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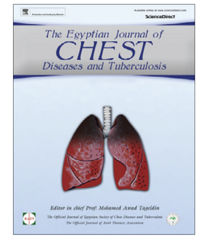

ORIGINAL ARTICLE

Impact of diabetes mellitus and its control on pulmonary functions and cardiopulmonary exercise tests

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KEYWORDS

Diabetes mellitus;
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Abstract *Background:* Diabetes mellitus (DM) is a leading public health problem with increasing incidence and long term complications. These complications are mainly a consequence of macrovascular and microvascular damages of the target organs. The presence of an extensive microvascular circulation and abundant connective tissue in the lungs, raises the possibility that lung tissue may be a target organ in diabetic patients.

Objectives: To study the impact of DM and its control on pulmonary function and cardiopulmonary exercise tests.

Methodology: This is a cross-sectional study carried out on diabetic mellitus patients (type I or type II $n = 30$) group II divided into two subgroups (group IIA) controlled diabetes (HbA1c $< 7\%$) ($n = 15$) and uncontrolled diabetes (group IIB) (HbA1c $\geqslant 7\%$ ($n = 15$). The control group (group I) was non diabetic healthy ($n = 15$). The following pulmonary function parameters were recorded: Forced Expiratory Volume in the first second (FEV1), Forced Expiratory Volume percent (FEV1/FVC %), Forced Expiratory Flow 25–75% (FEF 25–75%), peak expiratory flow (PEF) and MVV. Also maximum aerobic power (VO_2 max) using cardiopulmonary exercise test was measured.

Results: The mean FEV1, FEV1/FVC%, PEF, FEF 25–75%, MVV and VO_2 max values were low in diabetics (p value < 0.05) compared to non-diabetics. Also, uncontrolled diabetics show a greater decrease in these values than controlled diabetics.

Conclusion: The findings of the present study suggest that, the lung is a target organ for damage in DM and diabetics show a decrease in PFTs and VO_2 max compared to non-diabetics. And this deterioration is exaggerated in uncontrolled diabetics.

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Introduction

Diabetes mellitus describes a metabolic disorder of multiple etiology, characterized by chronic hyperglycemia with disturbances of carbohydrate, protein and fat metabolism, resulting from defects in insulin secretion or insulin action or both [1].

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Diabetes mellitus is a leading public health problem with increasing incidence and long term complications such as diabetic nephropathy, diabetic neuropathy, diabetic retinopathy etc. These complications are mainly a consequence of macrovascular and microvascular damages of the target organs [2].

Deterioration of pulmonary functions in DM is going to be eighty percent of all diabetics from the entire world population [1]. In 2000 the number of people with diabetes was 31.7 million and it is expected that by 2030 this will increase to 79.4 millions [3]. Several factors contributing to this include greater longevity, obesity, unsatisfactory diet, sedentary lifestyle and increasing urbanization. The cause of clinical diabetes is absolute or relative deficiency of insulin. The presence of an extensive microvascular circulation and abundant connective tissue in the lungs raises the possibility that lung tissue may be affected by microangiopathy process and non-enzymatic glycosylation of tissue proteins, induced by chronic hyperglycemia, thereby rendering the lung a "target organ" in diabetic patients. Since normal lung mechanics and gas exchange are influenced by the integrity of pulmonary connective tissue and microvasculature, abnormalities in either of these two structural components of the lung may lead to the development of measurable abnormalities of pulmonary function [4]. In 2004, Wendy et al. observed that a 10% decrease in FEV1 was associated with 12% increase in all-cause mortality [5]. As measures of airflow limitation predict all-cause mortality in diabetes, intensive glycemic management may reduce the risk of death through improved ventilatory function independent of other beneficial effects. So, the assessment of pulmonary function is an important investigation because early detection of functional impairment and its appropriate treatment will help to reduce morbidity and mortality [5].

Cardiopulmonary exercise testing (CPET) is being utilized to investigate cardiac and respiratory function. It can be used to identify an abnormality in patients with exercise intolerance or exercise related symptoms. It is also useful to evaluate patients with cardiovascular disease including cardiac failure and before heart and lung transplantation [6].

The VO_2 max (a measure included in CPET) is the maximum amount of oxygen that the body can use in one minute. VO_2 max (also maximal oxygen consumption, maximal oxygen uptake, peak oxygen uptake or maximal aerobic capacity) is the maximum capacity of an individual's body to transport and use oxygen during incremental exercise, which reflects the physical fitness of the individual. The name is derived from V – volume, O_2 – oxygen, max – maximum. VO_2 max is expressed either as an absolute rate in liters of oxygen per minute (L/min) or as a relative rate in milliliters of oxygen per kilogram of bodyweight per minute (i.e., mL/(kg min)). The latter expression is often used to compare the performance of endurance of sports athletes [7].

Accurately measuring VO_2 max involves a physical effort sufficient in duration and intensity to fully tax the aerobic energy system. In general clinical and athletic testing, this usually involves a graded exercise test (either on a treadmill or on a cycle ergometer) in which exercise intensity is progressively increased while measuring ventilation and oxygen and carbon dioxide concentration of the inhaled and exhaled air. VO_2 max is reached when oxygen consumption remains at a steady state despite an increase in workload [7].

There are several factors that affect VO_2 max, including muscle mass, blood oxygen levels, lung capacity and general fitness level. The maximum VO_2 is the first measurement to be examined because it establishes whether the patient's physiologic responses allow normal maximal aerobic function or not. Other measurements are then used to differentiate the cause of any exercise limitation whether or not the subject reaches his/her predicted maximum VO_2. Tests measuring VO_2 max can be dangerous in individuals who are not considered normal healthy subjects, as any problems with the respiratory and cardiovascular systems will be greatly exacerbated in clinically ill patients. Thus, many protocols for estimating VO_2 max have been developed for those for whom a traditional VO_2 max test would be too risky. These generally are similar to a VO_2 max test, but do not reach the maximum of the respiratory and cardiovascular systems and are called sub-maximal tests [8].

Another estimate of VO_2 max, based on maximum and resting heart rates, was created by a group of researchers from Denmark [9]. It is given by:

$$VO_2max = 15\frac{HR_{max}}{HR_{rest}}$$

This equation uses maximum heart rate (HR_{max}) and resting heart rate (HR_{rest}) to estimate VO_2 max in mL/(kg·min). "Maximal oxygen uptake (VO_2 max) is widely accepted as the single best measure of cardiovascular fitness and maximal aerobic power. Absolute values of VO_2 max are typically 40–60% higher in men than in women [10]."

Aim

The aim of the present study was to assess the pulmonary function test in patients with DM either controlled or not and also to study the changes that may occur in their VO_2 max.

Materials and methods

The present study (a cross-sectional study) included 30 patients group II; 15 patients with controlled DM (group IIA) and 15 patients with uncontrolled DM (group IIB) admitted to chest and internal medicine departments, Menoufiya University hospitals in the period from February 2013 to August 2013. We also included 15 healthy non diabetic subjects who volunteered as a control group.

Inclusion criteria: patients with DM either type I or II.

Group IIA: included in the study were patients with controlled diabetes which is defined as HbA1c $< 7\%$ and were 15 patients and the other group; group IIB was patients with uncontrolled diabetes which is defined as HbA1c $\geqslant 7\%$ and were 15 patients. The subjects of both genders in the age group between 25 and 60 years are included. 15 healthy non diabetic subjects were studied as a control group; group I.

Exclusion criteria: subjects with a past history of smoking, hypertension (HTN), respiratory diseases (Acute or chronic), chest wall injuries, congestive cardiac failure (CHF), and chest wall deformities were excluded from the study.

The subjects were properly explained about the objectives, methodology, expected outcome and implications of the study and written informed consents were obtained from them.

(1) Full history taking and complete clinical examination.
(2) Routine laboratory investigations including complete liver and kidney functions, complete blood count