

Cardiopulmonary Exercise Test and its Role in Modification of Anaesthetic Strategies

An Essay

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Presented By:

Yasmine Mahmoud Hussien Khater

(M.B, B.CH)

Faculty of Medicine, Cairo University

Supervised by

Prof. Dr. Amir Ibrahim Salah

Professor of Anaesthesia and Intensive Care

Faculty of Medicine, Ain Shams University

Dr. Ihab Hamed Abd El Salam

Assistant Professor of Anaesthesia and Intensive Care

Faculty of Medicine, Ain Shams University

Dr. Ghada Mohamed Samir

Lecturer of Anaesthesia and Intensive Care

Faculty of Medicine, Ain Shams University

**Faculty of Medicine
Ain Shams University
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List of Abbreviations

(a- $\dot{V}O_2$)	Arteriovenous oxygen
6MWT	6 minute walk test
ACC	American college of cardiology
ACE	Angiotensin converting enzyme
ACHD	Adult congenital heart disease
AHA	American heart association
AT	Anaerobic threshold
ATP	Adenosine triphosphate
BNP	Brain natriuretic peptide
BP	Blood pressure
CABG	Coronary artery bypass graft
CAD	Coronary heart disease
CO₂	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
COX₂	Cyclo-oxygenase-2
CPET	Cardiopulmonary exercise test
CRP	C-reactive protein
DLCO₂	Diffusing capacity of the lungs for carbon monoxide
DSE	Dobutamine stress echocardiography
DTS	Dipyridamole thallium-scanning

 List of Abbreviations

ECG	Electrocardiography
FEV1	Forced expiratory volume in one second
FFAs	Free fatty acids
HDU	High dependency unit
HF	Heart failure
HR	Heart rate
ICD	Implantable cardioverter defibrillator
ICU	Intensive care unit
IHD	Ischemic heart disease
IL	Interleukin
ISWT	Incremental shuttle walk test
IV	Intravenously
LV	Left ventricular
LVEF	Left ventricular ejection fraction
LVRS	Lung volume reduction surgery
MET	Metabolic equivalent threshold
MI	Myocardial ischaemia
NIBP	Non invasive blood pressure
NT	N-Terminal pro BNP
O₂	Oxygen
PAI-1	Plasminogen activator inhibitor
PTCA	Percutaneous transluminal coronary angiography
RER	Respiratory exchange ratio

 List of Abbreviations

SPO₂	Saturation
SV	Stroke volume
TNF-α	Tumour necrosis factor- α
V/Q	Ventilation/perfusion
VAT	Ventilatory an aerobic threshold
$\dot{V}CO_2$	Carbon dioxide output
$\dot{V}e$	Minute ventilation
VHD	Valvular heart disease
$\dot{V}O_2$	Oxygen uptake
$\dot{V}O_{2max}$	Maximal $\dot{V}O_2$

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Introduction

Preoperative assessment of the cardiac patient before noncardiac surgery is common in the clinical practice of the medical consultant, anesthesiologist and surgeon. Currently, most noncardiac surgical procedures are performed for patients of advanced age and the number of such surgeries is likely to increase with the aging of the population. These same patients have an increased prevalence of cardiovascular disease, especially ischemic heart disease, which is the primary cause of perioperative morbidity and mortality associated with noncardiac surgery. Patients who undergo noncardiac surgery may be at risk for cardiac morbidity and mortality, not only intraoperatively but also during their recovery period (**Freeman and Gibbons, 2009**).

The 3 major parameters that help to determine the risk of cardiac morbidity and mortality for patients who undergo noncardiac surgery and therefore, help determine the need for additional testing and specific pharmacologic therapy before and during the planned surgery are as follows: (1) the clinical characteristics of the patient, (2) the inherent cardiac risk of the planned surgical procedure, and (3) the patient's functional capacity (**Freeman and Gibbons, 2009**).

Exercise testing remains a remarkably durable and versatile tool that provides valuable diagnostic and prognostic information

regarding patients with cardiovascular and pulmonary disease. The addition of ventilatory gas exchange measurements during exercise testing provides a wide array of unique and clinically useful incremental information that has been poorly understood and underutilized by the practicing clinician. The reasons for this are many and include the requirement for additional equipment (cardiopulmonary exercise testing CPET systems), personnel who are proficient in the administration and interpretation of these tests, limited or absence of training of cardiovascular specialists and limited training by pulmonary specialists in this technique, and the lack of understanding of the value of CPET by practicing clinicians **(Carter and Jeukendrup, 2002)**.

Modern CPET systems allow for the analysis of gas exchange at rest, during exercise and during recovery. These advanced computerized systems provide both simple and complex analyses of these data that are easy to retrieve and store, which makes CPET available for widespread use. Hence, CPET offers the clinician the ability to obtain a wealth of information beyond standard exercise electrocardiography testing that when appropriately applied and interpreted can assist in the management of complex cardiovascular and pulmonary disease. Also, when combined with adjunctive imaging modalities offer greater diagnostic accuracy, additional information regarding cardiac structure and function and additional prognostic information **(Diamond, 2007)**.

Preoperative Assessment of Cardiac Patients in Noncardiac Surgery

Non cardiac surgery is a broad definition and encompasses procedures with large variations in postoperative stress response. Risk must be stratified according to patient-specific factors but also to surgery-specific risk, i.e. the increased oxygen demand as a consequence of surgery. Preoperative evaluation must embrace more than just risk factor analysis for ischaemic heart disease (IHD), it should involve detection of all cardiac disease and most importantly, objective assessment of functional capacity. The current obsession with one element of patient-specific risk; coronary artery disease (CAD) distract attention from these other components of risk (**London et al., 2004**).

The American College of Cardiology (ACC) Foundation and the American Heart Association (AHA) guidelines for considering cardiac risk of noncardiac surgery:

Are intended for physicians and nonphysician caregivers who are involved in the preoperative, operative and postoperative care of patients undergoing noncardiac surgery. They provide a framework for considering cardiac risk of noncardiac surgery in a variety of patient and surgical situations and provide quick references for decision making. The purpose of preoperative

evaluation is not to give medical clearance but rather to perform an evaluation of the patient's current medical status; make recommendations concerning the evaluation, management and risk of cardiac problems over the entire perioperative period and provide a clinical risk profile that the patient, primary physician and nonphysician caregivers, anesthesiologist, and surgeon can use in making treatment decisions that may influence short- and long-term cardiac outcomes. No test should be performed unless it is likely to influence patient treatment. The goal of the consultation is the optimal care of the patient. ACC/AHA focuses on the evaluation of the patient undergoing noncardiac surgery who is at risk for perioperative cardiac morbidity or mortality. In patients with known CAD or the new onset of signs or symptoms suggestive of CAD, baseline cardiac assessment should be performed (**Fleisher et al., 2007**).

1. History:

A history is crucial to the discovery of cardiac and/or comorbid diseases that would place the patient in a high surgical risk category. The history should seek to identify serious cardiac conditions such as:

- a. Unstable coronary syndromes.
- b. Prior angina, recent or past myocardial infarction (MI).
- c. Decompensated heart failure (HF).
- d. Significant arrhythmias and severe valvular disease.

It should also determine whether the patient has a prior history of a pacemaker or implantable cardioverter defibrillator (ICD) or a history of orthostatic intolerance

(Fleisher et al., 2007)

Influence of Age and Gender:

Advanced age is a special risk, not only because of the increased likelihood of coronary disease but also because of the effects of aging on the myocardium. The mortality of acute MI increases dramatically in the aged (**table1**). Intraoperative or perioperative MI has a higher mortality in the aged. Gender is important because premenopausal women have a lower incidence of CAD, and in general, symptomatic CAD occurs or more years later in women than in men. Women who have premature menopause, such as after oophorectomy, are an exception to this rule. Women with diabetes mellitus have an increased risk that is equivalent to men of the same age. The mortality rate after acute MI is greater for women than for men, but older age and diabetes mellitus account for much of this difference. Whether or not other factors such as coronary artery size or different pathophysiology also contribute to the increased risk in women is not yet fully understood (**Fleisher et al., 2007**).

Table (1): Clinical Predictors of Increased Perioperative Cardiovascular Risk

Major Unstable coronary syndromes Acute or recent* MI with evidence of important ischemic risk by clinical symptoms or noninvasive study Unstable or severe† angina (Canadian class III or IV‡) Decompensated heart failure Significant arrhythmias High-grade atrioventricular block Symptomatic ventricular arrhythmias in the presence of underlying heart disease Supraventricular arrhythmias with uncontrolled ventricular rate Severe valvular disease Intermediate Mild angina pectoris (Canadian class I or II‡) Previous MI by history or pathologic Q waves Compensated or prior heart failure Diabetes mellitus (particularly insulin-dependent) Renal insufficiency Minor Advanced age (older than 75 years) Abnormal electrocardiography results (e.g., left ventricular hypertrophy, left bundle branch block, ST-T abnormalities) Rhythm other than sinus (e.g., atrial fibrillation) Low functional capacity (e.g., inability to climb one flight of stairs with a bag of groceries) History of stroke Uncontrolled systemic hypertension
--

MI = myocardial infarction.

*—The American College of Cardiology National Database Library defines recent MI as greater than seven days but less than or equal to one month (30 days); acute MI is within seven days.

†—May include “stable” angina in patients who are usually sedentary.

(Christopher and Fleisher, 2007)

Functional capacity:

Exercise tolerance is a major determinant of perioperative risk. It is usually evaluated by the estimated energy requirement for various activities and graded in metabolic equivalents (MET) on a scale defined by the Duke Activity Status Index. One MET represents the oxygen consumption of a resting adult (3.5 mL/kg/min). More simply, the inability to climb two flights of stairs is associated with a positive predictive value of 89% for cardiopulmonary complications. In the absence of valve pathology, the ejection fraction of the left ventricle can be considered as an adequate measurement of the myocardial functional reserve. Patients with good functional capacity and no symptoms can be considered free of any severe coronary artery disease (**table2**). Despite its predictive value in the perioperative setting, the Duke Activity Status Index has never been specifically tested for ischaemic patients (**Chassot et al., 2002**).

I. The Duke Activity Status Index:

Represents a simple patient completed questionnaire which ascertains the maximum level of physical activity that an individual is able to perform. Unfortunately, patients' estimations of their exercise capabilities are very subjective and are frequently overestimated (**Angew, 2010**).