Correlation of non-invasive cardiac output measurements with VO₂ max and VO₂ at Anaerobic Threshold in cardiopulmonary exercise testing in high-risk surgical patients.

Hunter K¹, Hodgson LE^{1,2}, Venn R¹, Forni LG^{3,4}, Wakeling HG.¹
¹Worthing Hospital, Anaesthetic Dept, WSHFT, Worthing, UK, ²Faculty of Medicine, University of Southampton, ³Royal Surrey County Hospital, Intensive Care Dept, Guildford, UK, ⁴Faculty of Health & Medical Sciences, University of Surrey.

Demographics				History of				Medication		
	Age	Sex		IHD	CCF	Cerebrovasc. Disease	HTN	ACE-I/ARB	β-blocker	Diuretic
Mean	73	Female 15	% of sample	37%	29%	19%	52%	57%	27%	33%
Range	49-89	Male 36								
Standard Deviation	8									

Table 1. Sample characteristics

Value	O2 consumption at AT <11 ml/kg/min (n=21)	O2 consumption at AT≥11 ml/kg/min (n= 30)	p value
ΔCI	47%	85%	0.007
mean inotropy reserve (Wm-2)	0.3	0.56	0.054

Table 2. Mean percentage change (Δ) CI and mean inotropy reserve in patients who did and did not achieve VO₂ at AT of ≥11 ml/kg/min

Value	Peak VO2 <14 ml/kg/min (N=19)	Peak VO2 ≥ 14 ml/kg/min (N=29)	p value
ΔCI	45%	81%	0.004
mean inotropy reserve (Wm-2)	0.28	0.6	0.022

Table 3. Mean ΔCI and mean inotropy reserve in patients who did and did not achieve peak VO₂ of 14 ml/kg/min

Value	Correlation with VO2 at AT (if reached) (n=43)	Correlation with peak VO2 (n=51)
ΔCI	r 0.59 (p <0.001)	r 0.67 (p <0.001)
Inotropy reserve (Wm-2)	r 0.35 (p =0.021)	r 0.33 (p =0.018)

Table 4. Pearson Correlation between USCOM and CPET variables

Background and Goal of Study:

Cardio-pulmonary Exercise Testing (CPET) is a well-validated method of assessing cardiorespiratory performance. Measurements of oxygen consumption (VO₂) recorded at peak exercise & Anaerobic Threshold (AT) have been found in previous studies to identify those at highest risk of post-operative complications. The ultrasonic cardiac output monitor (USCOM) has been used as a non-invasive method of assessing cardiac function for several years. Recent work has demonstrated that the USCOM can be used to estimate inotropy (cardiac contractility), a well-recognised but seldom-quantified concept in cardiac physiology. Calculating inotropy in addition to the more routine haemodynamic measurements recorded by USCOM may provide a tool that could help in pre-operative risk profiling & haemodynamic optimisation peri-operatively.

We assessed baseline & change (Δ) in USCOM-obtained haemodynamic values pre- & post-CPET (bike ergometer), in high-risk pre-operative patients. Correlation with CPET markers was then performed.

Materials and Methods:

After ethical approval, 51 patients, under consideration for major non-cardiac surgery gave consent & were prospectively recruited to this observational study. USCOM measurements were obtained immediately pre- and post-CPET in the upright position. The difference between these values was calculated in order to find the percentage Δ in cardiac index (ΔCI) pre- & post-CPET, & inotropy reserve (peak exercise minus resting value). Inotropy reserve & ΔCI were compared with peak VO₂ (ml/kg/min) & VO₂ at AT.

References

Smith BE, Madigan VM. Non-invasive method for rapid bedside estimation of inotropy: theory and preliminary clinical validation. Br. J. Anaesth. (2013) 111 (4):580-588.

Older P, Smith R, Courtney P, Hone R. Preoperative evaluation of cardiac failure and ischemia in elderly patients by cardiopulmonary exercise testing. Chest 1993; 104: 701–4

Results and Discussion:

Mean age was 73(±8), (15 female, 36 male). Pre-CPET values (mean±SD) were: SV 49(±14) ml, HR 79(±15) beats per minute, (CI 2(±0.75) l/min/m², mean arterial pressure (MAP) 105(±15.5) mmHg & Inotropy 1.14(±0.4) Wm⁻². Post-CPET mean ΔSV was 14%, ΔCI 68%, ΔHR 49% & ΔMAP 4%. Mean O₂ consumption at AT was 12.5(±2.9) ml/kg/min.

In those patients (n=30) with a VO₂ at AT ≥11 ml/kg/min mean ΔCI was significantly higher vs the group (n=21) with a VO₂ <11 (or who did not reach AT) (table 2) (P = 0.007). This was predominantly due to a rise in HR rather than SV. There was a significant difference demonstrated in both mean ΔCI & inotropy reserve in patients who achieved a peak VO₂ >14 ml/kg/min vs ≤14 ml/kg/min (table 3).

ΔCI pre & post CPET correlated with VO₂ in those patients who reached AT & with peak VO₂ (table 4). Inotropy reserve still demonstrated positive correlation with these two CPET variables though not to the same degree. There was no significant correlation noted between static haemodynamic parameters and peak VO₂ & VO₂ at AT.

Conclusion(s):

In a cohort of high-risk individuals, ΔCI correlates well with traditional CPET markers of cardiovascular performance. USCOM assessment is simple to perform & holds promise as an adjunct to CPET or use where the later is not available.