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Status of pulmonary function tests and diffusion capacity in coronary artery disease patients

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Abstract

Prevalence of coronary artery disease is on the rise in both developing and developed countries. Lot of morbidity and mortality is associated with it. Because of the close structural and functional association of the heart and lungs, CAD can affect pulmonary functions. Being a low-pressure, low-resistance circuit with high compliance, pulmonary vasculature is highly responsive to ischemic changes in CAD. Pulmonary function tests along with diffusion capacity were assessed in 80 clinically and angiographically documented patients of CAD and in 45 healthy volunteers who served as controls. These lung functions were tested by using computerized MS medisoft Cardio-respiratory Instrument, HYP'AIR Compact. Height, weight, body surface area and systolic & diastolic blood pressures in both the groups were assessed. A standardized questionnaire related to cardio-respiratory health was also worked out. Each parameter of PFTs was statistically analyzed in both the groups by using unpaired T test.FVC, FEV1, PEFR, MVV, and diffusion capacity was found to be statistically reduced in CAD patients. A combination of restrictive and small airway obstructive type of impairment was seen in stable CAD patients in our study. CAD can disturb the alveolar-capillary interface and increases the resistance to gas transfer.

Key words: CAD, PFTs, Diffusion capacity

Introduction

Coronary Artery Disease (CAD) is the most common form of heart disease which is caused by the buildup of cholesterol in the inner layers of the arteries. As a result of that, the blood flow slows down and the cardiac muscles do not get adequate supply of blood particularly during exercise and exertion when the demand is high. Most people with CAD often experience Angina (pain, pressure, or burning in the chest, arm, or neck).

Prevalence of coronary artery disease is greatly increasing in our country for the last several years and is expected to assume epidemic proportions soon. Men are affected more than women. Coronary artery disease causes more deaths and disabilities, and incurs greater economic costs than any other illness in the developed world. Projections based on the Global Burden of Disease study estimate that by the year 2020, the burden of athero-thrombotic cardiovascular disease in India would surpass that in any other region in the world.[15] Studies in India have documented a five-fold higher prevalence of coronary heart disease in the urban as compared to the rural population.[3]

The lungs are linked in series with the cardiac pump, and they are not only influenced by mechanical alterations in pump function but also by neurohumoral modulators and cytokines involved in the pathogenesis of various heart diseases[11,17]. It has also been proposed that increased levels of circulating cytokines (such as tumor necrosis factor-[alpha] and interleukin-6) in CAD patients may induce changes in lung parenchyma[19]. The pulmonary vasculature is very commonly affected by cardiac pathology. The pulmonary vasculature is normally a low-pressure, low-resistance circuit with

high compliance and tremendous vascular reserve. High left atrial pressures may also induce chronic remodeling of the pulmonary vasculature and its wall thickening. There may also be an enhanced degree of airway reactivity.[2]

Tension and anxiety in CAD patient's further cause bronchial constriction constrict the airflow by activation of sympathetic nervous system. The lining of bronchial tubes becomes inflamed and hyperactive. Hyperventilation in anxiety causes carbon dioxide in the blood to decrease, and blood becomes more alkaline, which causes oxygen to be bound more tightly to hemoglobin and tissues get less oxygen. Low CO_2 reduces blood flow to the brain. This leads to dizziness, blurry vision, feelings of unreality, lightheadedness. Emotional stress both from within the individual as well as from the environmental sources play an important role in predisposition, precipitation & perpetuation of CAD[10,18].

CAD disturbs the alveolar-capillary interface and increases the resistance to gas transfer. Alveolar-capillary membrane conductance and capillary blood volume are subcomponents of the lung diffusion capacity.[1] Elevation of the capillary pressure causes alveolar-capillary membrane stress failure leading to a decrease in membrane conductance, an increase in capillary blood volume and subsequent impairment of diffusion capacity so single breath carbon monoxide diffusion capacity (DLCO) may give an early indication of alveolar-capillary membrane dysfunction in CAD patients.[9]

Various studies have described pulmonary function-related changes in patients with chronic left ventricular dysfunction & heart failure. These studies have varying conclusions ranging from essentially normal values, to primarily restrictive changes, to combined restrictive and obstructive changes.[5,12,13,14] Very less information is available about respiratory function tests in patients with a history of coronary artery disease (CAD) without the signs of CHF although PFTs in patients after cardiovascular surgery and after transplantation has been studied.[11,14,16,21] Lung diffusion capacity and PFT data is lacking in stable patients of CAD in spite of highly susceptible pulmonary vasculature to various neurohumoral changes due to coronary artery disease. The objective of this study was to assess the pulmonary functions along with diffusion capacity in stable patients of CAD.

Materials and Methods

Subjects: 80 clinically and angiographically documented patients of CAD from Guru Teg Bahadur Hospital were selected as subjects for the present study. All the patients were male and their CAD was stable for the past 2-6 yrs. They all belonged to the age group 35-55 yrs (mean age 48±6.57). All the subjects were on medication prescribed by the physician. Most of them were on ACE inhibitors, β-blockers and aspirin.

Inclusion criteria:

- Established adult CAD cases
- Stable CAD for the last 2-6 years
- Middle socioeconomic class.

Exclusion criteria:

- Subjects having any attack of angina or MI in the recent past (within 6 months)
- Subjects having any previous history of asthma, COPD, tuberculosis or diabetes mellitus
- Subjects having any history of smoking as smoking may be a confounding factor affecting both lung functions and cardio-vascular functions

45 healthy age and sex matched volunteers served as controls for our study. None of them had any history of CAD, hyprertension, asthma, COPD or tuberculosis and any family history of CAD.

Informed consent was taken from all the subjects and a standardized questionnaire related to cardio-respiratory health was worked out. Height, weight, body surface area and systolic & diastolic blood pressures were also noted down. Demographic details of both the groups are given in Table-I.

The procedure of PFTs was properly explained to all the subjects. These lung functions were tested by using computerized MS medisoft Cardio-respiratory Instrument, HYP'AIR Compact. Parameters of the PFTs recorded were: Slow vital capacity (SVC), Forced vital capacity (FVC), Forced expiratory volume in 1 sec (FEV1), FEV1/FVC ratio, Peak expiratory flow rate (PEFR) and Maximum voluntary ventilation (MVV). Diffusion capacity is measured by single breath carbon monoxide (DLCO) method. In this technique, subject breaths air through the mouth piece with nose clip. After a few normal breaths, the subject breaths out to residual volume, then immediately and rapidly inhale the test gas to total lung capacity, holds the breath for approximately 9-11 sec and finally breaths out at a moderately fast rate. After exhalation a sample of alveolar gas (carbon monoxide) is collected for analysis. All the parameters of PFTs were taken three times and the best reading was noted down. Each parameter of PFTs and DLCO in both the two groups was analyzed by using student's unpaired T test. P value was derived from two-tailed analysis and less than 0.05 was accepted as indicating significant difference between the compared values.

Results

In the present study FVC, FEV1, PEFR and MVV were found to be statistically reduced in CAD patients (Table:II). There was also a trend of deterioration of slow vital capacity (SVC) in these patients. Diffusion capacity (DLCO) was also significantly reduced in CAD patients as compared to normal healthy controls.

Discussion

Disorders of the heart frequently cause pulmonary dysfunction because of the close structural and functional association of the heart and lungs. The pulmonary vasculature is very commonly affected by cardiac pathology. The pulmonary vasculature is normally a low-pressure, low-resistance circuit with high compliance and tremendous vascular reserve. Although resting vascular tone is low, there are many identified mediators of pulmonary arterial tone that may help mediate pulmonary blood flow. Alveolar hypoxia is clearly a stimulus for increasing pulmonary vascular resistance although factors that mediate the response to hypoxia are not fully understood.

Almost all the parameters of PFTs were found to be deteriorated in CAD patients when compared to normal healthy controls. Statistically significant reduction in FVC, FEV1, PEFR and MVV indicate that a combination of restrictive (stiff lungs) and obstructive (cardiac asthma) derangements in lung functions occur in CAD patients even after medication and stable for 2-6 years. Reduced MVV in patients with CAD is likely related to the respiratory muscle weakness. This may result in a reduced ability to fully inspire, resulting in a reduced TLC and FVC. Medication may have improved the cardiac pathology but pulmonary vasculature resistance due to hypoxia is not being corrected. Our results are in consistent with Kindman et al and Kannel et al who also reported a combined restrictive and obstructive lung derangement.[12,13] These researchers have done PFTs in congestive heart failure cases and not in stable cases of CAD. Moreover diffusion capacity was not recorded by them.

In the present study we found a statistically significant reduction in diffusion capacity in CAD patients. CAD may disturb the alveolar-capillary interface and increases the resistance to gas transfer. Agostoni et al [1] reported that gas diffusion (DLCO) progressively worsens as CHF severity increases due to reduction in lung tissue participating to gas exchange. Alveolar-capillary membrane conductance and capillary blood volume are subcomponents of the lung diffusion capacity.[4] Elevation of the capillary pressure causes alveolar-capillary membrane stress failure (i.e. increase in capillary permeability to

water and ions, and disruption of local regulatory mechanisms for gas exchange), leading to a decrease in membrane conductance, an increase in capillary blood volume and subsequent impairment of diffusion capacity.

Buffalo health study have already revealed FEV1 as an independent predictor of overall long term survival rate and could be used as a tool in general health assessment.[20] Low grade systemic inflammation is also associated with atherosclerosis, reduced FEV1 might be an important risk factor for cardiovascular morbidity and mortality.[6] An effort towards improving FEV1 can also improve cardiovascular outcomes in CAD patients. Higher levels of inflammatory markers among persons with lower lung function, both in the entire cohort and in nonsmokers has also been reported.[8] A proinflammatory environment, in turn, may increase the risk of atherosclerosis and thrombosis and thus increase the risk for CHD. Interestingly, adjustment for markers of systemic inflammation only slightly decreased the hazard ratios, although this does not rule out systemic inflammation as a mechanism linking lung function and CHD risk. The association between lung function and incident CHD is not entirely due to confounding from smoking, and was found stronger among women than among men.[7]

Lung functions deteriorate as a complication of CAD or impairment of lung functions is a risk factor for the development and severity of CAD is still not understood. Different studies revealed different results but lung functions were found to be impaired in CAD patients. Our study demonstrated impaired PFTs and reduced diffusion capacity in stable CAD patients. Reduced alveolar-capillary membrane conductance and restrictive as well as obstructive type of impairment in lung functions are observed. More work is required in this field to exactly know the cause effect relationship for the impairment of lung functions in CAD patients even in stable condition.

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Table:1 Demographic details of CAD patients (group-I) and controls (group-II)

	CAD patients	**Controls**	**Significance**
Height (cm)	158.56 ± 7.81	157.66 ± 8.41	1.0
Age (yrs)	54.33 ± 8.34	55.31 ± 8.34	1.0
Weight (kg)	63.95 ± 10.03	62.42 ± 8.46	0.92
BMI(Kg/m2)	25.9 ± 4.7	25.75 ± 7.2	1.0
SBP (mm Hg)	128 ± 17.9	120.74 ± 14.3	0.835
DBP (mm Hg)	84.3 ± 10.13	80.02 ± 12.28	0.881

Table:2 PFTs and DLCO in CAD patients (group-I) and controls (group-II)

Parameters	**CAD patients**	**Controls**	**Significance**
SVC (Litres)	1.662 ± .081	2.96 ± 0.077	0.08
FVC (Litres)	1.588 ± .102	3.82 ± 0.66	0.013*
FEV1 (Litres)	1.336 ± .086	3.18 ± 0.51	0.012*
FEV1% (%)	82.815 ± 2.33	84.68 ± 12.44	0.915
PEFR (Litres/sec)	3.06 ± .238	4.28 ± 1.68	0.072
MVV (Litres/min)	45.74 ± 3.495	86.15 ± 14.56	0.001*
TLCO (Litres/min)	13.356± 1.089	20.58 ± 2.06	0.004*

*$p \leq 0.05$