Southampton NHS
University Hospitals NHS Trust

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CPET in Clinical Practice

Dr Sandy Jack

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UNIVERSITY OF LIVERPOOL

UNIVERSITY OF Southampton

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Cardio Pulmonary Exercise Testing (CPET)

CPET variables are associated with surgical outcome;
- **VO_2 at LT,**
- **VO_2 Peak and**
- **V_E/VCO_2**

CPET has the capacity to identify high risk surgical patients

CPET outperforms other methods that estimate functional capacity

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Risk Assessment

- Cardio-pulmonary (CPX) testing is an established tool for risk assessment of patient undergoing major surgery.
- An lactate threshold of <11 ml/kg/min is considered to be associated with increased risk
- Perioperative management has to be planned accordingly.

Older *et al* 2004

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Assessment of risk for major surgery

- Major surgery shown to place severe stress on patients cardiopulmonary reserve.
- Requiring increased oxygen demand of around 40%.
- High risk patients been assessed using tests such as transthoracic echocardiography and spirometry etc.

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Simple Walk Tests

- Subjective measurement of exercise tolerance using patient's walking distance or ability to climb stairs.
- Questionnaire
- 6 minute walk test
- Flights of stairs
- Incremental Shuttle walk test

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Simple tests

- ALL effort dependent, limited by patient's desire to continue.
- Patients who perform poorly may or may not be fit.
- Many patients cannot perform walk tests.
- No supplementary information as in CPET
  - E.g. ischaemia (early or late)
  - O2 pulse (O2 delivery mls/beat)- cardiac function

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"..the ability of either simple test to determine risk in a heterogeneous surgical population is poor."

Struthers et al. British Journal of Anaesthesia 2008 101(6):774-780

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The Role of CPET in Risk evaluation for Major Surgery

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Western Hospital Melbourne

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Surgical Stress and Oxygen Consumption

A patient undergoing a major operation has to increase oxygen delivery to meet the oxygen requirements (consumption) associated with the increased metabolic work required to survive and recover from surgery…..

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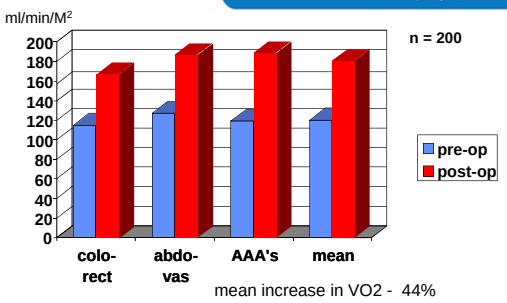

mean increase in VO2 - 44%

'Experience with perioperative invasive measurement of haemodynamic measurements in 100 elderly patients scheduled for major abdominal surgery.'

Older and Smith. Anaesth Intens Care (1988), 16, 389-395

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Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland
Anaesthesia, 2009, **64**, pages 883–893 doi:10.1111/j.1365-2044.2009.05983.x

REVIEW ARTICLE

Cardiopulmonary exercise testing as a risk assessment method in non cardio-pulmonary surgery: a systematic review

T. B. Smith,[1] C. Stonell,[2] S. Purkayastha[3] and P. Paraskevas[4]

1 Medical Student, 2 Consultant, Department of Anaesthesia, 3 Clinical Lecturer, 4 Senior Lecturer and Consultant Surgeon, Departments of Biosurgery and Surgical Technology and Academic Surgical Unit, St Mary's Hospital, Imperial College Healthcare NHS Trust, London, UK

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Systematic Review of Periop CPET

- 9 studies identified (1290 patients)
- No meta-analysis
- 6/7 with data found **VO_2** Peak to be predictive
- 4/6 with data found **AT** to be predictive

"We conclude that peak oxygen consumption and possibly anaerobic threshold are valid predictors of peri-operative morbidity and mortality in non-cardiopulmonary thoraco-abdominal surgery."

Smith *Anaesthesia* 2009

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Paper	Patients	n	Design	AT	VO2 P	Outcome
Older 1993	**Major intra-abdo**	**187**		**Y**	**-**	**CV mortality**
Older 1999	**Major intra-abdo**	**548**	**Intervention**	**Y**	**-**	**Mortality**
Snowden 2010	**Major intra-abdo**	**116**	**Blinded**	**Y**	**Y**	**D7 POMS**
Wilson 2010	**Major intra-abdo**	**843**		**Y**	**-**	**Mortality**
Hightower 2010	Major intrao-abdo	32	Blinded	Y	N	Morbidity
Nagamatsu 1994	Upper GI	52		Y	Y	CP comps
Nagamatsu 2001	Upper GI	91		N	Y	CP comps
Forshaw 2008	Upper GI	78		Y	Y	CP comps
McCullough 2006	**Upper GI ***	**109**		**Y**	**Y**	**Composite**
Nugent 1998	AAA	30		N	N	Mortality
Carlisle 2007	**AAA**	**130**		**Y**	**Y**	**Mortality**
Ebstein 2004	Hepatic transplant	59		Y	Y	Comps

12 studies / 2275 patients

Hennis *PMJ* 2011

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Best Practice & Research Clinical Anaesthesiology 25 (2011) 427–437

Contents lists available at ScienceDirect

Best Practice & Research Clinical Anaesthesiology

journal homepage: www.elsevier.com/locate/bean

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Perioperative cardiopulmonary exercise testing in the elderly

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[b] Anaesthesia and Critical Care Research Unit, University of Southampton, Southampton, UK

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NSQIP reported complications

- Cardiac 2.0%
- Neuro 1.2%
- Infection 8.1%
- Pulmonary 5.4%
- Renal 1.2%
- Vascular/thrombotic 1.7%

3.1% mortality / n=105,951

Khuri *Annals of Surgery* 2005

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Major Intra-abdominal Surgery

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Author & year	Outcome	CPET variables			
		AT	VO_2 peak	VE/VCO_2	Other CPET variables associated with outcome
Older et al. (1993) (n=187)	Cardiovascular related mortality	☑	-	-	-
Older et al. (1999) (n=548)	Cardiovascular related mortality	✓	-	-	VE/VO_2
	All-cause mortality	✓	-	-	VE/VO_2
Snowdon et al. (2010) (n=116)	Early morbidity - POMS (day 7)	☑	☑	☒	-
Wilson et al. (2010) (n=843)	All-cause hospital mortality	☑	-	☑	-
	90-day mortality	☑	-	☑	-
Hightower et al. (2010) (n=32)	Morbidity	☑	☒	☒	1. HR at AT 2. ΔHR from rest to AT

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Upper GI Surgery

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Author & year	Outcome	CPET variables			
		AT	VO_2 peak	VE/VCO_2	Other CPET variables associated with outcome
Nagamatsu et al. (1994) (n=52)	Cardiopulmonary complications	☑	☑	-	-
Nagamatsu et al. (2001) (n=91)	Cardiopulmonary complications	☒	☑	-	-
Forshaw et al. (2008) (n=78)	Cardiopulmonary complications	✓	✓	-	-
	Non-cardiopulmonary Complications, Unplanned ITU admission, and LOS	☒	☒	-	-
McCullough et al. (2006) (n=109)	Primary outcome composite (death, unstable angina, MI, DVT, PE, renal failure or stroke)	☑	☑	NS	-
	Hospital LOS	NS	☑	NS	-

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Vascular and Liver Transplant Surgery

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Author & year	Outcome	CPET variables				Non-CPET variables		Comparisons
		AT	$\dot{V}O_2$ peak	$\dot{V}_E/\dot{V}CO_2$	Other CPET variables associated with outcome	RCRI	Other variables associated with outcome	Which type of variable performed best (CPET or non-CPET)
Vascular surgery (AAA repair)								
Nugent et al. (1998) (n=30)	Postoperative complications	☒	☒	-	-	-	-	-
Carlisle and Swart (2007) (n=130)	All-cause mortality at mid term (median, 35 weeks)	☑	☑	☑	$\dot{V}_E/\dot{V}O_2$	☑	POSSUM SAPS II APACHEII	CPET
Liver transplant surgery								
Epstein et al. (2004) (n=59)	100-day mortality	☑	☑	-	-	-	-	-

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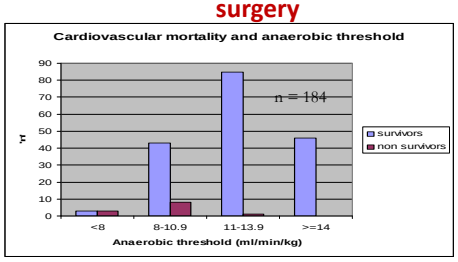
Cardiovascular mortality in patients >60yrs undergoing major intrathoracic or intra-abdominal surgery



Chest 1993 104: 701-04

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BJA
British Journal of Anaesthesia
Volume 105, Number 3, September 2010

British Journal of Anaesthesia 105 (3): 243–5 (2010)
doi:10.1093/bja/aeq207

EDITORIAL

Prognostic studies of perioperative risk: robust methodology is needed

M. P. W. Grocott[1,2,3*] and R. M. Pearse[4]

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EDITORIAL

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M. P. W. Grocott[1,2,3]* and R. M. Pearse[4]

"Confounding by indication"

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Predicting complications

- Plasma biomarkers (BNP/NT-proBNP/hsCRP)
- CPET (AT/VO2peak)
- Risk scores (Goldman/Lee)

- Cardiac/cardio-respiratory outcomes
- Not great predictors (individual patients)
- Even less good for "non-selected outcomes"

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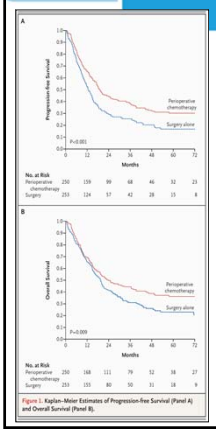

The NEW ENGLAND JOURNAL of MEDICINE
ESTABLISHED IN 1812 JULY 6, 2006 VOL. 355 NO. 1

Perioperative Chemotherapy versus Surgery Alone for Resectable Gastroesophageal Cancer

David Cunningham, M.D., William H. Allum, M.D., Sally P. Stenning, M.Sc., Jeremy N. Thompson, M.Chir., Cornelis J.H. Van de Velde, M.D., Ph.D., Marianne Nicolson, M.D., J. Howard Scarffe, M.D., Fiona J. Lofts, Ph.D., Stephen J. Falk, M.D., Timothy J. Iveson, M.D., David B. Smith, M.D., Ruth E. Langley, M.D., Ph.D., Monica Verma, M.Sc., Simon Weeden, M.Sc., and Yu Jo Chua, M.B., B.S., for the MAGIC Trial Participants*

3-week cycle:
Epirubicin IV bolus on day 1
Cisplatin IV bolus on day 1
Fluorouracil daily

Cunningham *NEJM* 2006

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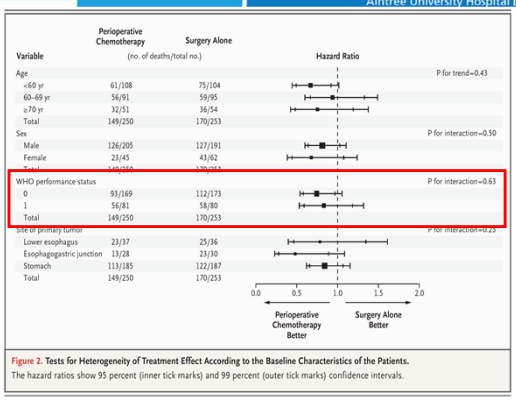

Figure 2. Tests for Heterogeneity of Treatment Effect According to the Baseline Characteristics of the Patients.
The hazard ratios show 95 percent (inner tick marks) and 99 percent (outer tick marks) confidence intervals.

Cunningham *NEJM* 2006