CPX International Inc.
formerly ISEIRE Inc.

Cardiopulmonary Exercise Testing & Anaesthesia

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The BMW factory
BMW 3.5 CSL

The BMW factory
engined etc.
BMW 2002

The incomparable ‘M1’

A male at rest with poor cardiac performance

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CARDIAC OUTPUT.....	3.2	PULMONARY SYSTOLIC.....	50
PULSE RATE.....	92.0	'' DIASTOLIC.....	28
SYSTEMIC SYSTOLIC.....	114.0	'' MEAN.....	35
'' DIASTOLIC.....	80.0	CENTRAL VEN. PRES.....	6
'' MEAN.....	91.3	WEDGE.....	24
CARDIAC INDEX.....	1.8	PULMONARY RESISTANCE.....	283
STROKE INDEX.....	19.7	MEAN PUL.CAP.PRES.....	29
SYSTEMIC RESISTANCE...	2133.3	PATIENT STATUS.....	awake
L.VENT.STR.W.INDEX....	18.0	VENTILATOR STATUS...	nil.
OXYGEN TRANS.CAP.....	621.4	&..INDEX....	351
OXYGEN CONSUMPTION....	174.5	&..INDEX....	99
OXYGEN EXTRACT.RATIO..	28		
A/V DIFF.....	5		
APPARENT Qs/Qt.....	10		

Same subject during exercise

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CARDIAC OUTPUT.....	7.3	PULMONARY SYSTOLIC.....	78
PULSE RATE.....	140.0	'' DIASTOLIC.....	37
SYSTEMIC SYSTOLIC.....	157.0	'' MEAN.....	51
'' DIASTOLIC.....	112.0	CENTRAL VEN. PRES.....	13
'' MEAN.....	127.0	WEDGE.....	35
CARDIAC INDEX.....	4.1	PULMONARY RESISTANCE.....	172
STROKE INDEX.....	29.5	MEAN PUL.CAP.PRES.....	41
SYSTEMIC RESISTANCE...	1249.3	PATIENT STATUS.....	awake
L.VENT.STR.W.INDEX....	36.9	VENTILATOR STATUS...	nil.
OXYGEN TRANS.CAP.....	1440.2	&..INDEX....	814
OXYGEN CONSUMPTION....	908.9	&..INDEX....	514
OXYGEN EXTRACT.RATIO..	63		
A/V DIFF.....	12		
APPARENT Qs/Qt.....	2		

COMMENTS (10,20) TRUE WEDGE DURING EXERCISE

A male at rest preoperatively

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CARDIAC OUTPUT.....	4.6
PULSE RATE.....	68
SYSTEMIC SYSTOLIC.....	163
'' DIASTOLIC.....	87
'' MEAN.....	112
CARDIAC INDEX.....	3.4
STROKE INDEX.....	50
SYSTEMIC RESISTANCE...	1975
L.VENT.STR.W.INDEX....	74
OXYGEN TRANS.CAP.....	588
OXYGEN CONSUMPTION....	125
OXYGEN EXTRACT.RATIO..	21
A/V DIFF.....	5
APPARENT Qs/Qt.....	4

PULMONARY SYSTOLIC.....	30
'' DIASTOLIC.....	13
'' MEAN.....	20
CENTRAL VEN. PRES.....	1
WEDGE.....	4
PULMONARY RESISTANCE.....	281
MEAN PUL.CAP.PRES.....	
PATIENT STATUS.....	awake
VENTILATOR STATUS...	nil.
&..INDEX....	440
&..INDEX....	93

Same patient post operatively (lactate 4.3)

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CARDIAC OUTPUT.....	5.2
PULSE RATE.....	84
SYSTEMIC SYSTOLIC.....	154
'' DIASTOLIC.....	86
'' MEAN.....	109
CARDIAC INDEX.....	3.9
STROKE INDEX.....	46
SYSTEMIC RESISTANCE...	1685
L.VENT.STR.W.INDEX....	67
OXYGEN TRANS.CAP.....	856
OXYGEN CONSUMPTION....	228
OXYGEN EXTRACT.RATIO..	27
A/V DIFF.....	5
APPARENT Qs/Qt.....	2

PULMONARY SYSTOLIC.....	39
'' DIASTOLIC.....	14
'' MEAN.....	22
CENTRAL VEN. PRES.....	1
WEDGE.....	4
PULMONARY RESISTANCE.....	315
MEAN PUL.CAP.PRES.....	
PATIENT STATUS.....	awake
VENTILATOR STATUS...	nil.
&..INDEX....	640
&..INDEX....	170

Even for patients with less obvious limitations, functional capacity or exercise tolerance is the single most important predictor of cardiac and pulmonary complications following noncardiac surgery. In a study comparing several clinical predictors and exercise, Gerson et al. (39) demonstrated that the inability to raise the heart rate to 99 beats/min while doing 2 mins of supine bicycle exercise was the most sensitive predictor of postoperative cardiac and pulmonary complications and death.

CRIT CARE MED 2004
VOL 32, NO.4 (SUPPL)

The predictive value of exercise capacity is further demonstrated by a study in which patients exercised on a supine ergometer while connected by mouth piece to a metabolic cart (40). An anaerobic threshold, defined as the level of oxygen consumption above which circulatory supply could no longer meet metabolic demand, was identified and correlated with postoperative outcome. In patients with anaerobic thresholds of 11 mL/kg/min or more, the mortality was 0.8% compared with 18% for those with thresholds below this level. Even in patients who experienced ischemia at the time of exercise testing, anaerobic threshold levels were highly predictive of postoperative mortality.

British Journal of Anaesthesia 115 (4): 494–7 (2015)
Advance Access publication 17 June 2015 · doi:10.1093/bja/aev150

Cardiopulmonary exercise testing before abdominal aortic aneurysm surgery: a validated risk prediction tool?

A. Hollingsworth[1], G. Danjoux[2,3] and S. J. Howell[4,5,*]

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[2] Department of Anaesthesia, James Cook University Hospital, Middlesbrough, UK,
[3] Health and Social Care Institute, Teesside University, Middlesbrough, UK,
[4] Leeds Institute of Biomedical and Clinical Sciences, University of Leeds, UK, and
[5] Department of Anaesthesia, Leeds General Infirmary, Leeds, UK

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tical validation.

Although not specifically relating to vascular surgery, the recently updated ACC/AHA guideline document on perioperative cardiovascular evaluation and management before noncardiac surgery, has for the first time made recommendations with respect to preoperative CPET: 'Cardiopulmonary exercise testing may be considered for patients undergoing elevated risk procedures in whom functional capacity is unknown.' They conclude that benefit of preoperative CPET *may* be greater than risk (Level of evidence B, IIb), however 'additional studies with broad objectives are required'.[24]

In conclusion, current data support an association between

UR062332(1) - Intensive Care Unit - Western Hospital - Melbourne Ver 5.0 January 2002

File Enter data View Consensus Drugs (a - k) Drugs (l - z) Procedures/Complications Procedures Info Protocols Help

Name : LOIS GEORGE *Sex :* M *Age :* 66 yrs *Weight :* 84 kg *Height :* 170 cm *BSA :* 1.95 Sq.m

UR Number : 062332 *Admission date :* Sunday 16/07/2000 *Admission time :* 15:45 hrs *Current S.I.R.S. status :* NEGATIVE

Admission diagnosis : ADENO CA CARDIA *APACHE III group :* GI neoplasm *Parent unit :* JONES

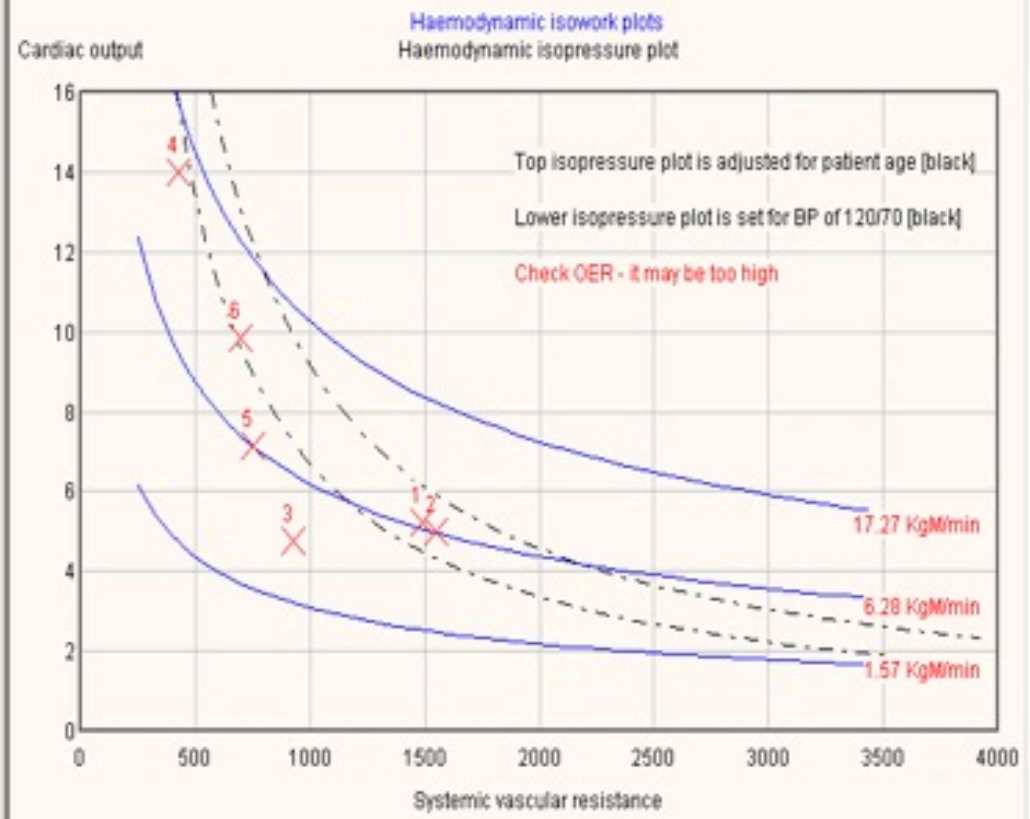
Admission source Elective pre-op admission *Native language* English *Interpreter* not needed *Religion* Unknown

G.P.: *..phone no.:* *Relative or contact :* NADIA LOUIS *..phone no.:* 93117510

Biochem | Haem | Gases | Urine | PA Cath. | PiCCO | Vent | LFT's | CardEnz | SP Te

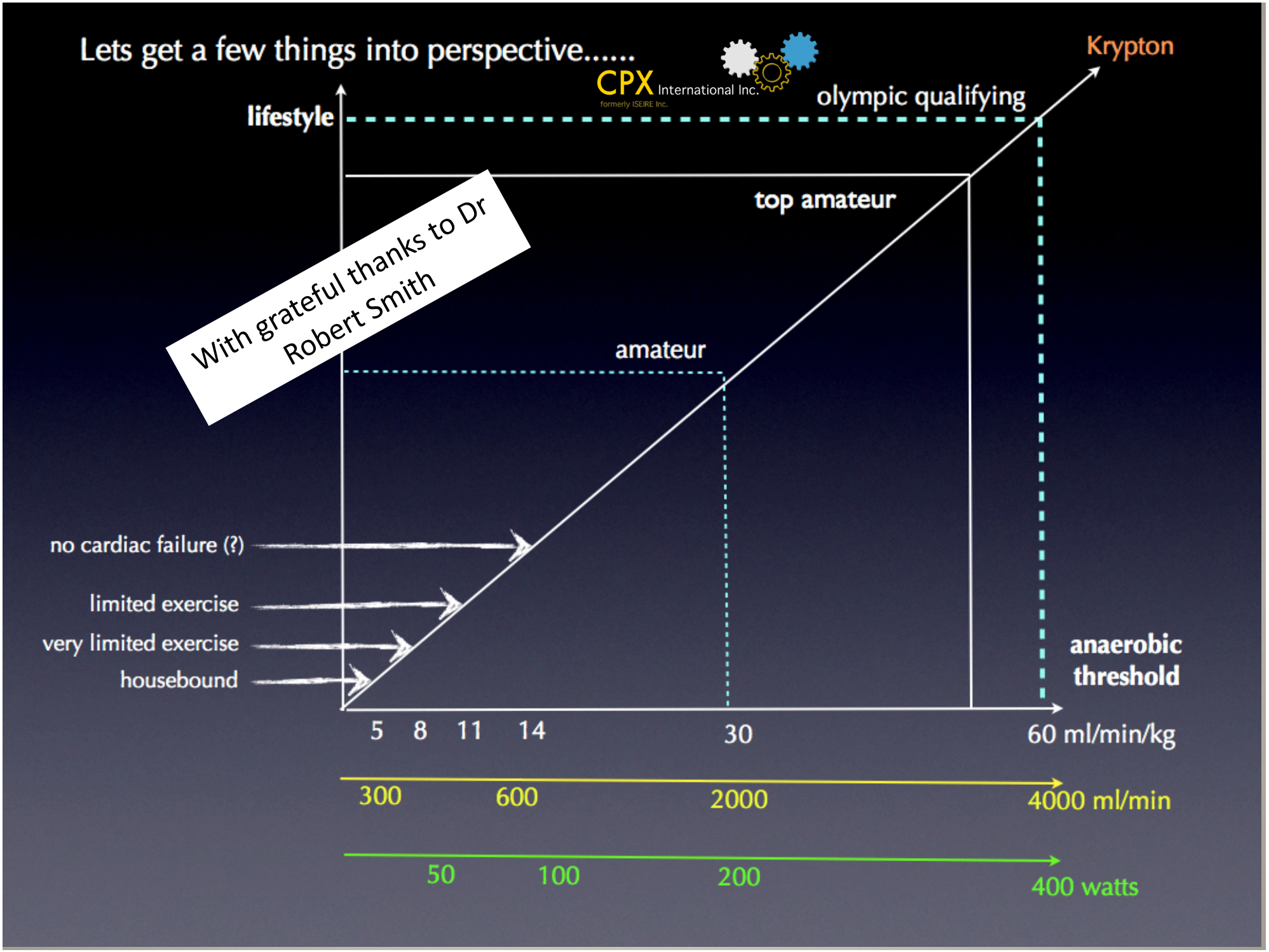
Day	Sunday		Monday		Tuesday	
Date	16Jul2000		17Jul2000		18Jul2000	
Time	08:45 PM	09:24 PM	02:35 PM	08:30 PM	04:22 AM	08:39 AM
CO / CI	5.2/ 2.7	5.0/ 2.6	4.8/ 2.5	14.0/ 7.2	7.2/ 3.7	9.8/ 5.1
pulse rate	60	59	64	103	80	90
blood pressure	164/70	157/74	92/49	129/52	119/49	151/63
mean BP	101	102	63	78	72	92
PA pressure	21/6	24/9	19/10	24/10	24/12	30/17
mean PAP	11	14	13	15	16	21
CVP	4	5	8	3	5	7
wedge	5	8	5	6	11	12
stroke vol/ind	87/45	84/43	75/38	136/70	89/46	109/56
LVSWI	59	55	30	68	38	61
SysVasRes	1486	1553	928	427	753	694
PulVasRes	92	96	134	50	56	76
E.Fraction						
E.Diast.Vol						
E.Sys.Vol						
OTI/OTI	887/455	843/433	549/282	2118/1088	895/460	1216/625
OCI/OCI	188/96	179/92	201/103	717/368	265/146	373/191
OER	21.2	21.2	36.7	33.9	31.9	30.7
lactate				3.7	6.2	1.6
ventilated	No	No	No	No	No	No
post-op.	No	No	Yes	Yes	Yes	Yes
Adrenaline				1.0		

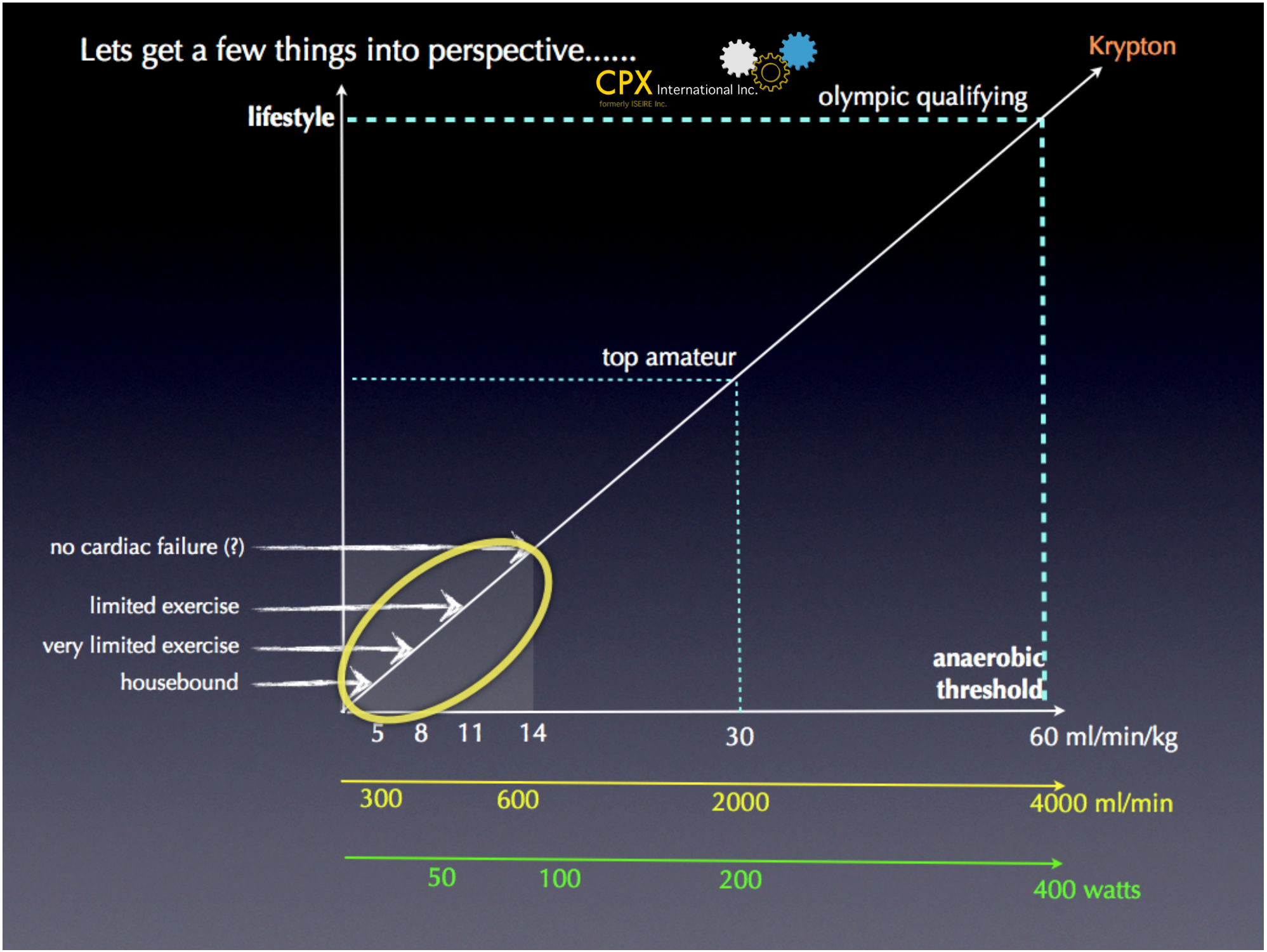
General | CardEnz | Biochem | H_Dynamic | Renal | HbDCurv | Haem | AcidBase | Paracetamol



For Help, press F1

Start | UR062332(1) - Intens... | 96% | 11:42 AM


Lets get a few things into perspective.....
CPX International Inc.
formerly ISEIRE Inc.
Krypton
olympic qualifying
lifestyle
top amateur
With grateful thanks to Dr Robert Smith
amateur
no cardiac failure (?)
limited exercise
very limited exercise
housebound
anaerobic threshold
5 8 11 14 30 60 ml/min/kg
300 600 2000 4000 ml/min
50 100 200 400 watts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CPX International Inc.
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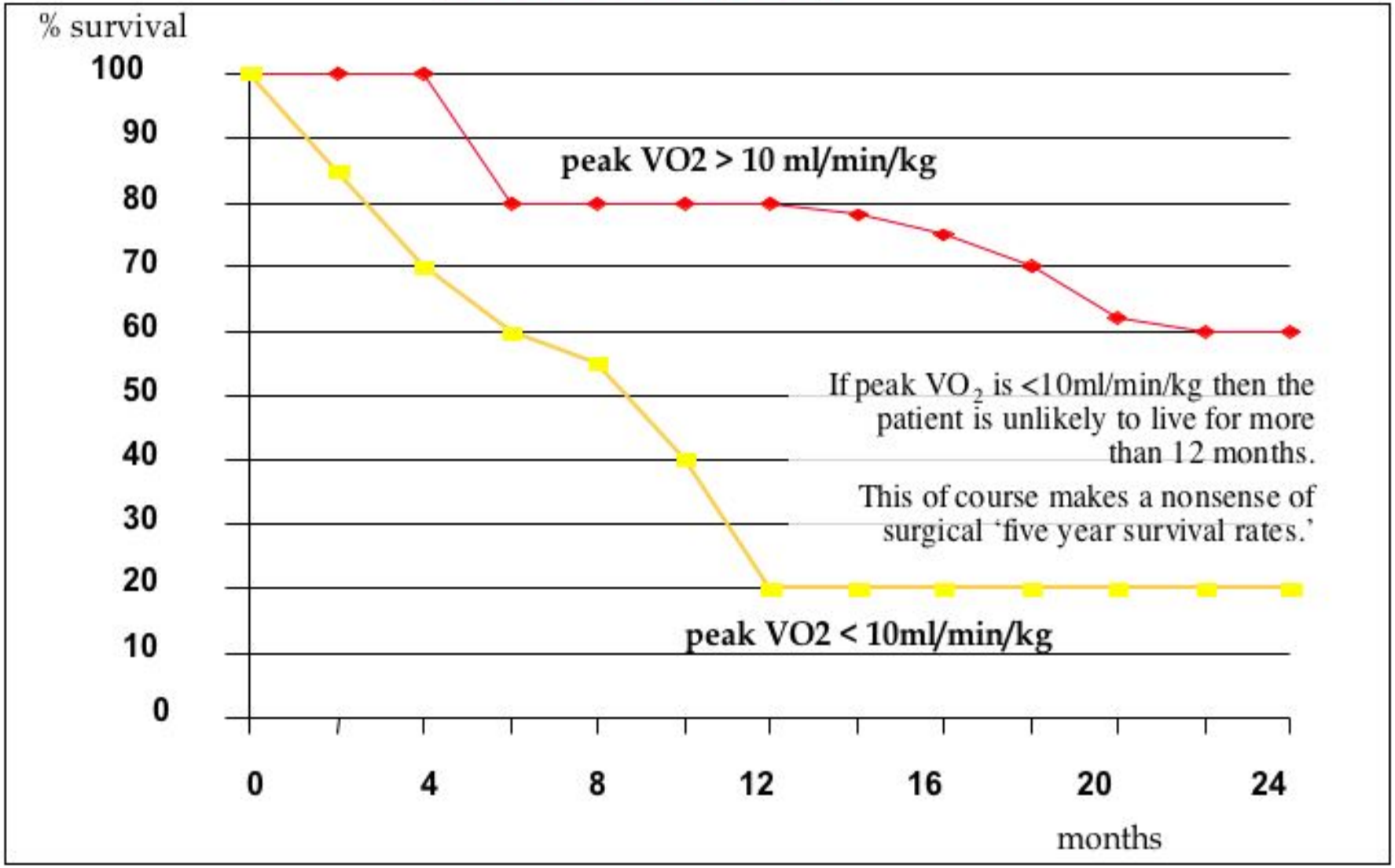
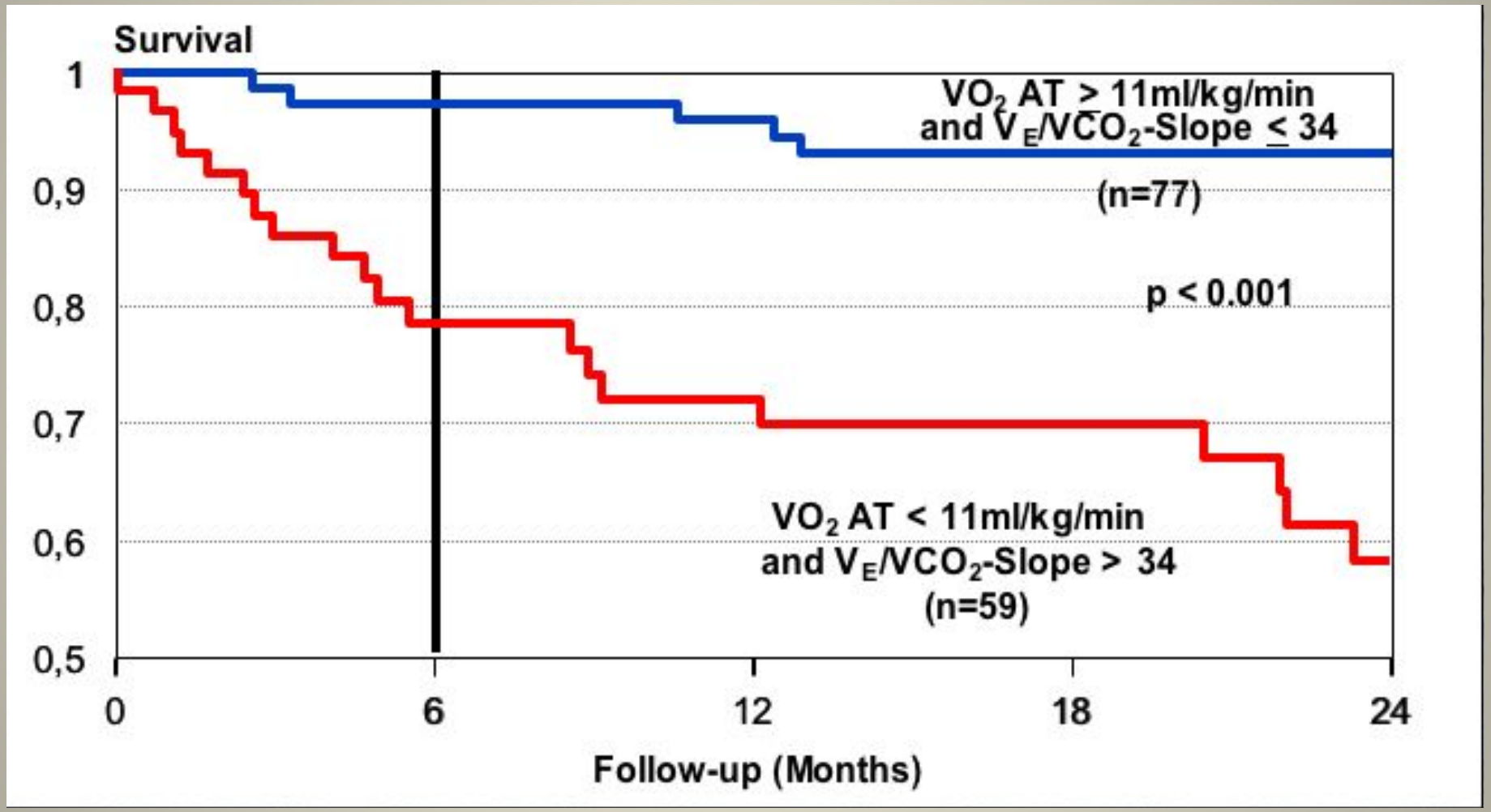
Krypton
olympic qualifying
lifestyle
top amateur
no cardiac failure (?)
limited exercise
very limited exercise
housebound
anaerobic threshold
5
8
11
14
30
60 ml/min/kg
300
600
2000
4000 ml/min
50
100
200
400 watts

Peak VO2 and longevity



Schalzic 1985

Gitt et al., Circulation 2002: Dec., 3079



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Pre-Anesthetic Testing

Volume 50, No. 1 January 1978

Postgraduate Educational Issue

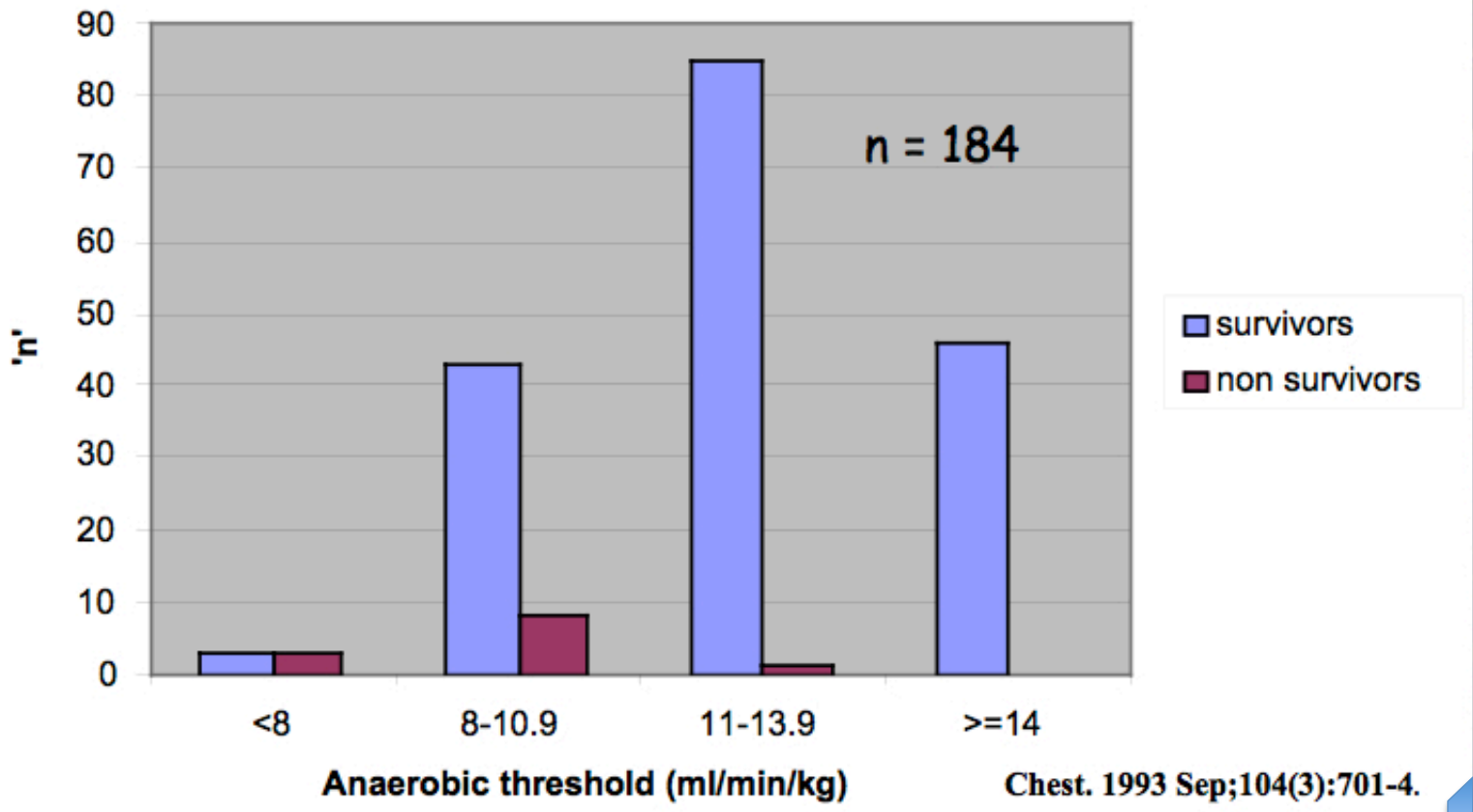
Containing a Symposium on Clinical Assessment

Edited by C. M. Conway and J. Norman

British Journal of Anaesthesia

Editor of General Issues: A. A. Spence

Cardiovascular mortality and anaerobic threshold



Chest. 1993 Sep;104(3):701-4.

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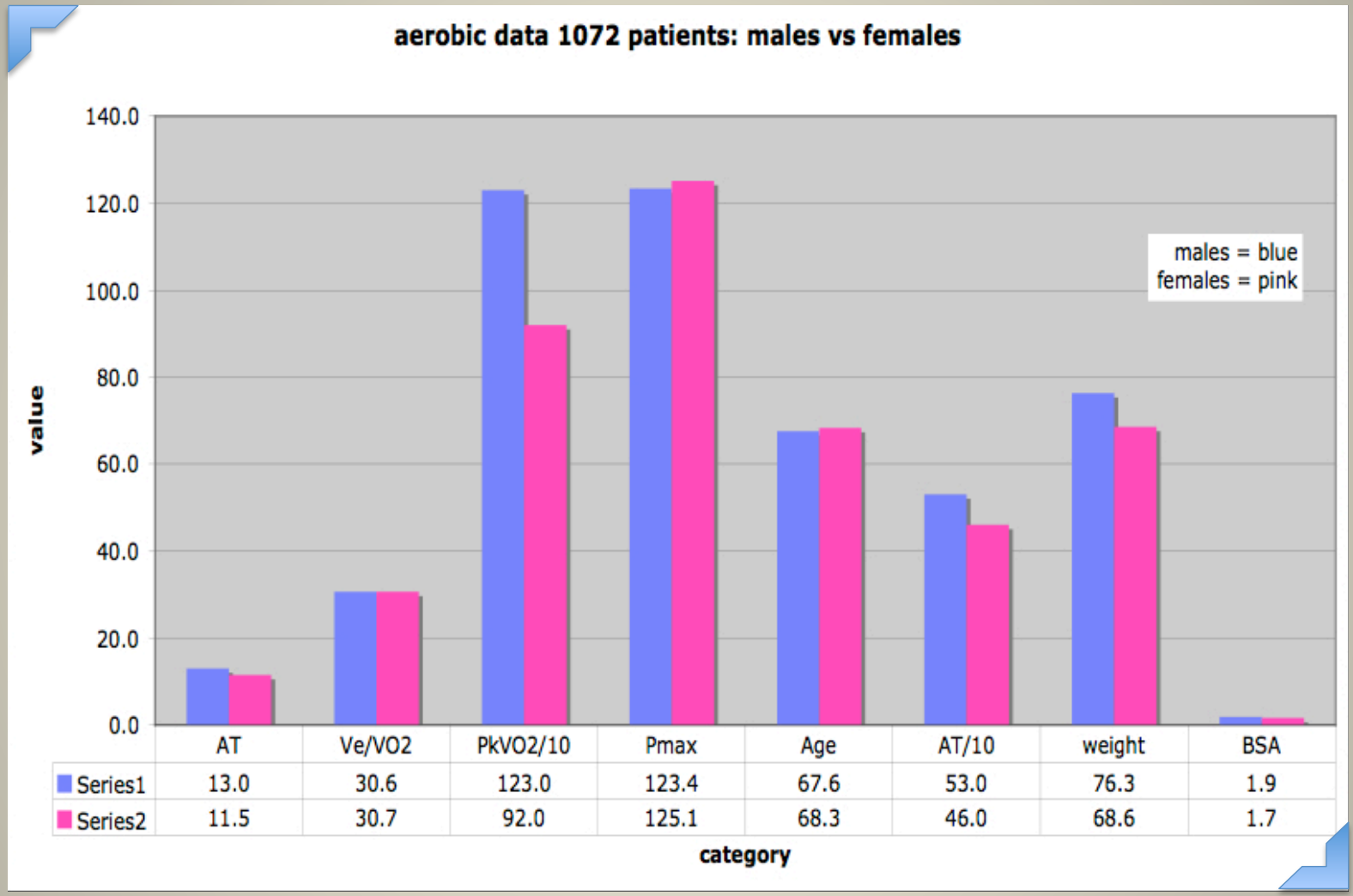

However !!!

Oxygen pulse = VO2/HR

Oxygen pulse = CO x a/v diff/HR

Oxygen pulse = SV x HR x a/v diff / HR

divide through by HR

Oxygen pulse = SV x a/v diff

Oxygen pulse = SV / 10

Study performed at Western Hospital 2002-2004

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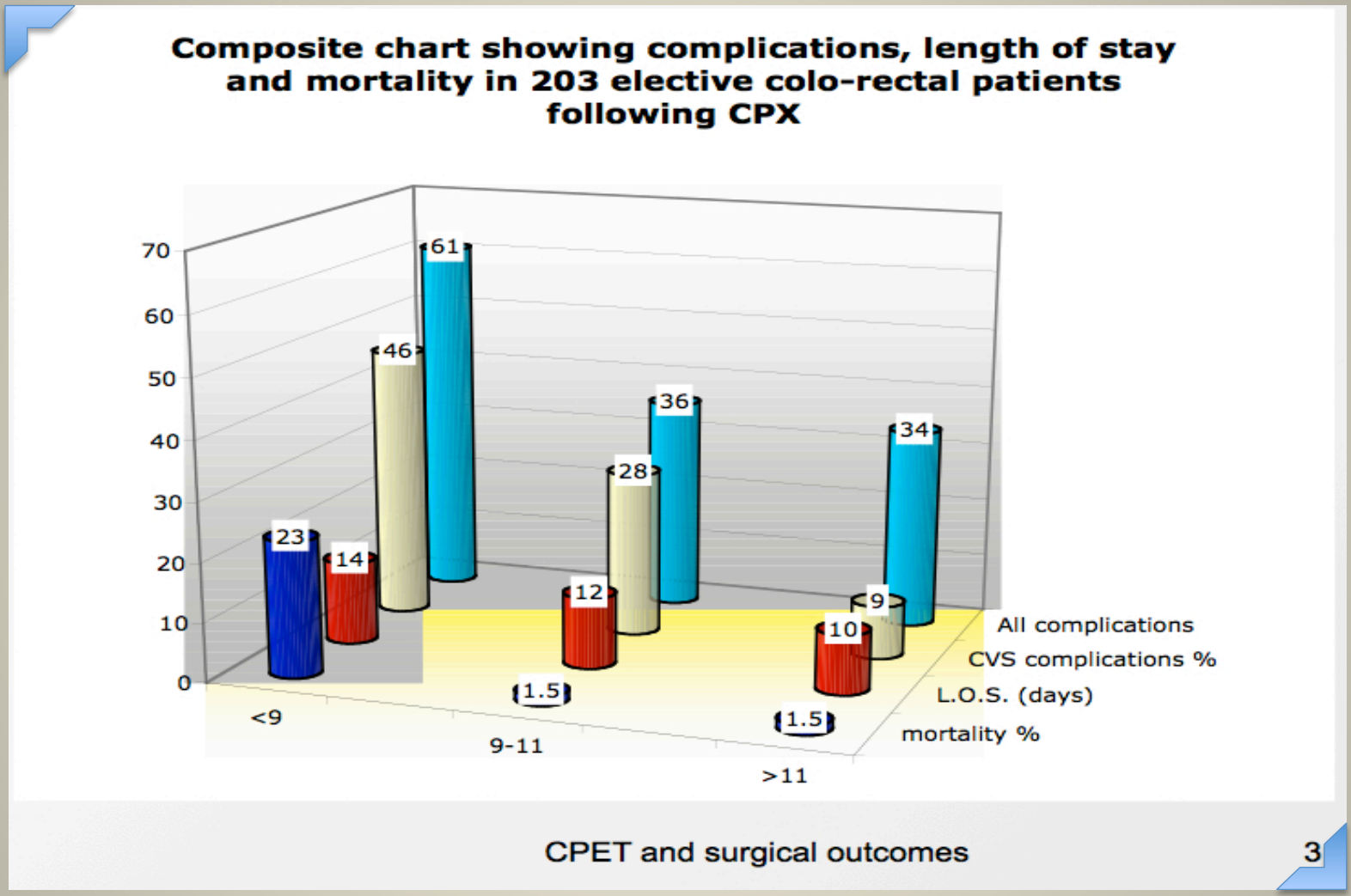
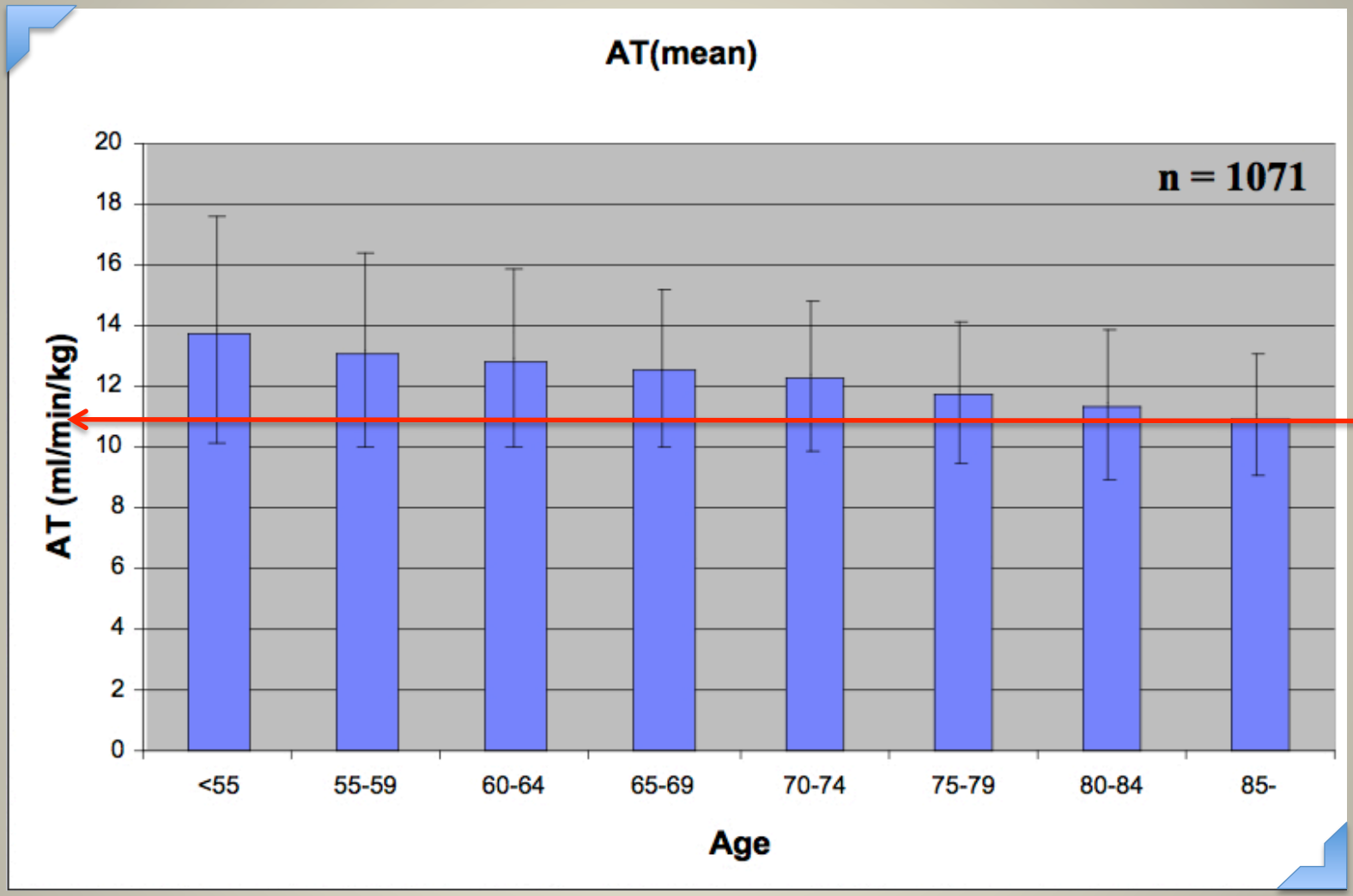


With my sincere thanks to Dr Robert Smith for this graph


AT(mean)
n = 1071
AT (ml/min/kg)
20
18
16
14
12
10
8
6
4
2
0
<55
55-59
60-64
65-69
70-74
75-79
80-84
85-
Age

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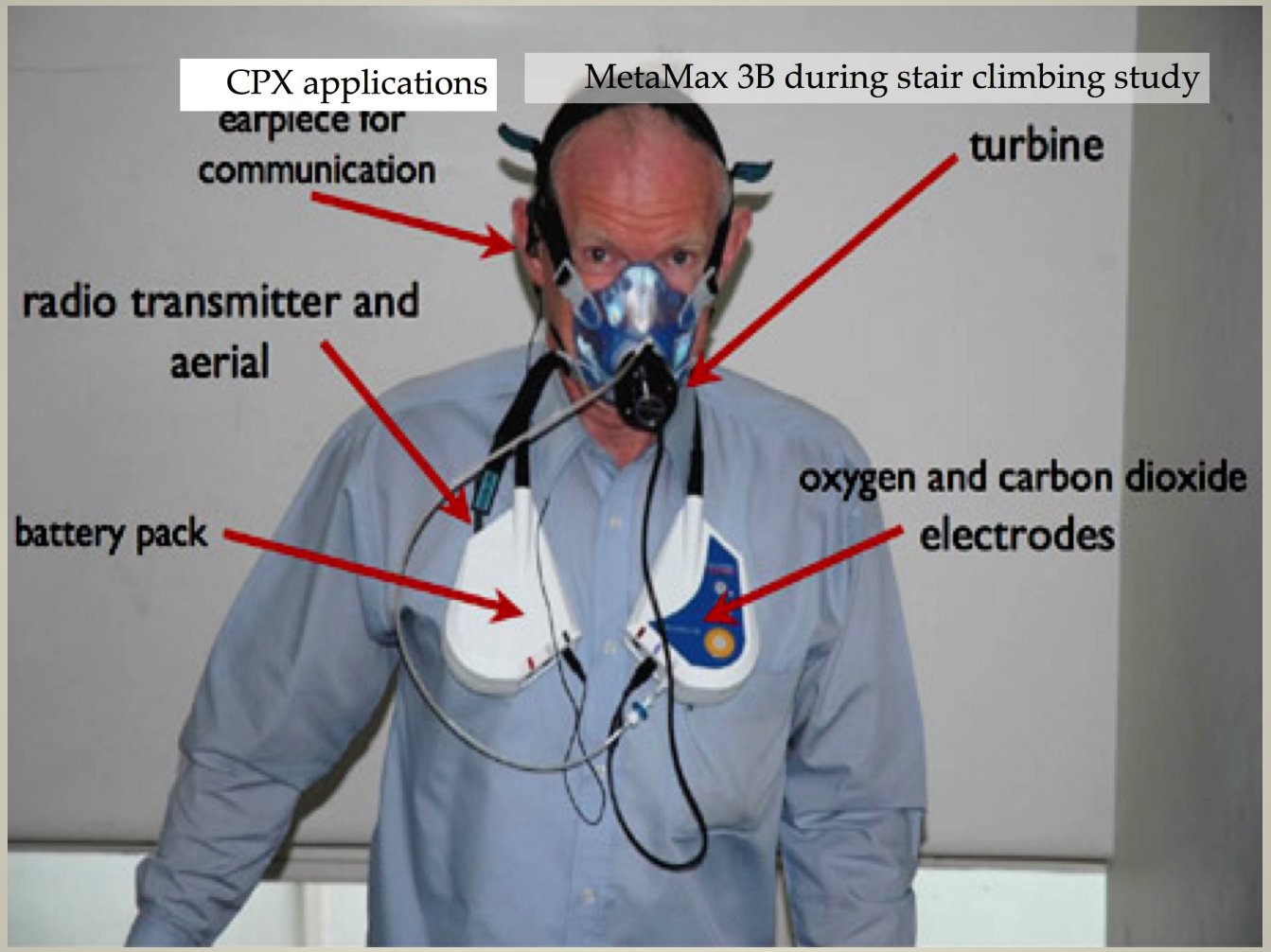

Power = mass(kg) x gravity x displacement(M)/time(sec)
Watts = 72 x 9.8 x 7/28 = 176 watts AT ??!!

The era of 'it's the risk of heart attack' that really matters.

Anesthesiology
59:499–505, 1983

Reinfarction Following Anesthesia in Patients with Myocardial Infarction

Tadikonda L. K. Rao, M.D., Kurt H. Jacobs, Ph.D.,† Adel A. El-Etr, M.D.‡*

The authors studied the incidence of and factors related to recurrent perioperative myocardial infarction retrospectively during 1973-1976 (Group 1) and prospectively during 1977-1982 (Group 2). Reinfarction occurred in 28 of 364 (7.7%) patients in Group 1 and 14 of 733 (1.9%) in Group 2 (P less than 0.005). When the previous infarction was 0-3 and 4-6 months old, perioperative reinfarction occurred in 36% and 26% of Group 1 patients, respectively, and only 5.7% and 2.3% of Group 2 patients, respectively, (P less than 0.05). In both groups, patients with associated congestive heart failure had a higher reinfarction rate. Patients who had intraoperative hypertension and tachycardia or hypotension develop had a higher incidence of reinfarction in both groups. The results suggest that preoperative optimization of the patient's status, aggressive invasive monitoring of the hemodynamic status, and prompt treatment of any hemodynamic aberration may be associated with decreased perioperative morbidity and mortality in patients with previous myocardial infarction

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The era of 'it's the risk of heart attack' that really matters? Perhaps not!

Chest. 1999;116(2):355-62

Cardiopulmonary exercise testing as a screening test for perioperative management of major surgery in the elderly.

Older P, Hall A, Hader R

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STUDY OBJECTIVE: To develop an integrated strategy for the identification and subsequent management of high-risk patients in order to reduce both morbidity and mortality.
DESIGN: Prospective consecutive series in which all patients underwent cardiopulmonary exercise (CPX) testing.
SETTING: CPX laboratory and level 3 ICU and high-dependency unit (HDU) of a metropolitan teaching hospital.
PATIENTS: Five hundred forty-eight patients >60 years of age (or younger with known cardiopulmonary disease) scheduled for major intra-abdominal surgery.
INTERVENTIONS: The patients were assigned to one of three management strategies (ICU, HDU, or ward) based on the anaerobic threshold (deltaT) and ECG evidence of myocardial ischemia as determined by CPX testing that was performed as part of the presurgery evaluation, and by the expected oxygen demand stress of the surgical procedure.

RESULTS: Overall mortality was 3.9%. Forty-three percent of deaths were attributed to poor cardiopulmonary function, as detected preoperatively. There were no deaths related to cardiopulmonary complications in any patient deemed fit for major abdominal surgery and ward management, as determined by CPX testing.

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CONCLUSIONS: In elderly patients undergoing major intra-abdominal surgery, the AT, as determined by CPX testing, is an excellent predictor of mortality from cardiopulmonary causes in the postoperative period. Preoperative screening using CPX testing allowed the identification of high-risk patients and the appropriate selection of peri-operative management.

The era of 'it's the risk of heart attack' that really matters. Definitely not!!

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Journal of the American College of Cardiology
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J Am Coll Cardiol. 2004;44(7):1446-53.

Vol. 44, No. 7, 2004
ISSN 0735-1097/04/$30.00
doi:10.1016/j.jacc.2004.06.059

Outcomes in Heart Failure Patients After Major Noncardiac Surgery

Adrian F. Hernandez, MD,* David J. Whellan, MD, MHS,* Sharon Stroud, BS,† Jie Lena Sun, MS,† Christopher M. O'Connor, MD, FACC,* James G. Jollis, MD, FACC*

Durham, North Carolina

OBJECTIVES The purpose of this study was to evaluate mortality and readmission rates of heart failure (HF) patients after major noncardiac surgery.

BACKGROUND There is a lack of generalizable outcome data on HF patients undergoing major noncardiac surgery because previous studies have been limited to a few academic centers or have not focused on this group of patients.

METHODS Using the 1997 to 1998 Standard Analytic File 5% Sample of Medicare beneficiaries, we identified patients with HF who underwent major noncardiac surgery. A multivariable logistic regression model was used to provide adjusted mortality and readmission rates in patients after noncardiac surgery. Patients with coronary artery disease (CAD) and all other remaining patients (Control) who had similar surgery served as reference groups.

RESULTS Of 23,340 HF patients and 28,710 CAD patients, 1,532 (6.56%) HF patients and 1,757 (6.12%) CAD patients underwent major noncardiac surgery. There were 44,512 patients in the Control group with major noncardiac surgery. After accounting for demographic characteristics, type of surgery, and comorbid conditions, the risk-adjusted operative mortality (death before discharge or within 30 days of surgery) was HF 11.7%, CAD 6.6%, and Control 6.2% (HF vs. CAD, $p < 0.001$; CAD vs. Control, $p = 0.518$). The risk-adjusted 30-day readmission rate was HF 20.0%, CAD 14.2%, and Control 11.0% ($p < 0.001$).

CONCLUSIONS In patients 65 years of age and older, HF patients undergoing major noncardiac surgery suffer substantial morbidity and mortality despite advances in perioperative care, whereas patients with CAD without HF have similar mortality compared with a more general population. (J Am Coll Cardiol 2004;44:1446–53) © 2004 by the American College of Cardiology Foundation

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Arena R, Myers J, Guazzi M. The future of aerobic exercise testing in clinical practice: is it the ultimate vital sign?

Future Cardiol. 2010;6(3):325-42.

The four traditional vital signs: resting heart rate, blood pressure, respiratory rate and body temperature, serve as the cornerstone of a physical examination. Other assessments such as pain have been proposed as additional vital signs. To this point however, there has been limited consideration for aerobic exercise assessment as a vital sign. A wealth of literature demonstrating the prognostic, diagnostic and interventional value of the aerobic exercise assessment now exists, supporting its use in numerous clinical scenarios. Moreover, the assessment of the aerobic exercise response allows for the manifestation of physiologic abnormalities that are not readily apparent during the collection of resting data. This review will provide evidence supporting the assertion that the aerobic exercise assessment may be afforded vital sign status in future clinical practice.

Belardinelli R, Lacalaprice F, Tiano L, Mucai A, Perna GP.
Cardiopulmonary exercise testing is more accurate than ECG-stress testing in diagnosing myocardial ischemia in subjects with chest pain.
Int J Cardiol. 2014;174(2):337-42.

CONCLUSIONS: In patients with chest pain, CPET showed a better diagnostic and predictive accuracy than traditional ET to detect/exclude myocardial ischemia. Its use should be encouraged among physicians as a first line diagnostic tool in clinical practice.

Hennis PJ, Meale PM, Hurst RA, O'Doherty AF, Otto J, Kuper M, et al. Cardiopulmonary exercise testing predicts postoperative outcome in patients undergoing gastric bypass surgery.
Br J Anaesth. 2012;109(4):566-71

RESULTS: The AT was lower in patients with postoperative complications than in those without [9.9 (1.5) vs 11.1 (1.7) ml kg(-1) min(-1), P=0.049] and in patients with a LOS>3 days compared with LOS </= 3 days [10.4 (1.4) vs 11.3 (1.8) ml kg (-1) min(-1), P=0.023]. ROC curve analysis identified AT as a significant predictor of LOS>3 days (AUC 0.640, P=0.030). The VO2 peak and VE/VCO2 were not associated with postoperative outcome. CONCLUSIONS: AT, determined using CPET, predicts LOS after gastric bypass surgery.

Snowden CP, Prentis JM, Anderson HL, Roberts DR, Randles D, Renton M, et al. Submaximal cardiopulmonary exercise testing predicts complications and hospital length of stay in patients undergoing major elective surgery. Ann Surg. 2010;251(3):535-41.

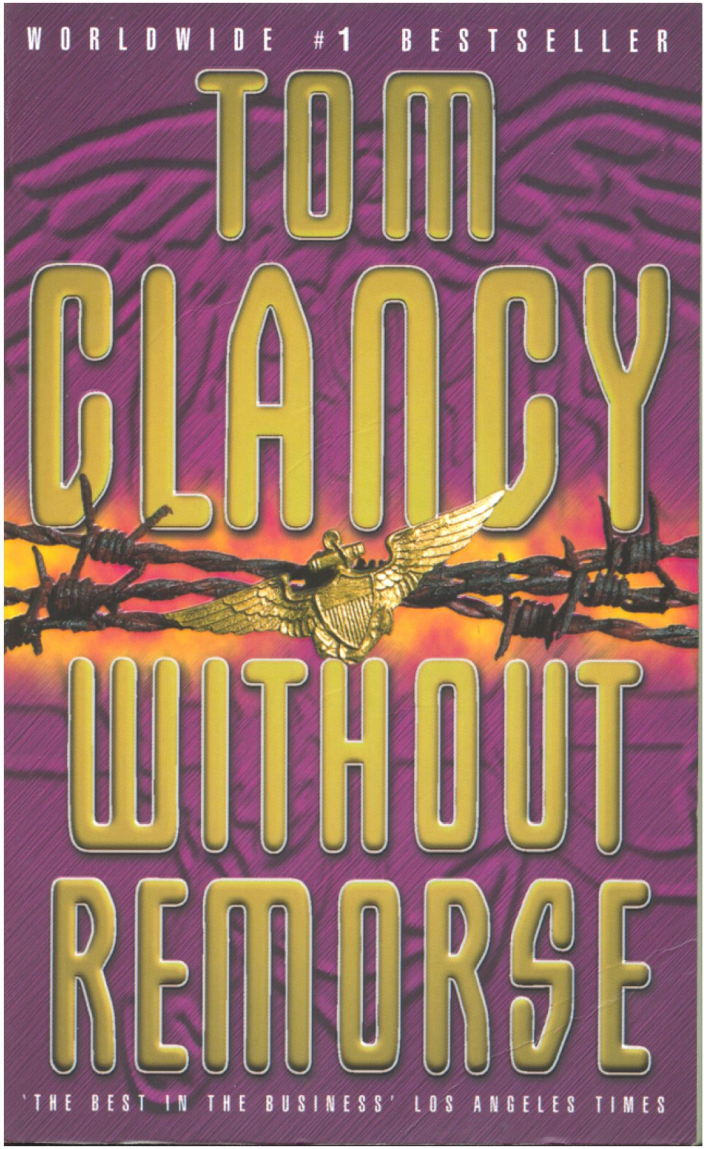
CONCLUSION: An objective measure of cardiorespiratory reserve was an independent predictor of a major surgical group with increased postoperative complications and hospital LOS. AT measurement significantly improved outcome prediction compared with an algorithm-based activity assessment.

Grant SW, Hickey GL, Wisely NA, Carlson ED, Hartley RA, Pichel AC, et al. Cardiopulmonary exercise testing and survival after elective abdominal aortic aneurysm repair.
Br J Anaesth. 2015;114(3):430-6.

CONCLUSIONS: CPET variables are independent predictors of reduced survival after elective AAA repair and can identify a cohort of patients with reduced survival at 3 years post-procedure. CPET is a potentially useful adjunct for clinical decision-making in patients with AAA.

Carlisle J, Swart M. Mid-term survival after abdominal aortic aneurysm surgery predicted by cardiopulmonary exercise testing.
Br J Surg. 2007;94(8):966-9.

CONCLUSION: Preoperative CPX testing, combined with simple co-morbidity scoring, identified patients unlikely to survive in the mid-term, even after successful AAA repair.



Famous for his authenticity, said in 1994

'I want her fully checked out, Kelly. When's the next time you're due into Baltimore?'

'A couple of weeks, maybe sooner. Why?'

Sarah handled that: 'I wasn't able to do a very thorough exam. She hasn't seen a physician in a long time, and I'll feel better if she has a CPX - complete history and physical.'

Pg 94 read it and see!

BMW M4