Maximal Voluntary Ventilation in Patients with Type I Diabetes Mellitus

Safaa Jawad Kadhem; F.I.B.M.S (internal medicine); Ali Hussein al- Bayaty
F.I.B.M.S (internal medicine)

Abstract

Background and study Objectives: Several studies in adults report abnormalities of lung function in patients with diabetes. The objectives of this study are to assess the Maximum Voluntary Ventilation (which is a measure of the mechanical factors of breathing) in patients with type I diabetes mellitus and its relation to the duration of diabetes.
Patients and methods: 36 patients with a known history of type I DM (26 male, 10 female) with an average age between 16-42 years were enrolled in this study with 38 sex and age matched healthy individuals as a control group. The MVV test was performed in both groups for at least 3 times to ensure reproducibility. The study group was subdivided according to the duration of diabetes into group1 for those < 5 years duration (13 patients), group2 for those between 5-10 years (11 patients) and group 3 for those > 10 years duration (12 patients).
Results: mean values of direct Maximal Voluntary Ventilation test was reduced in diabetic patients compared to their matched controls in all study groups but it was most obvious in group 2 and 3 as duration of diabetes increase
Conclusion: in patients with type I DM there is impaired mechanical factors of breathing manifested by increase in airway resistance, reduced compliances or respiratory muscle force as indicated by reduction in the mean values of direct Maximal Voluntary Ventilation test relative to their matched controls.

Introduction

Diabetes mellitus is a major, rapidly growing public health care problem. It is increasing in incidence, and brings with it long term complications (1) .Chronic hyperglycemia of diabetes mellitus is associated with continuing damage, dysfunction, and failure of various organs , especially the eyes, kidneys, nerves, heart, lungs and blood vessels.
The mechanism by which impaired glycemic control may lead to a reduction in lung function is uncertain, though it has been suggested that the increased systemic inflammation associated with diabetes (2) may result in pulmonary inflammation (3) as well, and hence, it can cause air way damage (4). Moreover, secondary reduction in the antioxidant defense of lung and increased susceptibility to environmental oxidative insults results in the subsequent loss of lung function (5) and ultimately, lung damage. It has been demonstrated that pulmonary complications in diabetes mellitus are due to a thickening of the walls of alveoli, alveolar capillaries and pulmonary arterioles, and these changes cause pulmonary dysfunction (6, 7). Diabetes mellitus can cause pulmonary complications due to collagen and elastin changes, as well as micro-angiopathy (8) . Furthermore, pulmonary function impairment and lung dysfunction in diabetic patients is secondary, due to immune function impairment (9).
Respiratory diseases are seldom attributed to DM but lungs are affected sub clinically as observed in various histopathological and experimental studies (10).
How lungs and their functions are affected in DM is still a topic of interest. The effects of DM on pulmonary functions have been observed in large number of studies but there is great variation. Some show mainly obstructive pattern whiles

some restrictive and others do not comment.

The interaction among pulmonary mechanics, respiratory muscle performance, and ventilator control has so far received little attention in subjects with insulin-dependent diabetes mellitus .Although many studies have described pulmonary abnormalities in human type I diabetes (11,12) very few investigations have been devoted to assessing airway involvement and muscle function under controlled conditions (11)or during stimulated breathing4 in insulin- dependent diabetic patients.

The basic concepts of normal pulmonary physiology that are involved in spirometry/pulmonary function testing include mechanics (airflows and lung volumes), ventilation–perfusion interrelationship, diffusion and gas exchange, as well as respiratory muscle strength(13).

Spirometry is a powerful tool that can be used to detect, differentiate, follow and manage type I DM patients with pulmonary disorders.

Maximal Voluntary Ventilation – (which is measured by spirometer) this test parameter reflects the status of the respiratory muscles, compliance of the thorax-lung complex, and airway resistance. MVV can therefore be viewed as a measure of respiratory muscle strength. One major cautionary note is that this test is effort dependant and therefore can be a poor predictor of true pulmonary strength and compliance.

Patients and method

The study was done in the pulmonary function test unit and Babylon center of diabetes in merjan teaching hospital during the period from April 2011 to February 2012.

36 patients with a known history of type I DM (26 male, 10 female) with an average age between 16-42 years were enrolled in this study. A detailed history was taken to determine the exact duration of diabetes and whether they would be included in the study or not on the basis of the exclusion criteria.

Diabetic patients were individually matched for age, height, and weight with 38 controls. Age and height were given more emphasis for matching as these two relate better to lung function than weight.

Controls were of a similar community with the same socio-economic status relative to diabetics; both were assessed by a detailed medical history.

The study group was subdivided according to the duration of diabetes into group1 for those < 5 years duration (13 patients), group2 for those between 5-10 years (11 patients) and group 3 for those > 10 years duration (12 patients).

Exclusion criteria: applied for both the study and control group patients with current or previous tobacco smoking abnormalities of the vertebral column or thoracic cage history of acute or chronic respiratory infections cardiopulmonary disease those who had undergone major abdominal or chest surgery Direct Maximal Voluntary Ventilation test was performed during inspiratory and expiratory phases of respiration on MIR SPIROLAB III system The patients were encouraged to practice this manoeuvre before doing the test. The test was performed with the patient in the standing position and the subject inspired and expired forcefully for the period of 12-15 seconds into the mouth piece which was connected with MIR SPIROLAB III System and results were appeared in computer and direct Maximal Voluntary Ventilation (MVV) test results were obtained.

Statistical analysis: Statistical analysis was done using a student t-test for independent group (two-tailed). The level of significance was taken as $p<0.05$.

Results

MVV test results in inspiratory and expiratory phases of respiration for group

1 patients and their matched controls are shown in Table 1. although these results are lower than control group but it was statistically insignificant, p-value > 0,5.

Table 1. Maximal Voluntary Ventilation data (MVV) between group 1 patients and their matched controls in Inspiratory and Expiratory phases of Respiration.

MVV RESULTS	GROUP 1 (n=13)	Control (n=14)	Percentage change (%)	p value
MVV in Inspiratory phase (liters / 15 sec.)	56.38 ± 2.18	68.11 ± 5.56	+ 16.26	P> 0.5
MVV in Expiratory phase (liters / 15 sec.)	57.22± 2.18	68.15 ± 5.5	+ 17.92	P> 0.5

MVV test results for group 2 and 3 patients and their matched controls are shown in table 2 and 3 respectively. These results shows statistically significant reduction in direct MVV test results in both groups which is most remarkable in group 3 patients as duration of diabetes increases.

Table 2. Maximal Voluntary Ventilation data (MVV) between group 2 patients and their matched controls in Inspiratory and Expiratory phases of Respiration.

MVV RESULTS	GROUP 2 (n=11)	Control (n=13)	Percentage change (%)	p value
MVV in Inspiratory phase (liters / 15 sec.)	33.34 ± 2.18	68.01 ± 5.6	+ 36.36	P=0.001
MVV in Expiratory phase (liters / 15 sec.)	34.12± 2.18	68.05 ± 5.2	+ 37.52	P= 0.001

Table 3. Maximal Voluntary Ventilation data (MVV) between group 3 patients and their matched controls in Inspiratory and Expiratory phases of Respiration.

MVV RESULTS	GROUP 3 (n=12)	Control (n=11)	Percentage change (%)	p value
MVV in Inspiratory phase (liters / 15 sec.)	24.38 ± 2.78	68.22 ± 4.56	+ 63.36	P= 0.001
MVV in Expiratory phase (liters / 15 sec.)	23.12± 2.18	67.15 ± 6.5	+ 63.93	P= 0.001

Discussion

The interaction among pulmonary mechanics, respiratory muscle perfor-mance, and respiratory muscles endurance has so far received little attention in patients with insulin-dependent diabetes mellitus. Although many studies have described pulmonary abnormalities in human type I diabetes (mainly restrictive pulmonary defect with reduction in FVC, small airways diseases, reduction in DLco), very few investigations have been done to assess pulmonary mechanics and muscle function under controlled conditions in insulin- dependent diabetic patients and no one of these studies has investigate the effect of duration of diabetes on these parameters.

The present study was designed to study the effects of duration of type I diabetes on pulmonary mechanics as indicated by reduction in the direct maximal voluntary ventilation.

In the present study, we found a reduction in inspiratory and expiratory volumes in consecutive breaths during the direct MVV test, which was most obvious as the duration of diabetes increases as indicated

by only mild decrease in group one patients which was statistically insignificant, while it was statistically significant in group 2 and 3 patients.

Many study has demonstrated that Maximal Voluntary Ventilation test is the only simple index of respiratory muscle endurance which reflects the function of the entire ventilatory apparatus and is a main pulmonary test used to categorizing dyspnoea(16,17). One study reported that the assessment of respiratory muscles weakness is important and MVV is an objective dynamic method for measuring the capacity of respiratory muscles (18). Similarly, another study reported that reduction in MVV may be caused by upper or lower airways obstruction, restriction or muscle weakness (19).

In addition, other investigators have founded that the decreased MVV values may be due to muscle weakness, airway obstruction, or poor effort (20). Keeping in view the observations about MVV and poor performing efforts demonstrated by these studies (20), in the present study, we tried to reduce a number of variables that could interfere with the pattern of breathing either before or during the experiment. This was reduced by adequately training the patients to do the procedure and by repeating the test for at least 3 times to ensure reproducibility

Neder et al., reported that the MVV is a test of the overall function of the respiratory system and is influenced not only by respiratory muscles strength, but also by the compliance of the lung-thorax system, the condition of the ventilatory control systems and the resistance of both airways and tissues. Additionally, they also reported that inspiratory and expiratory muscles are utilized during maximal voluntary effort and weakness or decreased endurance of either system may result in low MVV (21).

It has been found that normal individuals can sustain inspiratory and expiratory volumes during the testing interval whereas subjects with muscular weakness markedly decreased the MVV (22). In the present study, MVV test results in diabetic patients showed decline in respiratory endurance which may leads to respiratory exertion and breathless. Additionally, these results showed that the failure of diabetic patients to sustained inspiratory and expiratory volumes during the testing interval may be due to the muscular weakness.

Heimer et al studied the respiratory muscle strength and endurance in 39 diabetic patients. The Maximal Voluntary Ventilation was significantly decreased in the diabetic group and correlated with the duration of diabetes. This decline shows decreased respiratory muscle endurance in diabetic patients compared to the control group (14). In contrast to our study, this study does not specify the type of diabetes and does not categorized the patients according to the duration of diabetes.

Conclusion

In patients with type I DM there is impaired mechanical factors of breathing manifested by increase in airway resistance, reduced compliances or respiratory muscle force as indicated by reduction in the mean values of direct Maximal Voluntary Ventilation test relative to their matched controls and this reduction is more obvious with the increase in duration of diabetes.

Recommendations

It is advisable that physicians should concentrate on respiratory system in the same way as that of other systems affected by diabetes mellitus and pulmonary function test is done in diabetic patients with respiratory complaint (in the absence of obvious causes e.g. smoking, chest infection etc) and for preoperative evaluation in diabetic patients.

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