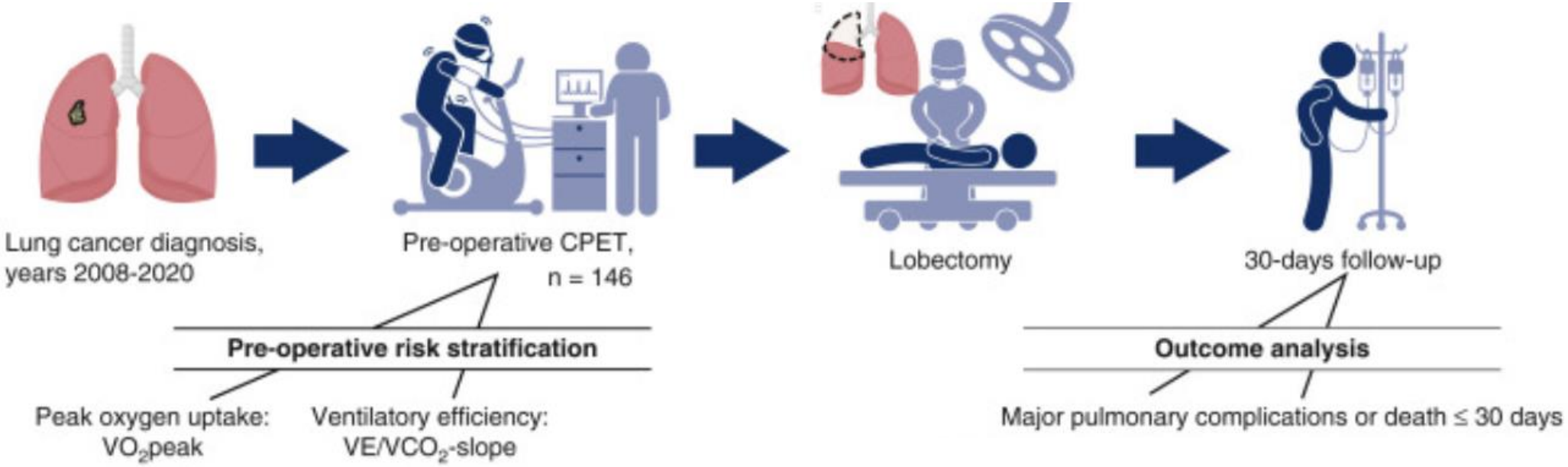
NYA RÖN

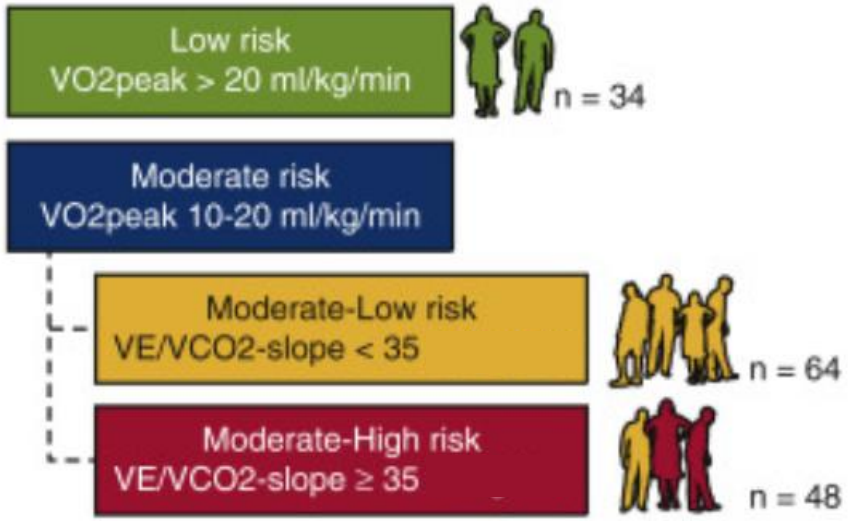
Mått på ventilatorisk effektivitet förbättrade riskstratifiering

Karolina Kristenson, med dr, specialistläkare, anestesi och intensivvård, medicinskt ansvarig anestesiläkare, lungkirurgi, torax–kärlklinike Universitetssjukhuset i Linköping

Kristofer Hedman, docent, ST-läkare, klinisk fysiologi, fysiologiska kliniken, Universitetssjukhuset i Linköping

Kristenson K m.fl. JTCVS Open. 2022 Jul 3;11:317-326.
Kristenson & Hedman. Läkartidningen 40-41/2023


Lung cancer diagnosis, years 2008-2020
Pre-operative CPET, n = 146
Lobectomy
30-days follow-up
Pre-operative risk stratification
Peak oxygen uptake: VO2peak
Ventilatory efficiency: VE/VCO2-slope
Outcome analysis
Major pulmonary complications or death ≤ 30 days


Low risk
VO2peak > 20 ml/kg/min
n = 34
Moderate risk
VO2peak 10-20 ml/kg/min
Moderate-Low risk
VE/VCO2-slope < 35
n = 64
Moderate-High risk
VE/VCO2-slope ≥ 35
n = 48

Kan man ytterligare förbättra riskstratifieringen genom CPET?

I Linköpingsmaterialet

Original Article

VE/VCO_2 slope threshold optimization for preoperative evaluation in lung cancer surgery: identifying true high- and low-risk groups

Karolina Kristenson[1]^, Johan Hylander[2], Miklos Boros[1], Kristofer Hedman[3]

VE/VCO2-slope i tre grupper förbättrar dess prediktiva förmåga

<30 30-40 >40

Percent predicted peak oxygen uptake is superior to weight-indexed peak oxygen uptake in risk stratification before lung cancer lobectomy

Karolina Kristenson, MD, PhD,[a] and Kristofer Hedman, MD, PhD[b]

% förväntat VO2peak är bättre än ml/kg/min för att identifiera individer som drabbas av allvarlig komplikation

Kristenson m.fl. J Thorac Dis. 2024 Jan 30;16(1):123-132.
Kristenson & Hedman. JTCVS 2024 Mar 5: Online ahead of print.

Sammanfattning lungcancer

- Ergospirometri är en etablerad metod i riktlinjer och vårdprogram
  - Det vetenskapliga underlaget bygger på relativt små studier, men talar åt samma håll.
- Fungerar bäst för att identifiera de med klart hög eller klart låg risk, vilket också kanske är det viktigaste?
- VE/VCO2-slope framstår som enskilt starkast riskmarkör, där >39-40 är associerat med hög risk och <30 är associerat med låg risk för komplikationer

- Problem är tillgången på ergospirometri vid thoraxkirurgiska center runt om i världen, samt kunskap om metoden

Innehåll

- Thoraxkirurgi vid Lungcancer

- Annan större kirurgi

Riktlinjer?

European Heart Journal (2022) **43**, 3826–3924
https://doi.org/10.1093/eurheartj/ehac270

ESC GUIDELINES

2022 ESC Guidelines on cardiovascular assessment and management of patients undergoing non-cardiac surgery

Halvorsen m.fl. European Heart Journal (2022) 43, 3826–3924

Riktlinjer?

Sid 3849:

4.2. Functional capacity

Quantifying functional capacity has been a pivotal step in pre-operative cardiac risk assessment.[10] Although the validity of interview-based assessment of functional capacity has been questioned,[93] a recent large prospective cohort study of high-risk patients undergoing NCS found self-reported inability to climb two flights of stairs added incremental value to the 30 day cardiac event rate when added to the RCRI.[94]

Metabolic equivalents (METs) <4 have long been considered to indicate poor functional capacity; however, studies using METs have been based on subjective interviews and not shown proven value. In the Measurement of Exercise Tolerance before Surgery (METS) study, the Duke Activity Status Index (DASI) (https://www.mdcalc.com/duke-activity-status-index-dasi#evidence) had a more precise estimation of cardiac risk than subjectively assessed functional capacity, improving risk estimation using RCRI.[95] A DASI score <34 was associated with increased odds of 30 day death or MI.[96] From the DASI score, METs can be calculated as VO_2 max (maximal oxygen consumption)/3.5; where VO_2 max (mL/kg/min) = 0.43 × DASI + 9.6. Furthermore, cardiopulmonary exercise testing (CPET) did not predict 30 day mortality, post-operative MI, or cardiac arrest.[94,95] It should be noted that a relatively low number of primary outcome events limited the statistical power of the analysis.

Halvorsen m.fl. European Heart Journal (2022) 43, 3826–3924

Refererar till METS-studien i the Lancet 2008

Assessment of functional capacity before major non-cardiac surgery: an international, prospective cohort study

Duminda N Wijeysundera, Rupert M Pearse, Mark A Shulman, Tom E F Abbott, Elizabeth Torres, Althea Ambosta, Bernard L Croal, John T Granton, Kevin E Thorpe, Michael P W Grocott, Catherine Farrington, Paul S Myles, Brian H Cuthbertson, on behalf of the METS study investigators

- Prospektiv, internationell multicenterstudie (25 sjukhus)
- 1401 patienter som genomgick ”major” icke-kardiell kirurgi

- Jämför subjektiv uppskattning av kondition, DASI-frågeformulär, ergospirometri, NT-pro-BNP för att predicera hjärtinfarkt eller död inom 30 dagar efter kirurgi

- Hittar att CPET inte var direkt bättre än DASI för att predicera deras outcome

Wijeysundera m.fl. Lancet 2018; 391: 2631–40

Men…

- Studien var ”under-powered” med färre events än väntat
- De studerar endast VO2peak
- Hjärtinfarkt och död är inte de allvarliga komplikationer som CPET i andra studier visat sig bäst att predicera (bättre för lungkomplikationer)

Wijeysundera m.fl. Lancet 2018; 391: 2631–40

Riktlinjer?

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

D.Z.H. Levett[1,2,10,*], S. Jack[1,2,10], M. Swart[3,10], J. Carlisle[3], J. Wilson[4], C. Snowden[5], M. Riley[6], G. Danjoux[7], S.A. Ward[8], P. Older[9], M.P.W. Grocott[1,2,10] and For the Perioperative Exercise Testing and Training Society (POETTS)

Perioperative Exercise Testing and Training Society (POETTS)

Levett m.fl. British Journal of Anaesthesia (2018) 120 (3), 484-500

Riktlinjer?

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

D.Z.H. Levett[1,2,10,*], S. Jack[1,2,10], M. Swart[3,10], J. Carlisle[3], J. Wilson[4], C. Snowden[5], M. Riley[6], G. Danjoux[7], S.A. Ward[8], P. Older[9], M.P.W. Grocott[1,2,10] and For the Perioperative Exercise Testing and Training Society (POETTS)

Recommendations: Indications for CPET

(1) To estimate the likelihood of perioperative morbidity and mortality and contribute to preoperative risk assessment (Grade B).

(2) To inform the processes of multidisciplinary shared decision-making and consent (Grade C).

(3) To guide clinical decisions about the most appropriate level of perioperative care (ward vs critical care; Grade B).

(4) To direct pre-operative referrals/interventions to optimize comorbidities (Grade C).

(5) To identify previously unsuspected pathology (Grade B).

(6) To evaluate the effects of neoadjuvant cancer therapies including chemotherapy and radiotherapy (Grade B).

(7) To guide prehabilitation and rehabilitation training programmes (Grade B).

(8) To guide intraoperative anaesthetic practice (Grade D).

Levett m.fl. British Journal of Anaesthesia (2018) 120 (3), 484-500

Historiskt VO2@AT och/eller VO2peak

Preoperative Evaluation of Cardiac Failure and Ischemia in Elderly Patients by Cardiopulmonary Exercise Testing*

Paul Older, M.B., B.S.; Robert Smith, M.B., B.S.; Peter Courtney, M.B., B.S.; and Rodney Hone, B.Appl.Sc.

Older m.fl. Chest (1993) 104:101-04

Cardiopulmonary Exercise Testing as a Screening Test for Perioperative Management of Major Surgery in the Elderly*

Paul Older, MBBS; Adrian Hall, MBBS; and Raymond Hader, MBBS†

Older m.fl. Chest (1999) 116:355-362

Tröskelvärde VO2@AT: 11 ml/kg/min

Systematisk översikt

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

J. Moran[1,*], F. Wilson[1], E. Guinan[1], P. McCormick[2], J. Hussey[1] and J. Moriarty[3]

37 inkluderade studier, VO2peak och/eller VO2@AT

Sammantaget stor blandning kirurgiska ingrepp,
men **VO2@AT ~9-12 ml/kg/min** respekrive **VO2peak ~15 ml/kg/min** hade prognostiskt värde i flera studier.

Moran m.fl. Br J Anaesthesia (2016) 116 (2): 177–91

Ventilatorisk effektivitet nytt i sammanhanget

Ventilatory inefficiency adversely affects outcomes and longer-term survival after planned colorectal cancer surgery

R. Jonathan T. Wilson*, David R. A. Yates, James P. Walkington and Simon J. Davies

Wilson m.fl. Br J Anaesthesia (2019), 123 (2): 238e245

Contents lists available at ScienceDirect

European Journal of Surgical Oncology

journal homepage: www.ejso.com

CPET and cardioesophagectomy: A single centre 10-year experience

Steve Benington [a, *], Angella Bryan [a, b], Owen Milne [a], Bilal Alkhaffaf [c, d]

Beningtgon m.fl. Eur J Surg Onc 45 (2019) 2451e2456

Visat sig starkare markör än VO2peak och VO2@AT i flera studier om man inkluderar **allvarliga pulmonella komplikationer.**

Kombinationen VO2peak + VE/VCO2-slope

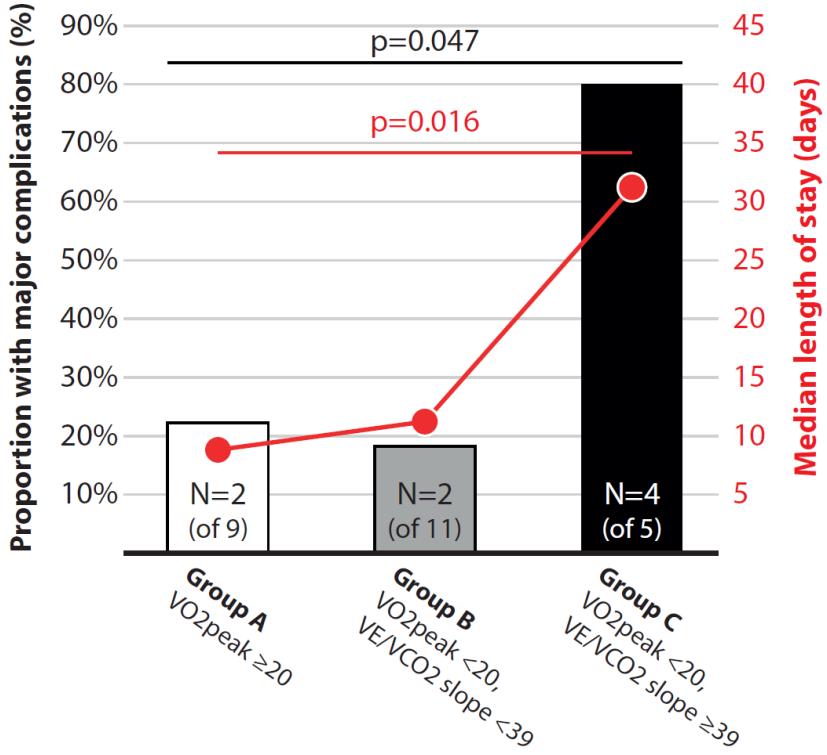
ORIGINAL ARTICLE

Peak oxygen uptake in combination with ventilatory efficiency improve risk stratification in major abdominal surgery

Karolina Kristenson[1] | Edvard Gerring[2] | Bergthor Björnsson[3] | Per Sandström[3] | Kristofer Hedman[2]

Pilotstudie Linköping, större bukkirurgi (n=25)
Allvarlig komplikation innan utskrivning
+ vårdtid.

Intryck av betydande ökning av komplikationer hos de med VE/VCO2-slope >39.



Kristenson m.fl. Physiological Reports (2024);12:e15904

Sammanfattning bukkirurgi

- VO2peak och VO2@AT tycks vara associerat med postoperativ morbiditet och mortalitet, men beror på population (inkl typ av kirurgi)
- Generellt ju större ingrepp, desto större prediktiv förmåga
- En lång rad mindre studier, men större material saknas i stort

- Ventilatoriska mått har endast börja leta sig in i bukkirurgikontexten, och tycks så långt vara minst lika bra som VO2peak/VO2@AT för att förutse kardiopulmonella komplikationer.

Kristofer.hedman@liu.se

Tack för uppmärksamheten!

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