

Cardiopulmonary Exercise Testing in Coronary Artery Disease Male Aviators Prior to Refighting: A Suggested Modality

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Abstract

Background: Exercise testing provides valuable diagnostic and prognostic information regarding patients with cardiovascular and pulmonary disease. The aim of this study is to assess maximum oxygen consumption (O₂ Max), oxygen consumption at Lactate threshold and exercise ECG, heart rate, BP response in aviators with CAD who are being considered for refighting. **Subjects and Methods:** We included 7 males from age group 35 – 56 y who were CAD patients for medical evaluation at our center. A normogram was earlier obtained by subjecting 72 males between the age 18 – 60 year by random selection during medical for initial entry to Airforce and routine annual medical in serving personnel. **Results:** These males were subjected to cardiopulmonary stress test, after an echocardiogram was done to assess structural heart disease. The data obtained was compared with the normogram for age. **Conclusion:** In this study, we conclude that in our population a healthy aviator reaches an average of 80% of age predicted VO₂ max (normogram for age 30 – 39 and 40 – 49 attached above). Aviator no, 2,3,4,5,7 were reflighted,

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Introduction

In several Air Forces around the world an aviator is not permitted to fly after a myocardial infarction as he has a definite risk of developing an arrhythmia from the scar region (Scar VT/ VF); there are apprehensions about performance abilities and in flight recurrence of a MI. In the Indian Air Force, refighting is permitted in transport aircraft provided the pilot has normal echocardiogram, Holter, a negative TMT and CAG does not reveal significant disease in epicardial arteries other than infarct related artery.

Exercise testing provides valuable diagnostic and prognostic information regarding patients with cardiovascular and pulmonary disease. The addition of ventilatory gas exchange measurements during exercise testing allow for the analysis of gas exchange at rest, during exercise, and during recovery and yield measures of oxygen uptake (O₂), carbon dioxide output (CO₂), and ventilation (E). These data can be readily integrated with standard variables measured during exercise testing, including heart rate, blood pressure, work rate, electrocardiography findings, and symptoms, to provide a comprehensive assessment of exercise tolerance and exercise responses.^[1] CAD patients are often smokers and may have associated

COPD which affects their exercise capacity. Maximum oxygen consumption (O₂ Max) is a physiological measure of combined efficacy of heart – lungs – muscles and metabolic combine. Cardiopulmonary exercise testing (CPET) provides assessment of the integrative exercise responses involving the pulmonary, cardiovascular, haematopoietic, neuropsychological, and skeletal muscle systems, which are not adequately reflected through the measurement of individual organ system function. This non- invasive, dynamic physiological overview permits the evaluation of both submaximal and peak exercise responses, providing the doctor with relevant information for clinical decision making. CPET is increasingly being used in a wide spectrum of clinical applications for the evaluation of undiagnosed exercise intolerance and for the objective determination of functional capacity and impairment. Its use in patient management is increasing with the understanding that resting pulmonary and cardiac function testing cannot reliably predict exercise performance and functional capacity and that overall health status correlates better with exercise tolerance than with resting measurements.^[1] To assess maximum oxygen consumption (O₂ Max), oxygen consumption at Lactate threshold and exercise ECG, heart rate, BP response in aviators with CAD who are being considered for refighting.

Subjects and Methods

Study Population

We included 7 males from age group 35 – 56 y who were CAD patients for medical evaluation at our centre. A normogram was earlier obtained by subjecting 72 males between the age 18 – 60 year by random selection during medical for initial entry to Airforce and routine annual medical in serving personnel.

Study Area

This study was conducted in the department of cardiology in the Air Force Central Medical Establishment, Subroto Park, New Delhi.

Study Duration

The duration of the study was over a period of from 2011 to 2013.

Data Collection

CAD patients were subjected to CPET (Cardio Pulmonary Exercise Test) after assessing structural heart disease by echocardiogram. QUARK CPET coupled along with Mortara treadmill was used. Bruce protocol for graded exercise was used to standardize results of stress test along with ventilatory protocols.

Quark CPET is manufactured by Cosmed and gives 01 min analysis of oxygen consumption, CO₂ production. It has an inflow and an outflow sensor for oxygen and CO₂, which enables these measurements. The lactate threshold is a derived parameter from this. There is a turbine in the breathing apparatus which measures flow rates and minute ventilation. The equipment needs preparation with regular calibration using a standard premixed gas cylinder supplied by the company. The individual is made to wear the breathing mask in an airtight manner and then made to exercise on the treadmill [Figure 1,2]

Data Analysis

Data were analyzed by using Microsoft excel.



Figure 1:



Figure 2:

Results

Table 1: Normogram (own data) Age 30 – 39 y

		VO ₂ MAX (ml/Kg/min)	% Pred.	METS
Smoker	1	22.62	48	6.4
	2	41.33	76	11.8
	3	39.48	81	11.2
	4	35.64	76	10.1
	5	34.88	75	9.9
	6	39.36		11.2
	7	38.81	75	8.2
	8	35.8	84	10.2
	9	32.16	72	9.1
	10	28.56	64	8.1
	11	32.5	70	9.2
Smoker	12	24.15	54	6.9
	13	28.5	77	8.1
	14	26.46	58	7.5
Smoker	15	34.45	76	9.8
Smoker	16	34.55	68	9.8
	17	31.33	72	8.9

Table 2: Normogram (own data) Age 40 – 49 y

	VO ₂ MAX (ml/Kg/min)	% Pred.	METS	
1	37.86	93	10.8	
2	28.3	78	8	Smoker
3	35.31	87	10	
4	30.01	78	8.5	
5	30.13	76	8.6	
6	25.43	72	7.2	
7	29.65	77	8.4	
8	38.75	105	11	
9	28.73	85	8.2	
10	31.92	81	9.1	
11	32.48	80	9.2	
12	32.78	78	9.3	
13	35.03	88	10	
14	42.83	110	12.2	
15	42.7	99	12.2	
16	29.51	72	8.4	Smoker
17	27.91	65	7.9	
18	27.33	73	7.8	
19	31.03	75	8.8	
20	29.13	69	8.3	
21	33.37	95	9.5	
22	34.64	82	9.8	
23	27.69	65	7.9	

These males were subjected to cardiopulmonary stress test, after an echocardiogram was done to assess structural heart disease. The data obtained was compared with the

normogram for age. Selected parameters from the data obtained have been projected below:

Table 3: CAD Patients

S. No.	Age	Wt Kg	Ht Cm	BMI Kg/sqm	Diagnosis	LVEF	VO2 MAX LT	VO2 MAX. PRED	% PRED
1	40	73	181	22.2	AWMI(Old) Post CABG	30-35%	2.01	25.45	57
2	50	59	166	21.4	IWMI	60%	25.74	36.52	89
3	43	88	170	30.4	Post PTCA & Stenting to RI	60%	18.39	24.37	70
4	35	72	176	23.2	AWMI (Post PTCA to LAD and LCX)	50%	40.91	36.49	88
5	56	83	181	25.3	AWMI (Post PTCA to LAD SR stenting Done)	60%	26.07	33.77	108
6	44	80	176	25.8	AWMI	40%	25.82	23.56	66
7	54	61	163	22.9	CAD,PTCA &Stenting to LCX and OMI, Rep. PTCA & stenting to LCX	60%	39.26	37.11	109

Discussion

In several Air Force around the world an aviator is not permitted to fly after a myocardial infarction as he has a definite risk of developing an arrhythmia from the scar region (Scar VT/ VF); there are apprehensions about performance abilities and in flight recurrence of a MI. In the Indian Air Force, reflighting is permitted in transport aircraft provided the pilot has normal echocardiogram, Holter, a negative TMT and CAG does not reveal significant disease in epicardial arteries other than infarct related artery and there is no In stent restenosis.

In order to assess the cardiovascular system more physiologically and to permit flying in certain fit aviators with good effort tolerance despite a small myocardial scar, CPET is being suggested as the primary modality to assess physiological fitness.

The cardiovascular and respiratory systems work together to provide delivery system (of O₂) and removal (of CO₂) from the tissues (2). This happens by

(a) External respiration:

- (i) Pulmonary ventilation
- (ii) Pulmonary diffusion, or the exchange of O₂ and CO₂ between the lungs and the blood

(b) Internal respiration:

- (i) Transport of O₂ and CO₂ in the blood;
- (ii) Capillary gas exchange or the exchange of O₂ and CO₂ between the capillary blood and the working muscle.

Increase in oxygen uptake by the working muscles is contributed most by an increase in cardiac output (heart rate x stroke volume), which may increase to up to 6 times that at rest.^[3] Increase in blood flow to the lungs occurs by increased cardiac output and pulmonary vessel dilatation. This is accompanied by a greater extraction of O₂ from the blood, which results in a widening of the arteriovenous oxygen (a- O₂) difference.^[4]

Increase in minute ventilation (E) during exercise must be matched by an increase in blood flow; that is, cardiac output must increase to appropriately match ventilation so that necessary gas exchange can occur.^[5] Mismatch occurs when cardiac output fails to increase as in heart failure, LV dysfunction etc and ventilation fails to increase in

pulmonary conditions like COPD, Bronchial asthma, ILD etc.^[6,7] This is seen as increase in VE/ CO₂ slope.

This study is an observation study to collect data with respect to aviators with coronary artery disease, who are being reflighted. The data was compared with baseline values obtained by us by subjecting 72 healthy males to CPET in different age groups. It was observed that the exercise in CPET as measured by actual oxygen consumption was lower than that derived by the duration of exercise done on only exercise / treadmill equipment (which is not coupled with ventilation parameters and derives METS by stages and duration of exercise). On an average, smokers had a lower predicted for age maximum oxygen consumption. The exercise training can be used to improve effort tolerance, delaying Lactate threshold and improve efficiency of work in healthy aircrew to improve their performance.^[8,9] Stroke volume calculations help assess improvement in stroke volume in real time during exercise. This along with Maximum oxygen consumption, Stroke volume improvement, Lactate threshold reached at level of exercise (in METS), VE/ CO₂ slope and the usual exercise stress parameters based on ECG findings can be used to reflight aircrew with cardiopulmonary disorders in addition to other standard tests.

In our study, we observed that in our population a healthy aviator reaches an average of 80% of age predicted VO₂ max [Table 1 & 2] Normogram for age 30 – 39 and 40 – 49 attached above). Well trained and reasonably fit aviators despite having an infarcted myocardial segment performed at more than 70 % of VO₂ max. Therefore, if an aviator performs upto 70 % of age predicted VO₂ max with anaerobic threshold being achieved at 40 % of age predicted VO₂ max he could be considered for reflighting. This data was used to safely reflight aviator no. 2,3,4,5 and 7.

Conclusion

In this study, we conclude that in our population a healthy aviator reaches an average of 80% of age predicted VO₂ max (normogram for age 30 – 39 and 40 – 49 attached above). Aviator no, 2,3,4,5,7 were reflighted, Therefore, if an aviator performs upto 70 % of age predicted VO₂ max

with anaerobic threshold being achieved at 40 % of age predicted VO2 max he could be considered for reflighting.

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