The Leeds Teaching Hospitals NHS
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elcc EUROPEAN LUNG CANCER CONFERENCE

Geneva, Switzerland
15-18 APRIL 2015

CARDIOPULMONARY FUNCTION TEST: WHAT MAKES SENSE

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Exercise testing is increasingly used to assess the aerobic reserve of lung resection candidates.

These tests have the capability to assess the entire oxygen transport system and to detect possible deficits that may predispose to postoperative complications.

Therefore, the potential exists to evaluate much of the cardiopulmonary system with just one test
(Olsen GN. Chest 1989; 95: 218-225)

Types of exercise tests

Test low-tech:

- 6-min walking test
- Shuttle test
- Stair climbing test

Test high tech:

- VO2/VCO2 measurement (Cycle, treadmill)

Cardiopulmonary exercise test

- Performed in a controlled environment.
- Continuous monitoring of various parameters.
- Easy standardization and good reproducibility of results.
- PeakVO2 is the single most important parameter as a direct measure of exercise capacity.
- CPET does not only allow assessment of over-all cardio-pulmonary reserves, but in case of a limitation of exercise capacity, to find the reason for this, such as pulmonary, cardiovascular, or musculo-skeletal limitations.

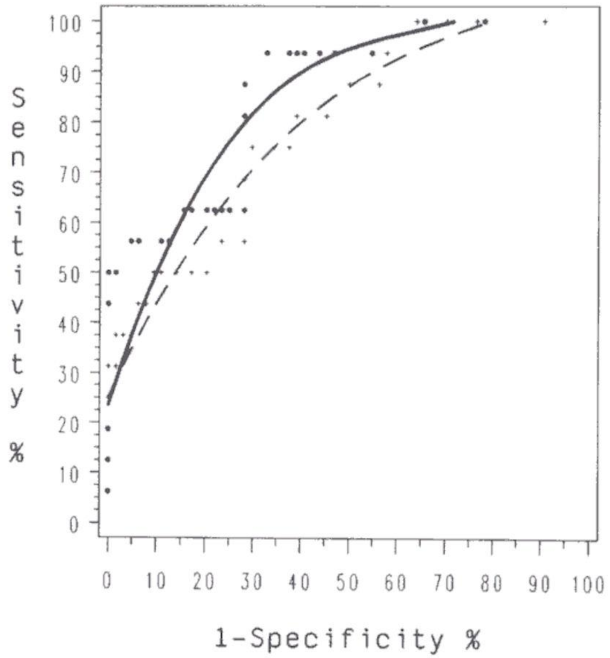
VO2max and postop morbidity

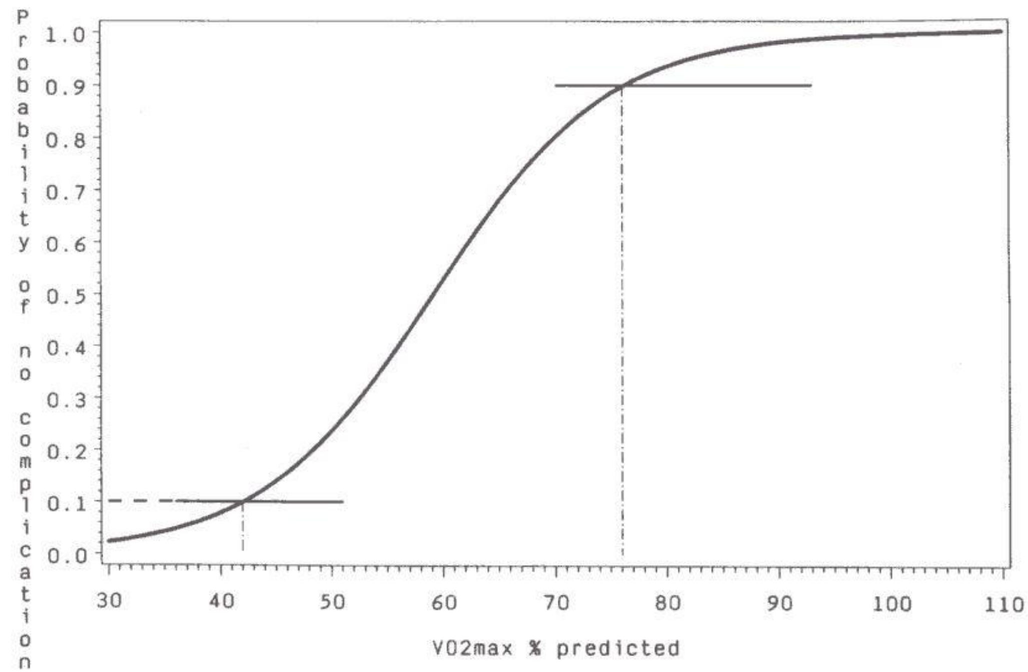
Exercise Capacity as a Predictor of Postoperative Complications in Lung Resection Candidates

CHRIS T. BOLLIGER, PAUL JORDAN, MARKUS SOLÈR, PETER STULZ, ERICH GRÄDEL, KAREL SKARVAN, SERGE ELSASSER, MICHAEL GONON, CHRISTOPH WYSER, MICHAEL TAMM, and ANDRÉ P. PERRUCHOUD

Division of Pneumology, Department of Internal Medicine, the University Computer Center, the Cardiothoracic Unit, Department of Surgery, and the Department of Anesthesiology, University Hospital, Basel, Switzerland

Am J Respir Crit Care Med 1995





Eur Respir J 2000; 15: 828–832

European Respiratory Journal
ISSN 0903-1936

Exercise capacity and extent of resection as predictors of surgical risk in lung cancer

M.H. Brutsche*, A. Spiliopoulos**, C.T. Bolliger***, M. Licker**, J-G. Frey*, J-M. Tschopp*

Table 3. – Results of stepwise logistic regression analysis

Parameter	Step	Coeff	SEM	Improvement Chi-squared	p-value
Constant factor	0	2.9883	1.2	-	-
$V'O_{2,max}$·kg body weight^{-1} % pred	1	-0.0573	0.014	19.7	<0.0001
Resection %	2	0.0343	0.015	5.3	0.02

Table 4. – Probabilities of postoperative complications based on exercise tests and lung resection according to stepwise logistic regression analysis

$V'O_{2,max}$·kg body weight^{-1} % pred	SE/ wedge	LE	BLE	PE
120	0.03	0.04	0.07	0.11
110	0.04	0.07	0.12	0.17
100	0.08	0.11	0.19	0.27
90	0.13	0.19	0.29	0.39
80	0.21	0.29	0.42	0.53
70	0.31	0.42	0.56	0.67
60	0.45	0.56	0.69	0.78
50	0.59	0.69	0.80	0.86

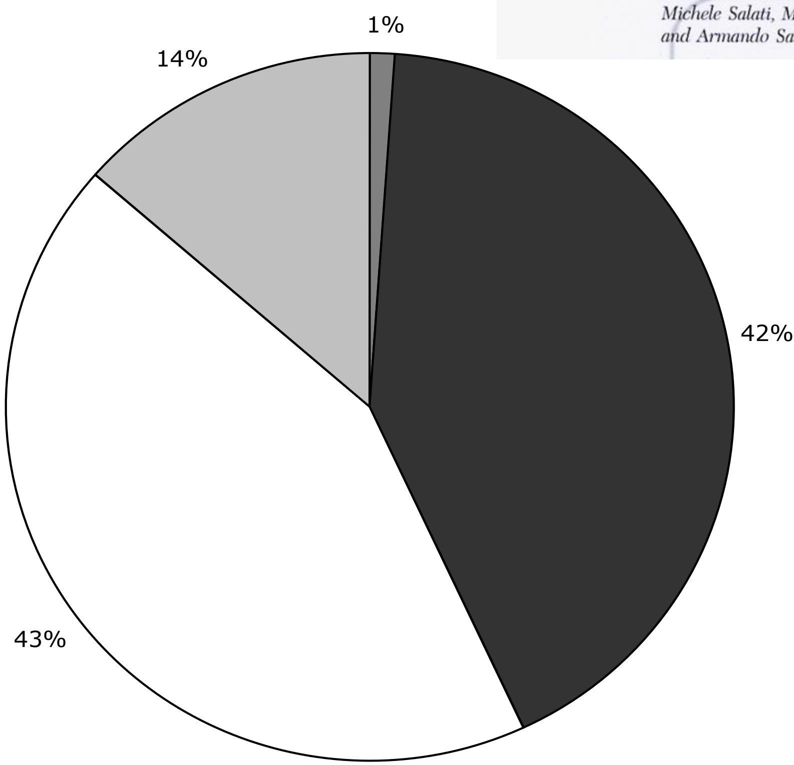
6 of 7 pts with VO2<60% had compl (86%)
11 of 17 with VO2 < 15 ml/kg/min had compl (65%)
8 of 65 with VO2 > 90% had compl (12%)

- January 2006-June 2008: 263 CPET
- 59 wedge or segmentectomy
- 204 major resections (177 L, 27 P)

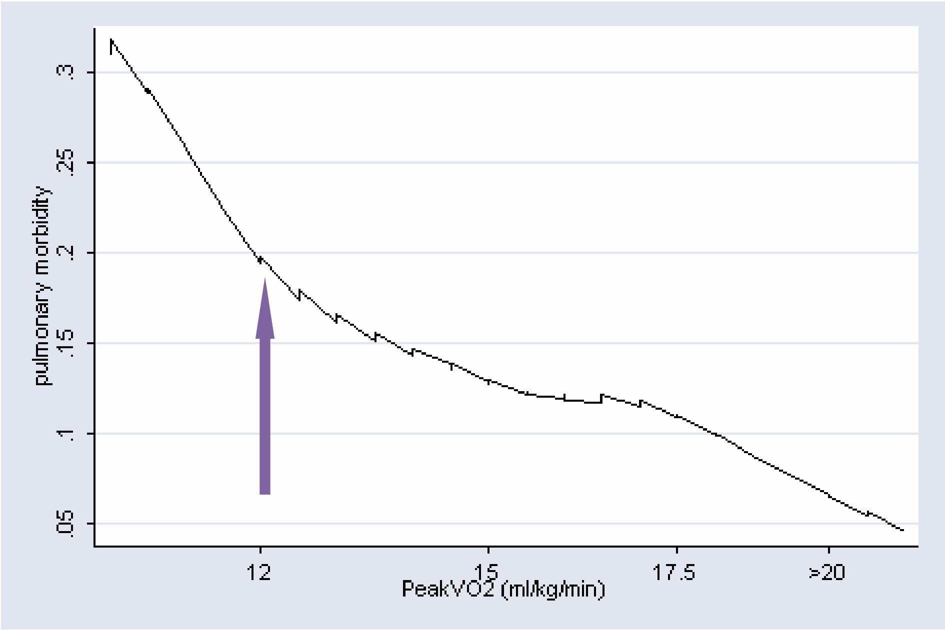
CHEST Original Research

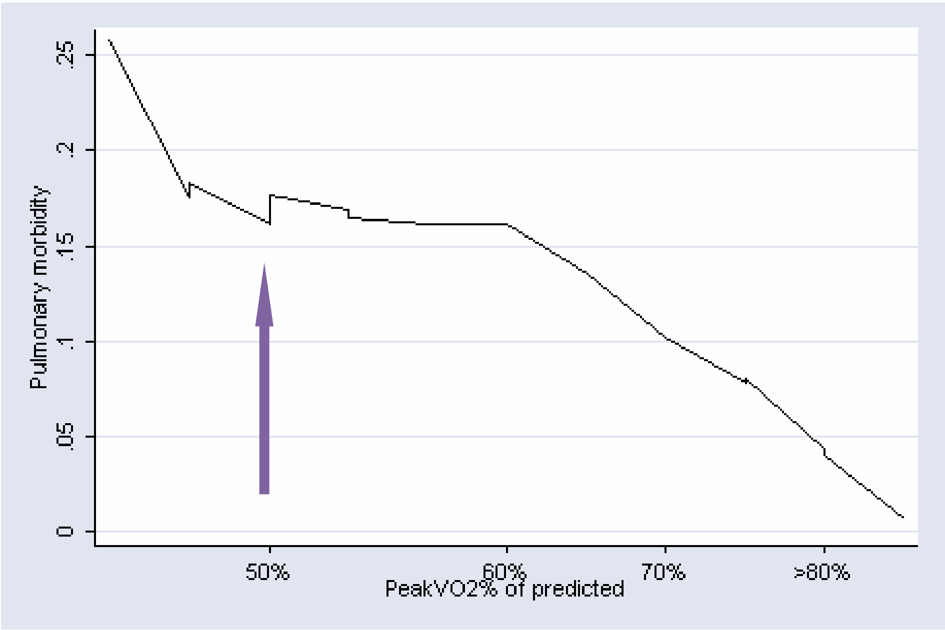
Peak Oxygen Consumption During Cardiopulmonary Exercise Test Improves Risk Stratification in Candidates to Major Lung Resection*

Alessandro Brunelli, MD; Romualdo Belardinelli, MD; Majed Refai, MD; Michele Salati, MD; Laura Socci, MD; Cecilia Pompili, MD; and Armando Sabbatini, MD



Respiratory complications by peakVO2 (204 anatomic resections)





Brunelli A et al. CHEST 2009

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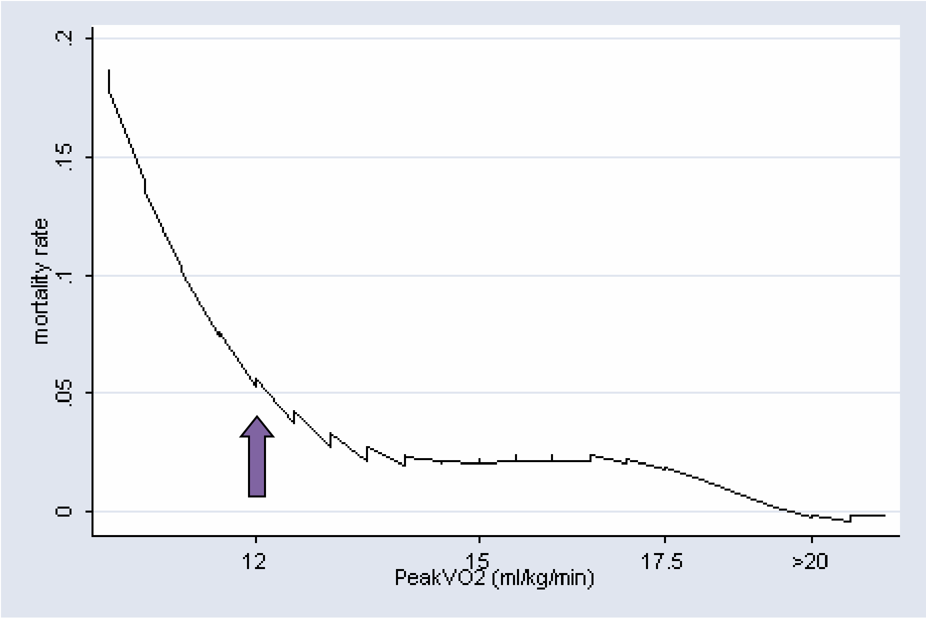
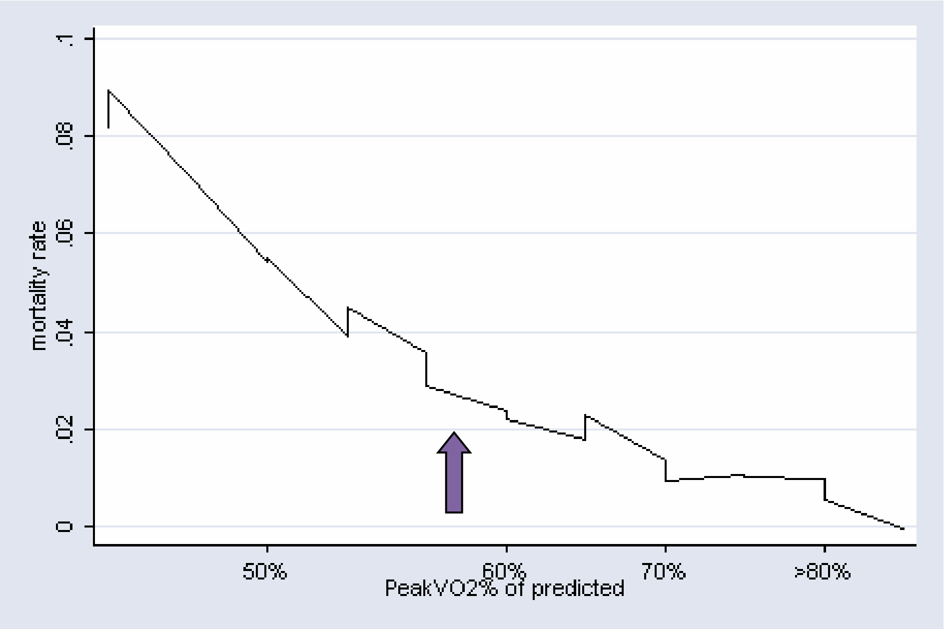
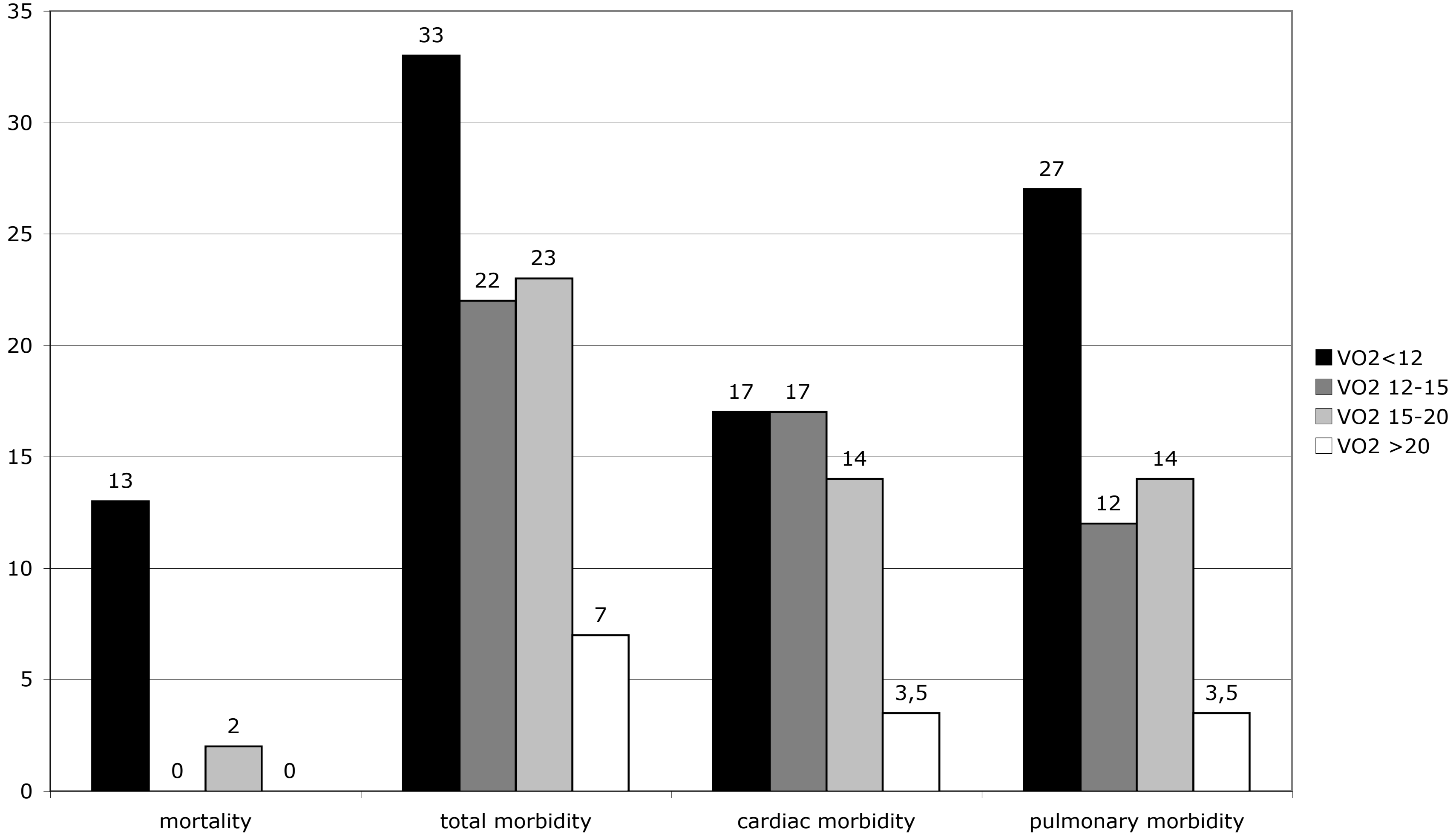
Mortality and peakVO2 (204 anatomic resections)



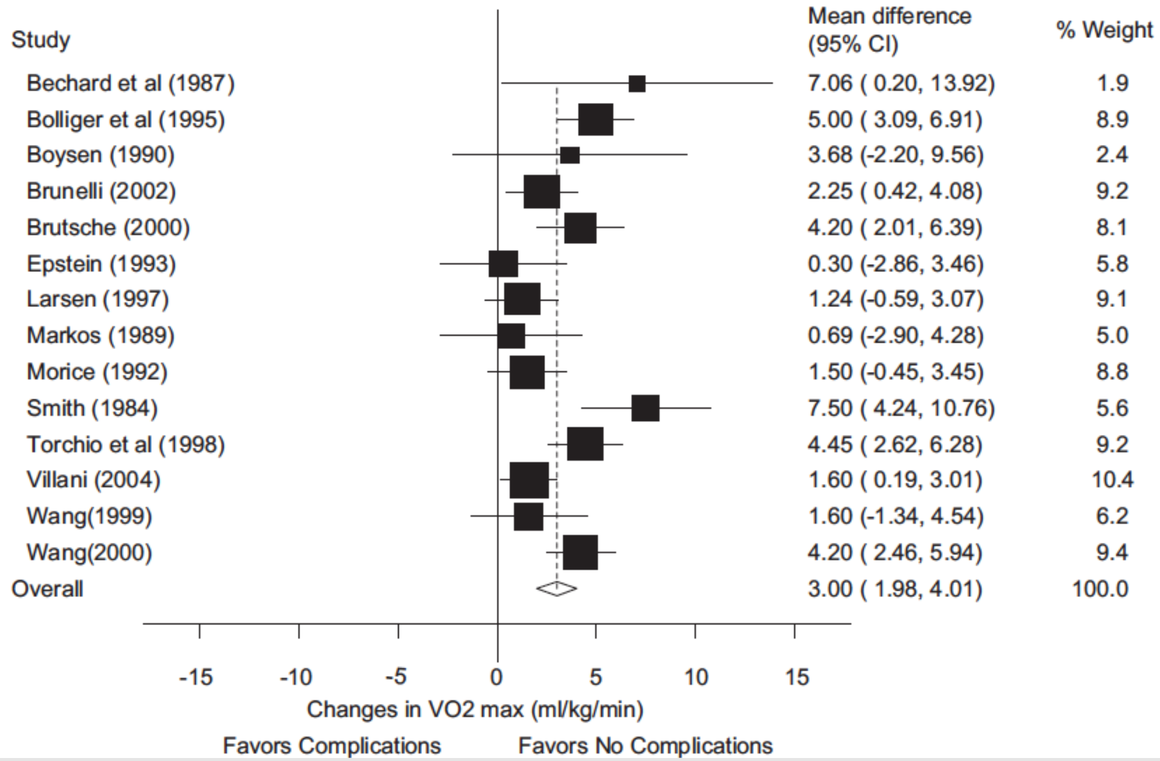


Brunelli A et al. CHEST 2009

Stratification of outcomes by peakVO2



Brunelli A et al. CHEST 2009

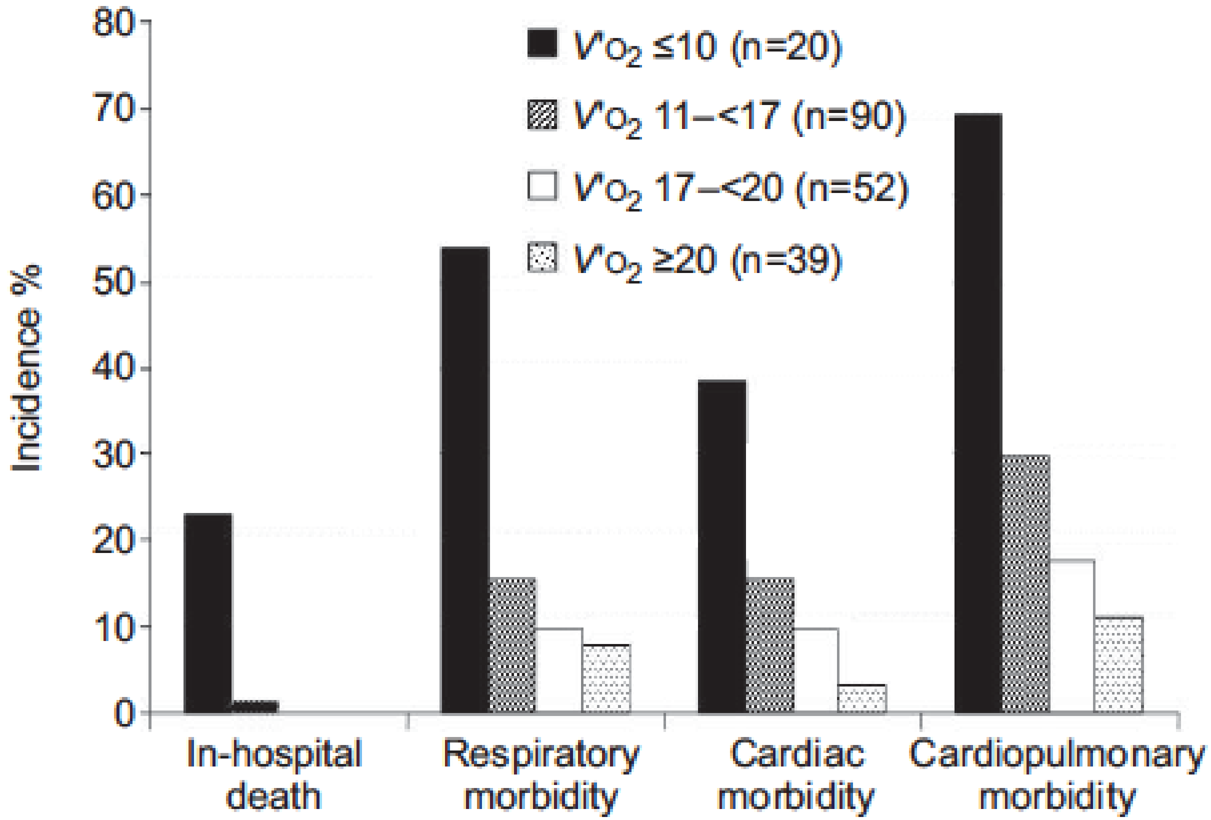


Variable	N	NPPC, $\bar{X}$(SD)	PPC, $\bar{X}$(SD)
Primary outcomes			
VO_{2max} ($ml\,kg^{-1}\,min^{-1}$)	14	20.0(2.7)	16.8(3.1)
VO_{2max} (% predicted)	11	80.9(13.8)	72.9(17.6)

Benzo R et al. Respir Med 2007

	Area under the curve	SE	Lower–upper bound	p-value	Cut-off	Sensitivity %	Specificity %
Total morbidity							
V'_{O_2} kg^{-1}	0.717	0.045	0.651–0.777	0.0001	12.8	51	85
V'_{O_2} kg^{-1} PBW	0.710	0.045	0.643–0.771	0.0001	15.8	64	69
V'_{O_2} % pred	0.657	0.045	0.589–0.722	0.0010	58	75	48
ASA score	0.593	0.039	0.523–0.661	0.0156	3	71	48
ppo FEV_1	0.565	0.045	0.495–0.633	0.7880	64	65	49
Cardiovascular complications							
V'_{O_2} kg^{-1}	0.708	0.065	0.640–0.771	0.0011	13.6	63	72
V'_{O_2} kg^{-1} PBW	0.738	0.054	0.671–0.798	0.0001	16.2	75	61
V'_{O_2} % pred	0.633	0.061	0.562–0.700	0.0029	53	64	61
ASA score	0.630	0.046	0.560–0.695	0.0080	3	79	47
ppo FEV_1 % pred	0.492	0.066	0.422–0.562	0.9030	80	29	79
Pulmonary complications							
V'_{O_2} kg^{-1}	0.723	0.057	0.654–0.784	0.0001	12.3	56	86
V'_{O_2} kg^{-1} PBW	0.691	0.065	0.580–0.718	0.0020	12.1	45	94
V'_{O_2} % pred	0.616	0.066	0.544–0.684	0.0169	37	30	95
ASA score	0.597	0.044	0.527–0.664	0.0269	3	73	47
ppo FEV_1	0.545	0.051	0.480–0.614	0.3716	64	73	50

Licker M et al. Eur Respir J 2011



Licker M et al. Eur Respir J 2011

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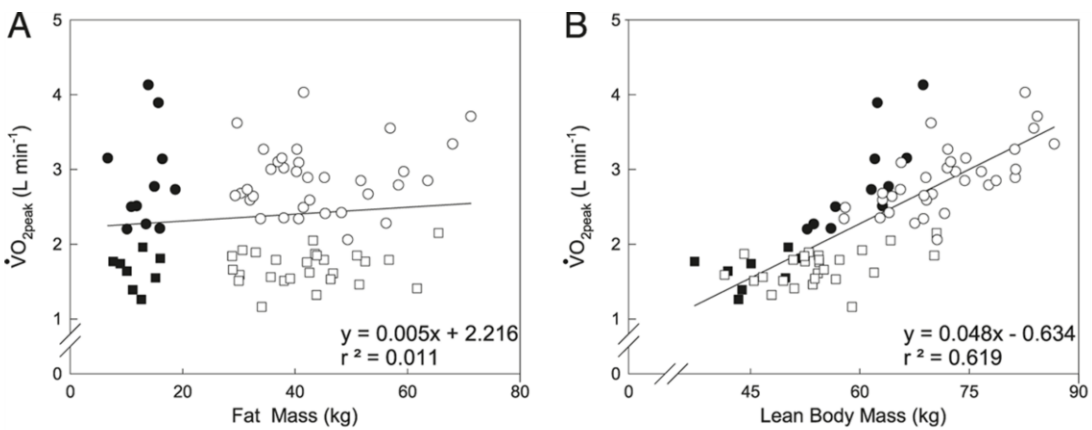
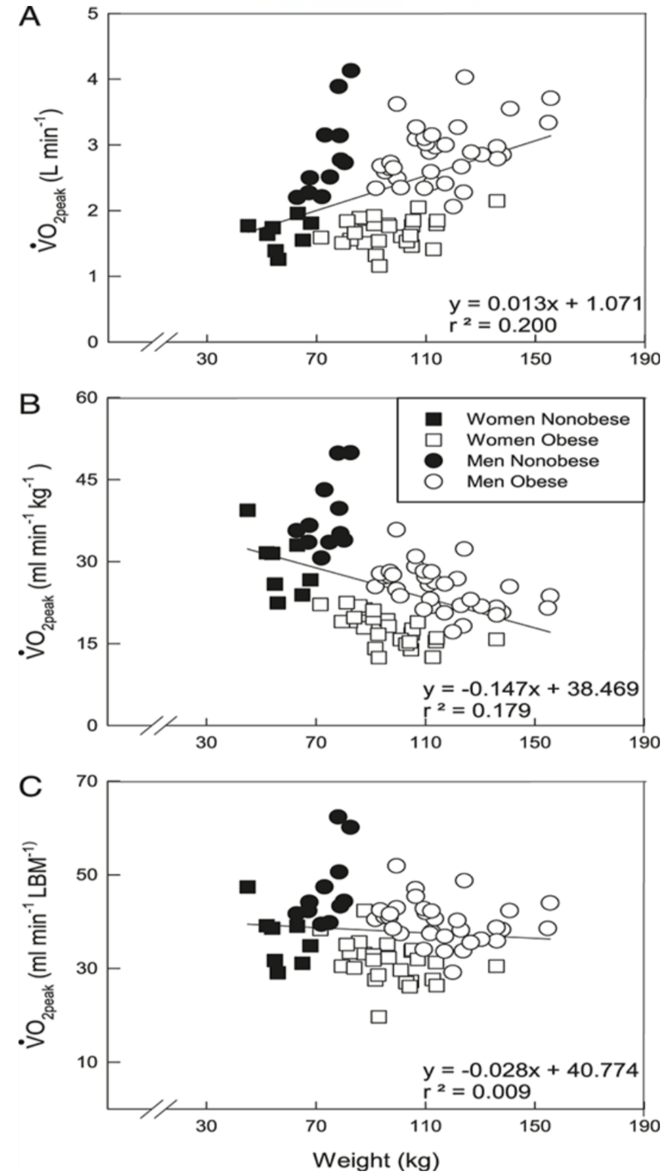
CHEST Original Research

PULMONARY PHYSIOLOGY

Quantification of Cardiorespiratory Fitness in Healthy Nonobese and Obese Men and Women

Santiago Lorenzo, PhD; and Tony G. Babb, PhD





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Original Research

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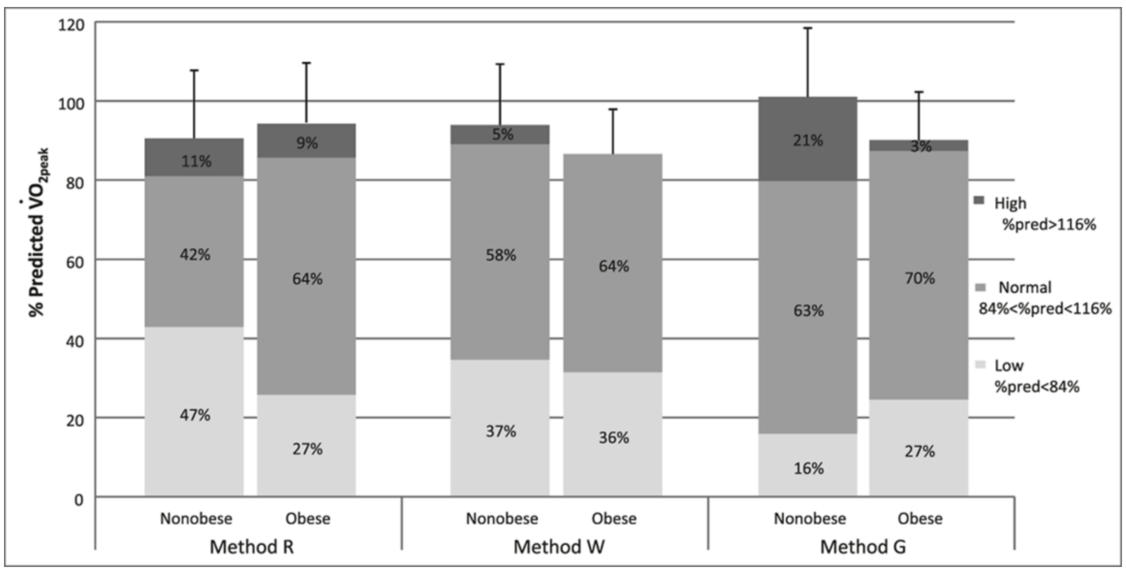
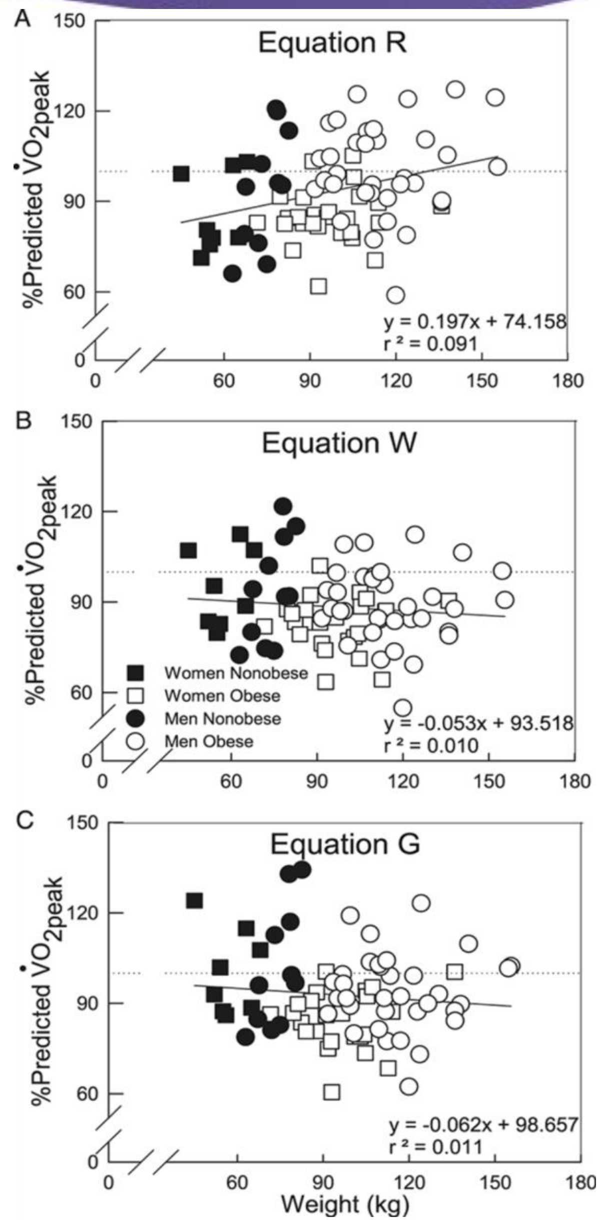




Effect of pre-operative training in lung cancer patients

Short term aerobic training. 4-6 sessions/week, 4-6 weeks + pt education and breathing techniques

Jones L Cancer 2007, 20 pts

Increase in peak VO2max (2.3 ml/kg/min)
Increase in 6MWT (40 m)
No changes in PFTs

Bobbio A EJCTS 2008, 12 pts

- **Increase in peak VO2** (2.8mL/kg/min)
- **No improvement of PFT**

Divisi D EJCTS 2013, 27 pts

- **Increase in peak VO2** (6.3 ml/kg/min)
- **Increase in PaO2** (22 mmHg)
- **Increase in PFTs** (FEV1, FEV1/FVC)

7.4.3. In patients with lung cancer being considered for surgery and deemed at high risk (as defined by the proposed functional algorithm, ie, PPO FEV_1 or PPO DLCO < 60% and $\dot{V}O_2max$ < 10 ml/kg/min or < 35%), preoperative or postoperative pulmonary rehabilitation is recommended (Grade 1C).

Brunelli A et al CHEST 2013;143(5 Suppl):e166S

Beyond VO2max:
VE/VCO2

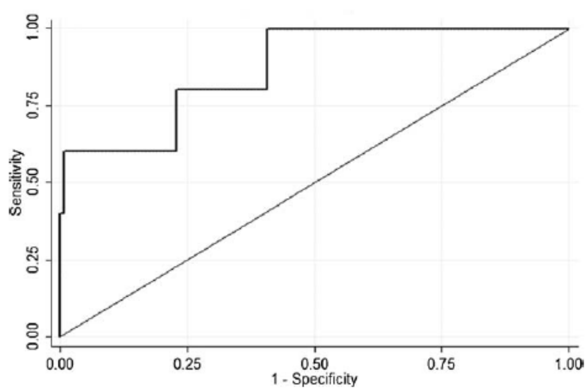
Exercise ventilatory inefficiency and mortality in patients with chronic obstructive pulmonary disease undergoing surgery for non-small-cell lung cancer

Roberto Torchio[a,*], Marco Guglielmo[a], Roberto Giardino[b], Francesco Ardissone[b], Claudio Ciacco[a], Carlo Gulotta[c], Aleksandar Veljkovic[d], Massimiliano Bugiani[e]

EJCTS 2010

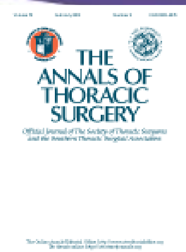
	Odds ratio	95% confidence interval	z	$p > z$
Risk of death				
V'_E/V'_{CO_2} slope	1.24	1.06–1.44	2.77	0.0060
BMI	0.75	0.55–1.04	−1.73	0.0830
Risk of complications				
$V'_{O_2\ peak}$	0.05	0.01–0.58	−2.39	0.0170
BMI	1.17	1.00–1.37	1.97	0.0490

VE/VCO2 slope < 34: 98% survival probability
VE/VCO2 slope≥34: 5.5% probability of death

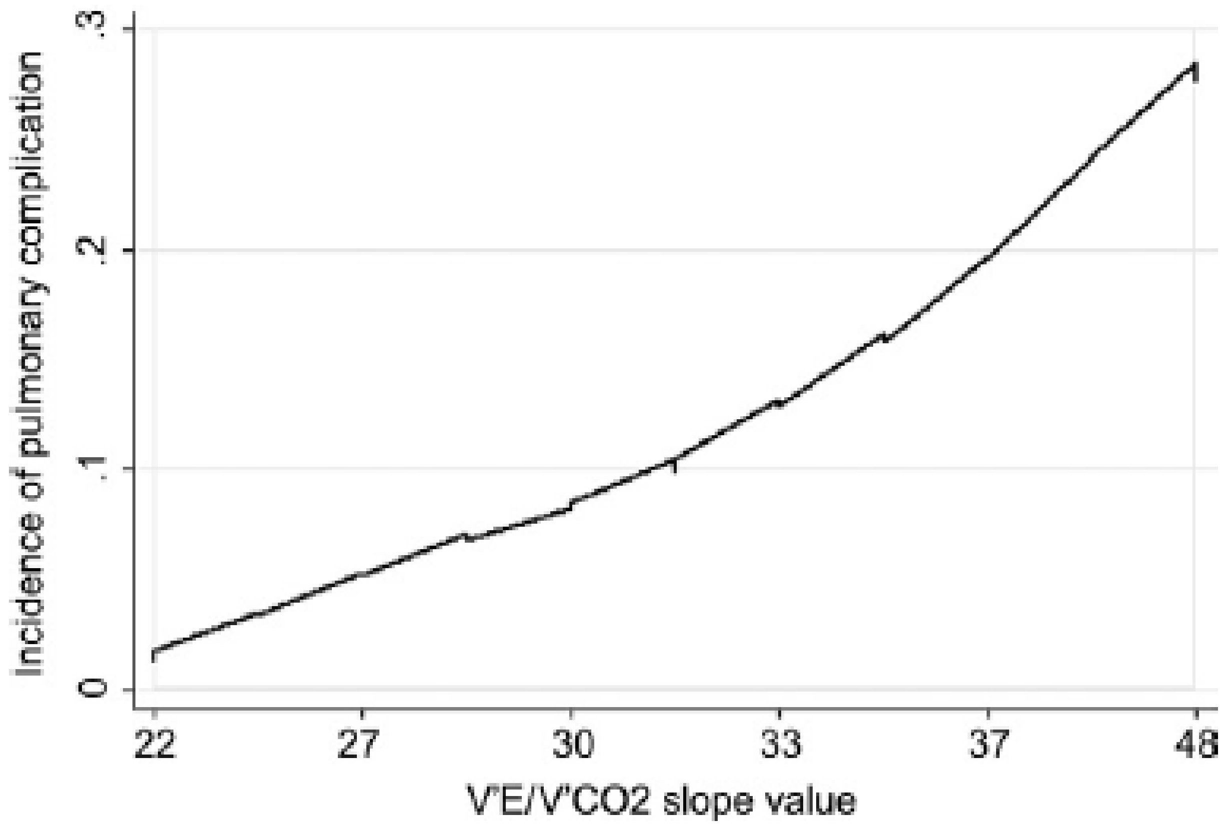


c-index 0.87

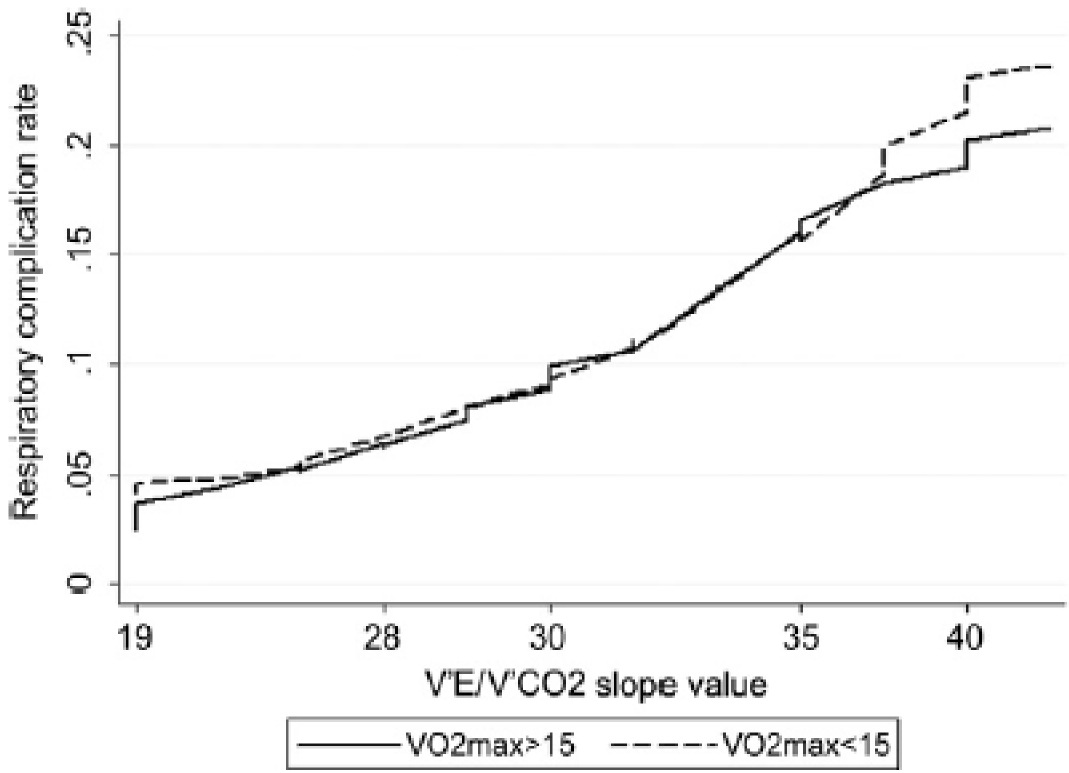
Minute Ventilation-to-Carbon Dioxide Output ($\dot{V}E/\dot{V}CO_2$) Slope Is the Strongest Predictor of Respiratory Complications and Death After Pulmonary Resection



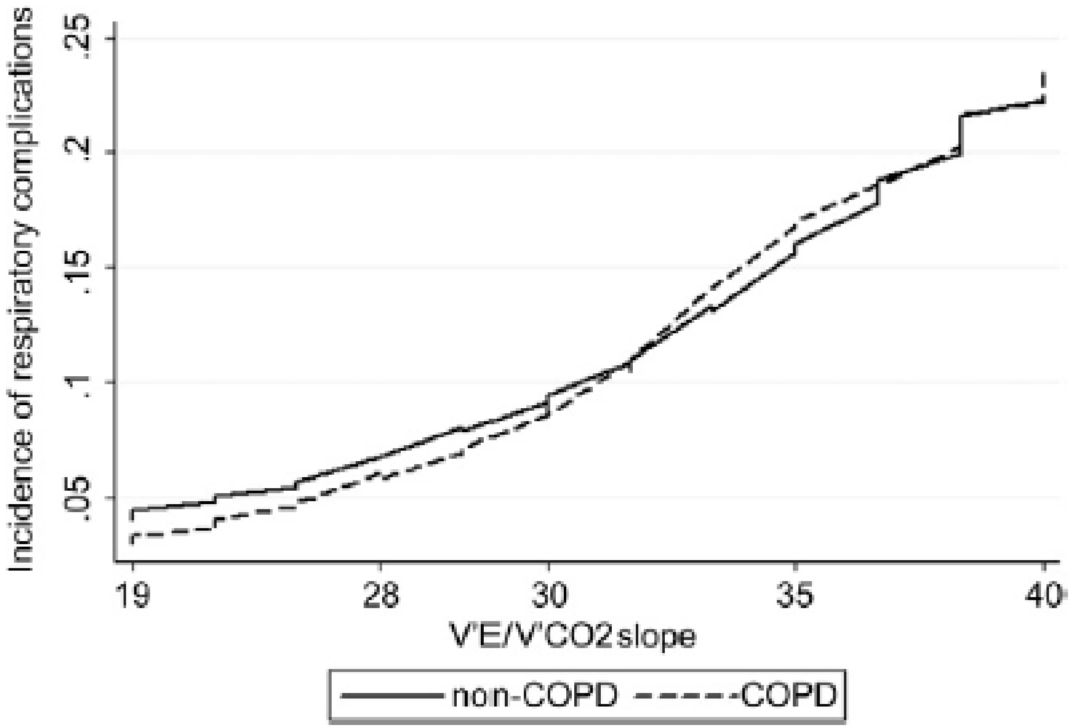
Alessandro Brunelli, MD, Romualdo Belardinelli, MD, Cecilia Pompili, MD,
Francesco Xiumé, MD, Majed Refai, MD, Michele Salati, MD, and
Armando Sabbatini, MD



VE/VCO2 is a predictor of respiratory complications either in pts with VO2<15 and VO2>15 mL/kg/min



VE/VCO2 is a predictor of respiratory complications either in pts with and without COPD



VE/VCO2 > vs. < 35: RC 22% vs 7.6%; death 7.6% vs. 0.2%

CPET and cardiac risk

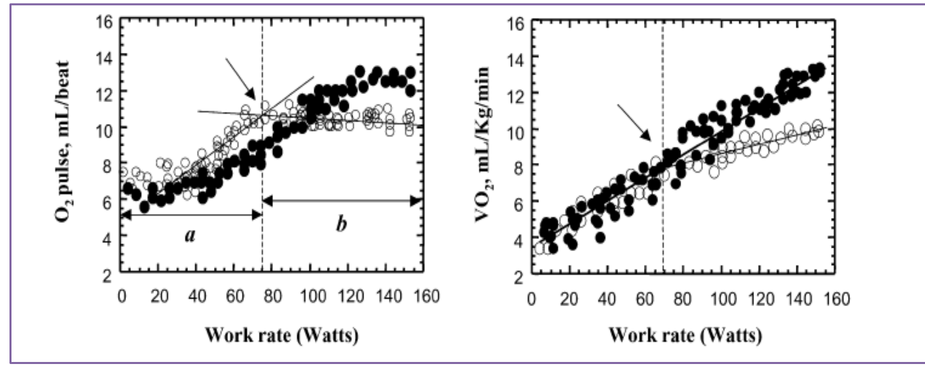
European Heart Journal (2003) 24, 1304–1313

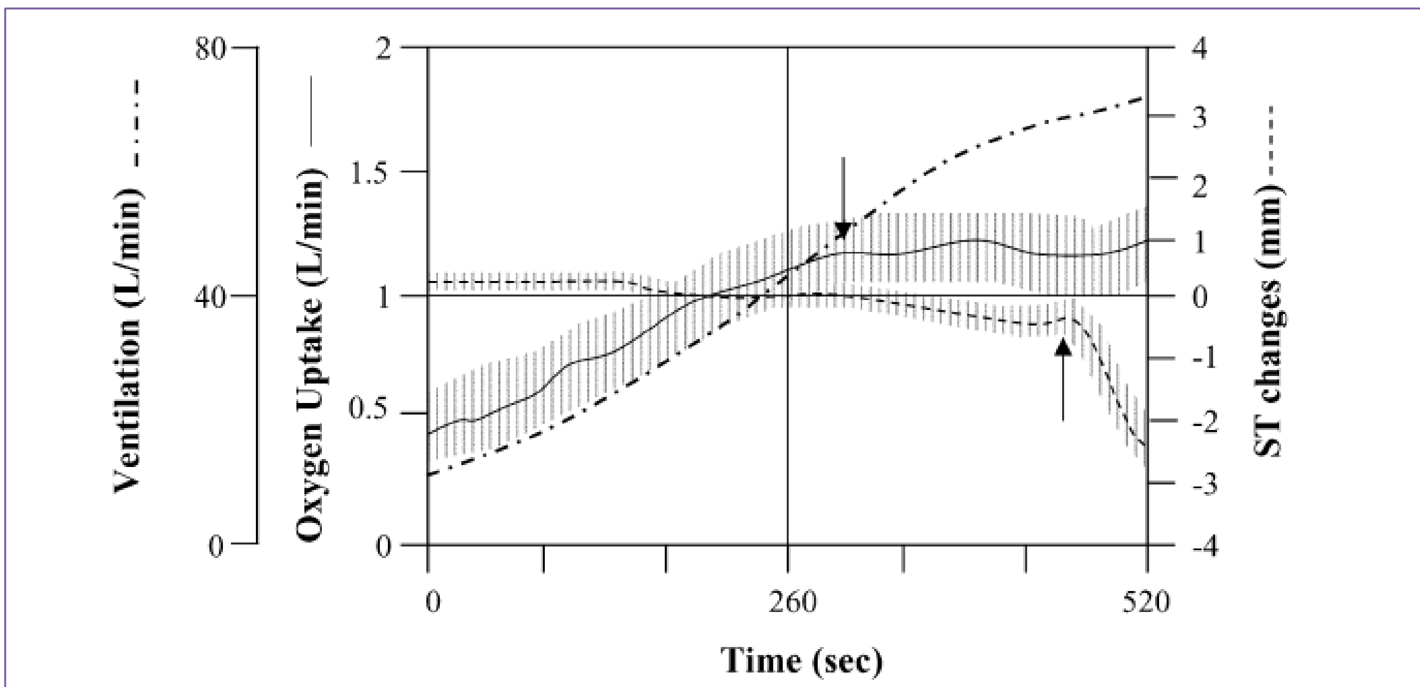
ELSEVIER

EUROPEAN SOCIETY OF CARDIOLOGY

Exercise-induced myocardial ischaemia detected by cardiopulmonary exercise testing

Romualdo Belardinelli[a*], Francesca Lacalaprice[a], Flavia Carle[b], Adelaide Minnucci[b], Giovanni Cianci[a], GianPiero Perna[a], Giuseppe D'Eusanio[a]

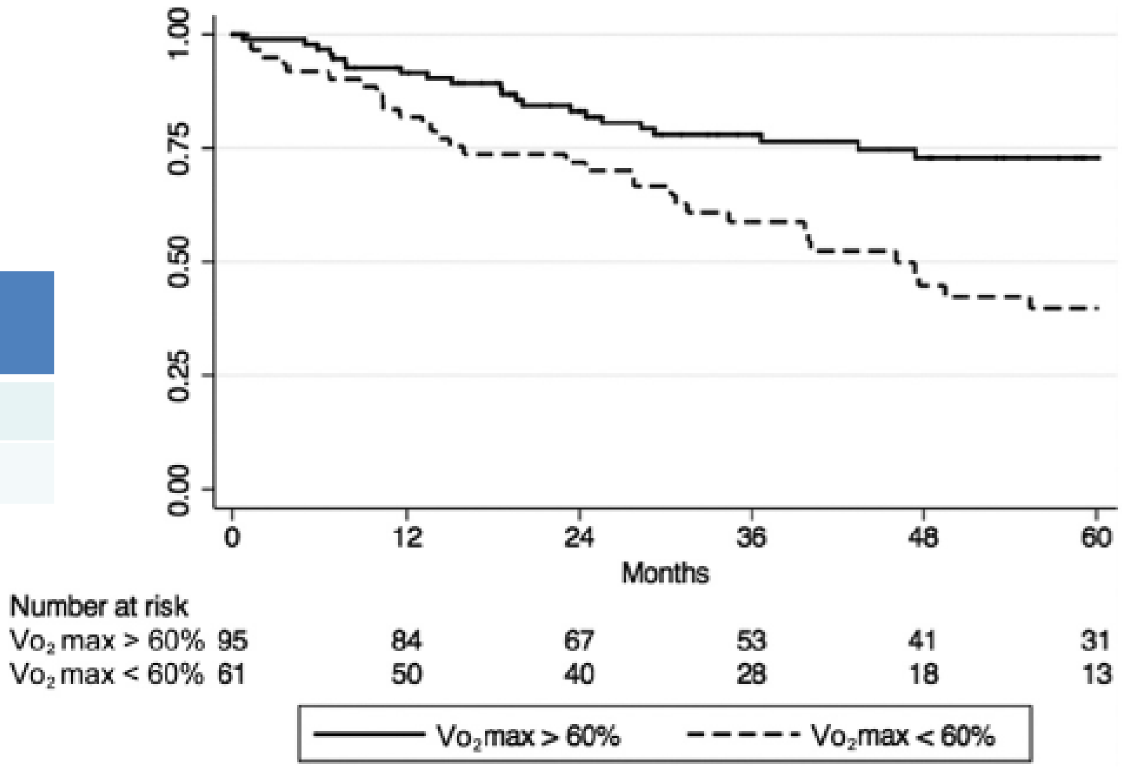




VO2max AND survival

Overall Survival

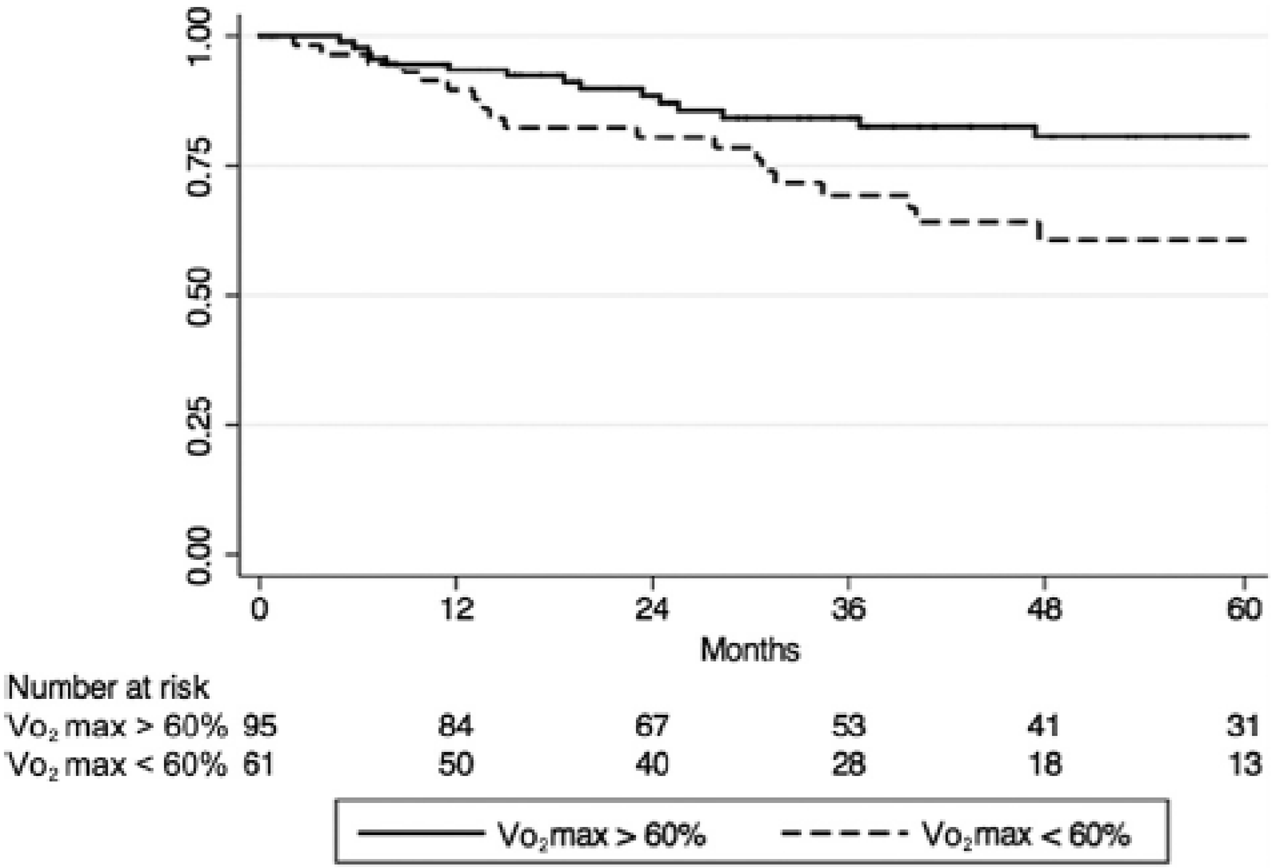
PREDICTORS	HR	P value
Age>70	2.3	0.005
VO2max<60%	2.4	0.001



P=0.0004

Brunelli A et al. Ann Thorac Surg 2014; 98:238

Cancer specific Survival



P=0.01

Brunelli A et al. Ann Thorac Surg 2014; 98:238

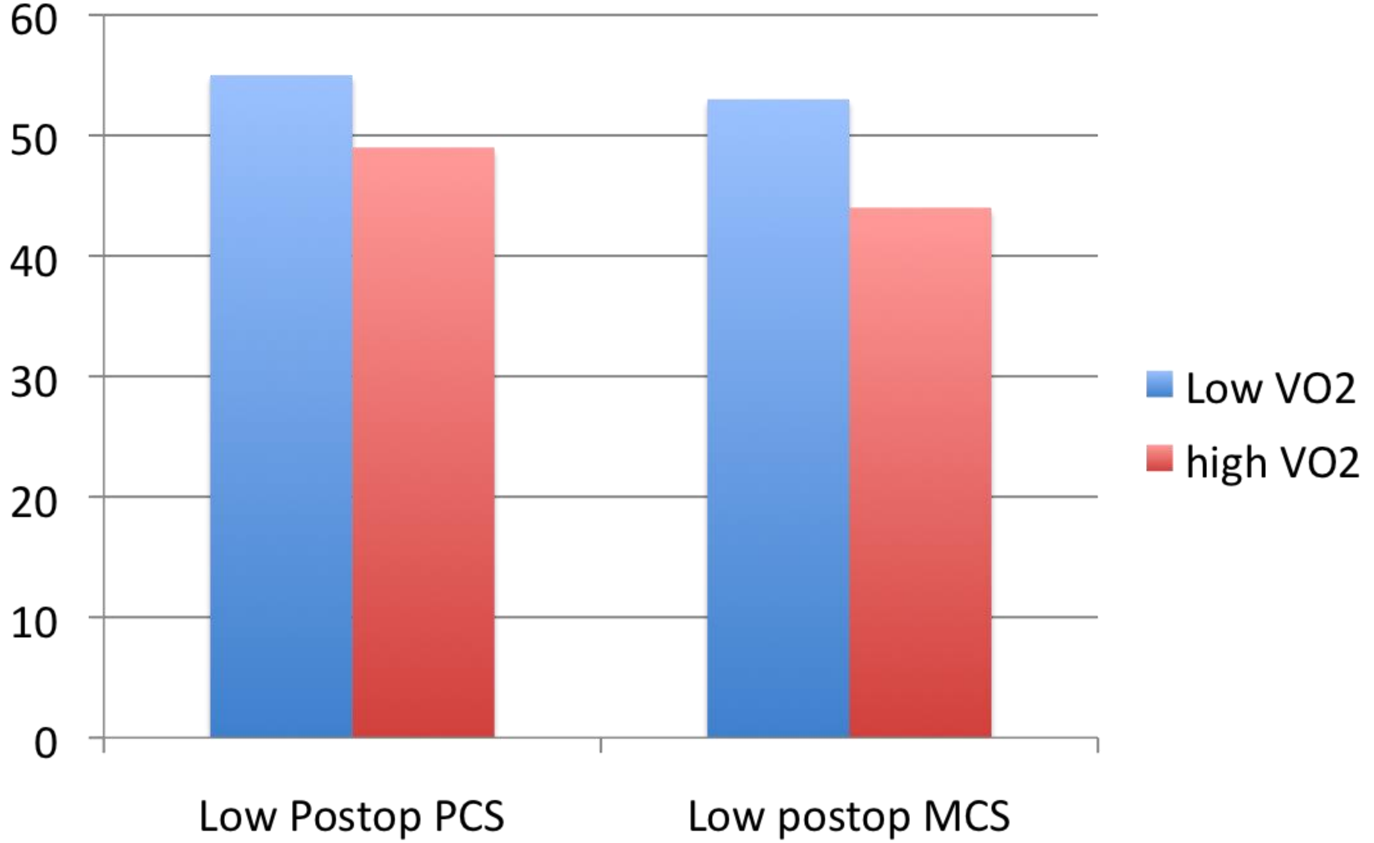
VO2max AND quality of life after surgery

Quality of life after lung resection is not associated with functional objective measures

Postop QoL scale	VO_2max >15 mL/kg/min [155]	VO_2max <15 mL/kg/min [66]	P-value
PCS	49.7 [7.6]	47.7 [8.1]	0.1
MCS	49.1 [10.4]	46.3 [12.3]	0.2
PF	50 [7.6]	44.5 [9.7]	<0.0001
RP	45 [11.4]	44 [12.5]	0.6
BP	51.1 [10.5]	52.6 [9.9]	0.3
GH	49.1 [8.6]	46.5 [9.7]	0.09
VT	56.1 [8.9]	52.1 [10.7]	0.006
SF	48.6 [10]	46.6 [10.3]	0.2
RE	46.5 [12.7]	45.1 [13.2]	0.4
MH	48 [10.2]	43.9 [13.5]	0.04

Pompili C et al. Eur Respir J 2013

Proportion of patients with postoperative low Physical or Mental QoL scores



Individual objective components of health, such as VO2max, when they are extrapolated from the patients contextual framework, may constitute only the basis of self-rating, which can be subsequently modified by the context of the evaluation

CPET in the guidelines

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ESTS

Recommendations:

1- Cardio-pulmonary exercise tests are performed in controlled environment, reproducible and safe. PeakVO2 measured during an incremental exercise on treadmill or cycle should be regarded as the most important parameter to consider, as a measure of exercise capacity and highly predictive of postoperative complications.

Level of evidence 2++; Grade of recommendations B

2- The following basic cut-off values for peakVO2 should be considered :

peakVO2> 75% of predicted value or 20mL/min/kg qualifies for pneumonectomy

peakVO2 < 35% or 10 mL/min/kg indicates high risk for any resection.

Evidence is thin to recommend cut-off values for lobectomy

Level of evidence 2++; Grade of recommendations C

European Respiratory Society

CHEST Supplement

DIAGNOSIS AND MANAGEMENT OF LUNG CANCER, 3RD ED: ACCP GUIDELINES

3.2.1.3. In patients with lung cancer being considered for surgery, with either a PPO $FEV_1 < 30\%$ predicted or a PPO DLCO $< 30\%$ predicted performance of a formal cardiopulmonary exercise test (CPET) with measurement of maximal oxygen consumption ($\dot{V}O_2max$) is recommended (Grade 1B).

3.9.2. In patients with lung cancer being considered for surgery and a $\dot{V}O_2max < 10$ml/kg/min or $< 35\%$ predicted it is recommended that they are counseled about minimally invasive surgery, sublobar resections or nonoperative treatment options for their lung cancer (Grade 1C).

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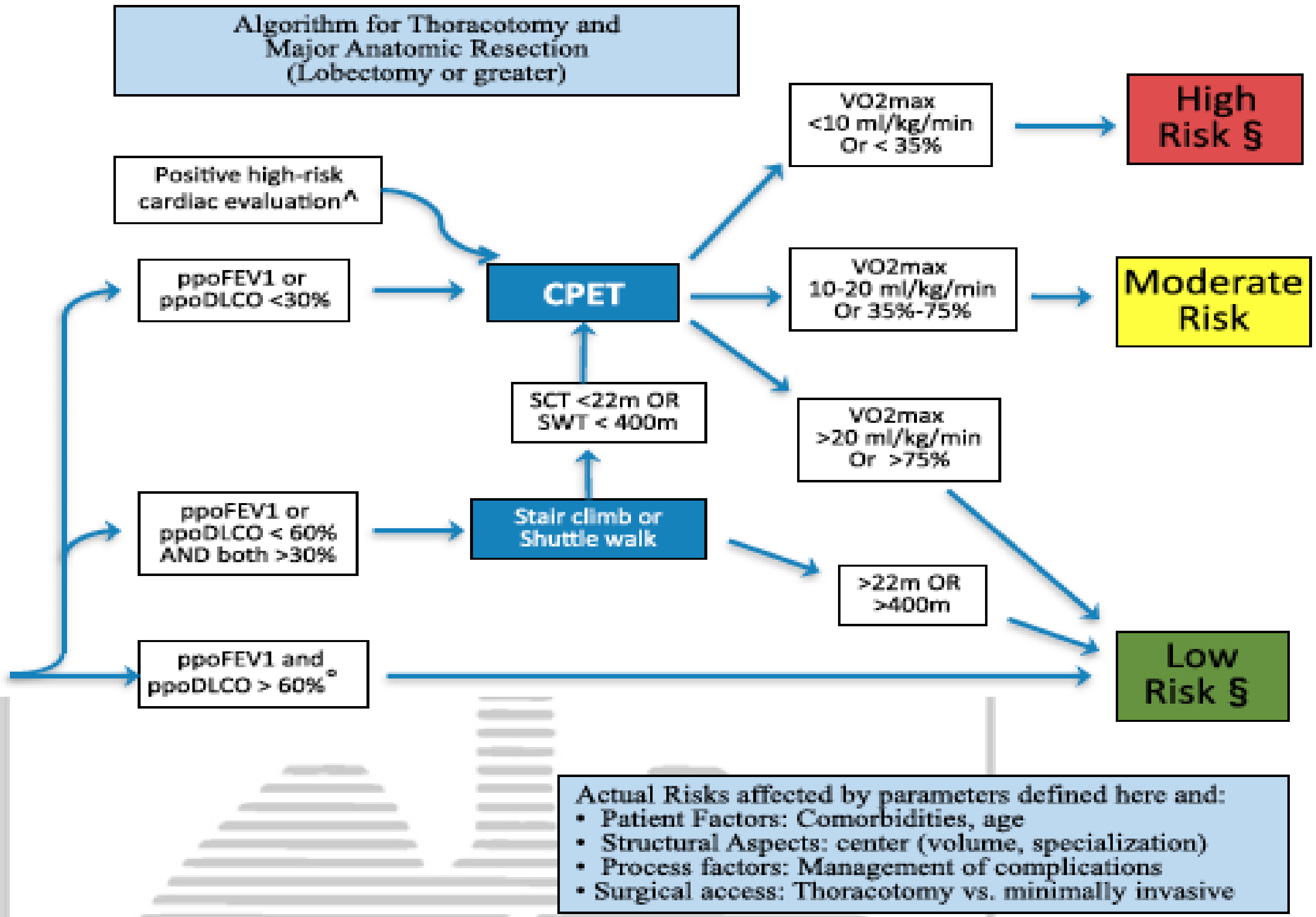
Physiologic Evaluation of the Patient With Lung Cancer Being Considered for Resectional Surgery

Diagnosis and Management of Lung Cancer, 3rd ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines

Alessandro Brunelli, MD, FCCP; Anthony W. Kim, MD, FCCP; Kenneth I. Berger, MD, FCCP; and Doreen J. Addrizzo-Harris, MD, FCCP



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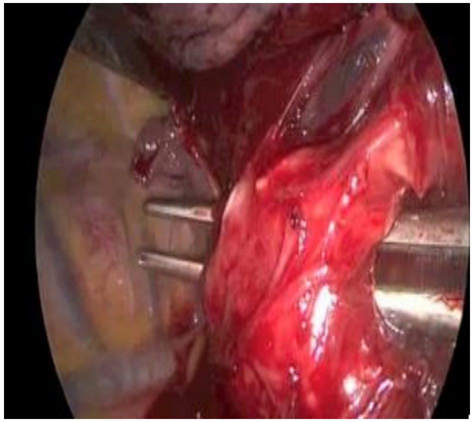
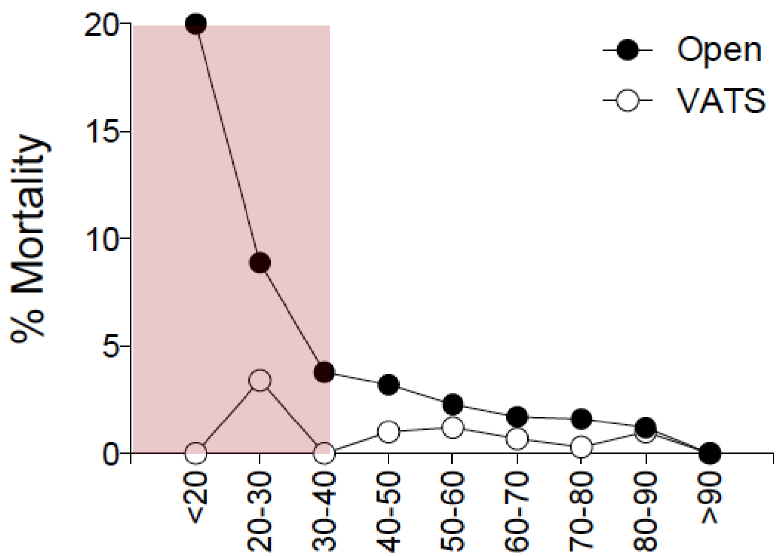
CPET and VATS lobectomy:
is VO2max still a reliable indicator?



Mortality in High Risk patients

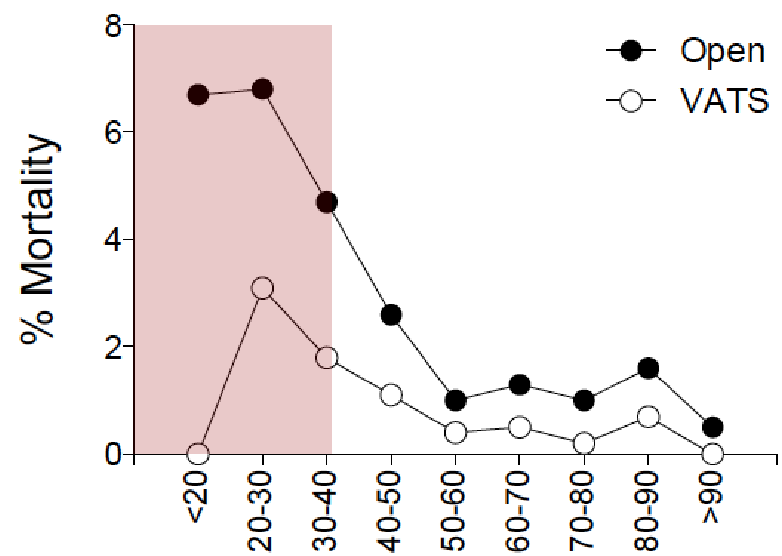
ppoFEV1 <40%

Open 4.8%
VATS 0.7%
p=0.003



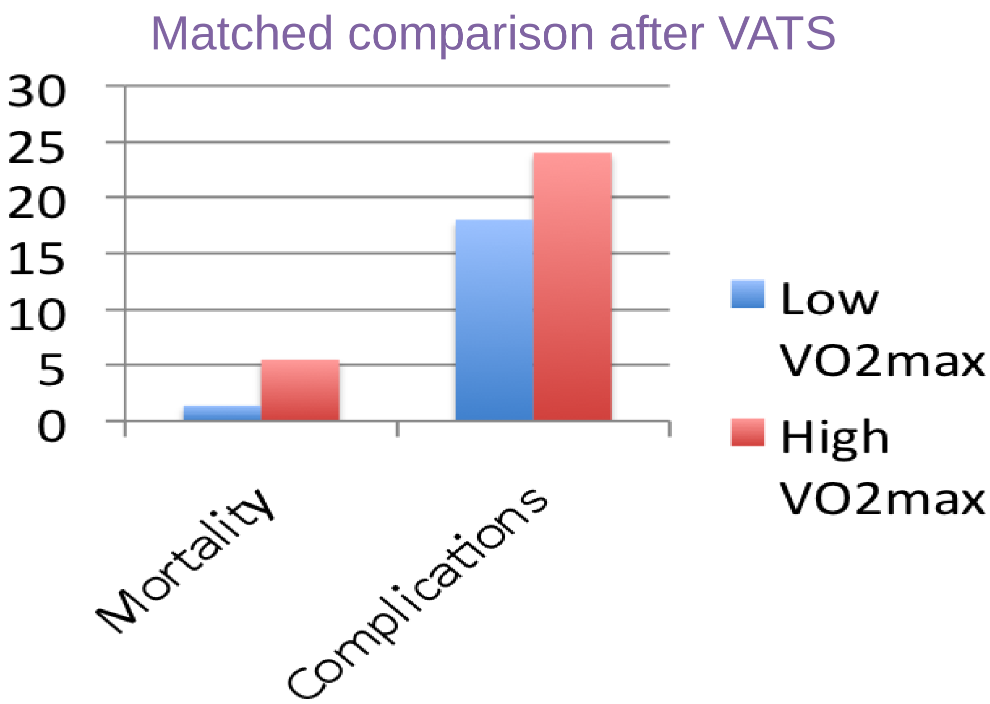
ppoDLCO <40%

Open 5.2%
VATS 2.0%
P=0.003



Burt BM et al. JTCVS 2014; 148:19-28

1684 lobectomies patients with VO2max available in ESTS database
281 VATS lobectomies



Low VO2max (<15 ml/kg/min) was not associated with increased surgical risk after VATS lobectomy, challenging the traditional operability criteria