UDC 616.379-008.64:[616.092:612.217.1]

O.K. Sivozhelezova[1,2], K.M. Ivanov[1], I.V. Miroshnichenko[1], A.K. Kunarbaeva[1]

[1] — Federal State Budget Educational Institution of Higher Education Orenburg State Medical University of Ministry of Health of Russian Federation, Internal Medicine Department, Laboratory of Respiratory Physiology and Pathology, Orenburg, Russia

[2] — Orenburg Departmental Clinical Hospital, Orenburg, Russia

RESPIRATORY MUSCLES STRENGTH CHANGE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS COMPLICATED BY THE DIABETIC FOOT SYNDROME

Abstract

The relationship between cardiorespiratory disorders and the diabetic foot syndrome has not been adequately studied. In particular, there is no information on the strength of the respiratory muscles in this category of patients. **The objective of the study**: to reveal respiratory muscles weakness in patients with type 2 diabetes mellitus complicated by the diabetic foot syndrome. **Materials and methods.** 72 patients were examined, 16 of them with type 2 diabetes mellitus complicated by Wagner grade I-IV neuroischemic diabetic foot made up the first (main) group. The second group (comparisons) included 29 patients with type 2 diabetes mellitus not complicated by the diabetic foot syndrome. The third group (comparisons) included 27 patients without diabetes. The groups were randomized by gender and exclusion criteria. RM strength determination was carried out by measuring the maximum static inspiratory and expiratory mouth pressures, which the patient created during the maximum inspiration and maximum expiration with closed airways. **Results**. Respiratory muscles strength on inspiration in patients with type 2 diabetes mellitus complicated by the diabetic foot was reduced by 18.5 cm H_2O ($p<0.01$) compared with diabetic patients without diabetic foot syndrome and by 17.3 cm H_2O ($p<0.01$) compared with patients without diabetes. The expiratory effort showed a decrease in respiratory muscles strength in patients of the first group by 49.4 cm H_2O ($p <0.01$) compared to patients of the second group and by 27.4 cm H_2O ($p <0.05$) compared to patients of the third group. In women with the diabetic foot syndrome, the inspiratory muscles strength was reduced in comparison with patients without diabetic foot and without diabetes by 27.1 ($p <0.01$) and by 23.3 ($p< 0.05$) cm H_2O respectively. In men with the diabetic foot syndrome, the same index was lowered by 13.9 ($p> 0.05$) and 17.7 ($p <0.05$) cm H_2O compared to the second and third groups respectively. The expiratory effort revealed a decrease in respiratory muscles strength in men in all groups in approximately the same range, without a significant difference between the groups. In women with the diabetic foot syndrome, there is a significant decrease in expiratory muscles strength: by 48.4 cm H_2O ($p <0.01$), compared to women of the second group, and by 20.6 cm H_2O ($p <0.05$) patients of the third group. **Conclusions**. Patients with type 2 diabetes mellitus complicated by the diabetic foot syndrome showed a decrease in inspiratory and expiratory muscles strength. In women with the diabetic foot syndrome, there is a more significant decrease in respiratory muscles strength on expiration compared to men with this pathology.

Key words: *diabetes mellitus, diabetic foot syndrome, respiratory muscles strength*

For citation: Sivozhelezova O.K., Ivanov K.M., Miroshnichenko I.V., Kunarbaeva A.K. RESPIRATORY MUSCLES STRENGTH CHANGE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS COMPLICATED BY THE DIABETIC FOOT SYNDROME. The Russian Archives of Internal Medicine. 2018; 8(3): 204-208. [In Russian]. DOI: 10.20514/2226-6704-2018-8-3-204-208

Contacts e-mail: siv.olga@mail.ru

DOI: 10.20514/2226-6704-2018-8-3-204-208

RM — respiratory muscles, DM — diabetes mellitus, DFS — diabetic foot syndrome

Introduction

Diabetes mellitus (DM) is one of the topic medical, social and economic health issues not only in Russia but also in many countries due to the increase of the incidence rate and the frequency of diabetic complications [1]. Diabetic foot syndrome (DFS) is the most common and socially significant late diabetic complication, which worsens the quality of life of patients [2, 3].

There are data on various pulmonary function impairments in patients with DM without respiratory and cardiovascular systems pathology [4, 5]. The decrease of the Tiffeneau index and FEV1 has provided authors with an opportunity to think about obstructive changes of pulmonary function in patients with DM [5, 6]. On the contrary, the data gathered by E. I. Sokolov support a restrictive respiratory pattern in DM [7], especially in patients with severe complications [8]. It remains unclear whether functional changes in the lungs precede the emergence of DM or develop later.

Previous authors have described the correlation between respiratory dysfunction and diabetic complications (retinopathy and nephropathy) [9]. At the same time M. S. Boulbou et al. did not reveal any connection between functional impairments of the respiratory system and other diabetic complications [10]. The correlation between cardiorespiratory disorders and DFS has not been adequately studied. In particular, there is no information on changes in the respiratory muscles (RM) strength in this category of patients. The RM dysfunction is today conventionally subdivided into fatigue and weakness. Respiratory muscle fatigue is a process in which there is a decrease in the strength and speed of contraction of RM as a result of the fact that they work excessively. Muscle fatigue is an inversive process. Functional recovery is possible after rest. RM weakness is the state of their reduced strength at rest. The most common cause of RM weakness is metabolic, inflammatory and degenerative changes leading to RM, nerves or neuromuscular junction dysfunction [11]. It should be assumed that the development of RM fatigue or weakness is possible in patients with DM.

Objective: To reveal RM weakness in patients with type 2 DM complicated by the diabetic foot syndrome on the basis of changes in respiratory muscles strength.

Materials and methods

72 patients were examined, treated at the non-governmental healthcare organization Departmental Clinical Hospital at Orenburg Station of OAO Russian Railways, Surgical Department and Department of Internal Medicine. The patients were divided into 3 groups. The first (main) group consisted of 16 patients with type 2 DM complicated by Wagner grade I-IV neuroischemic DFS (classification of the International Working Group on the Diabetic Foot, 2000). The second group consisted of 29 patients with type 2 DM without DFS. At enrollment, type 2 DM was subcompensated and decompensated in all patients. Inclusion criteria: confirmed type 2 DM; the absence of concomitant bronchopulmonary diseases, other visceral diseases in the decompensation stage; and the ability of patients to perform breathing manoeuvres during the examination of the respiratory system. Exclusion criteria: Wagner grade V DFS, significant organic lesion of CNS, acute disorder of cerebral circulation in past medical history, lower limb amputation in past medical history, third-degree obesity (BMI > 40 kg/m^2), II-III CHF, moderate to severe anemia (hemoglobin < 90 g/l), significant liver and renal dysfunction, non-sinus rhythm, administration of psychotropic agents. The third group consisted of 27 patients without DM.

RM strength determination was carried out by measuring the maximum static inspiratory and expiratory mouth pressures, which the patient

created during the maximum inhalation and maximum exhalation with closed airways For this purpose, MicroRPM for RM testing by Micro Medical Ltd. (UK) was used to determine MIP (maximal inspiratory pressure) and MEP (maximal expiratory pressure) in cm H_2O. No less than 3 manoeuvres were carried out with the rest periods of 1 minute. Only the best result was recorded. Patients were sitting, and a nose clip was used to prevent air leakage. The requirement for recording the maximal inspiratory and expiratory pressures was to maintain them for at least 1 second. The normal values of MIP were: men > 100 cm H_2O, women > 70 cm H_2O. The normal values of MEP were: men > 140 cm H_2O, women > 90 cm H_2O.

The study was approved by the Ethics Committee. All patients signed the informed consent (PIC) to participate in the study.

Statistical analysis was carried out using the Statistica 7.0 software package on the base of nonparametric methods (the Wilcoxon-Mann-Whitney test). Differences between the examined groups were considered significant at $p < 0.05$.

Results and Discussion

Patients were randomized by gender, age, body mass index (BMI), hypertension and coronary heart disease (CHD) (Table 1).

The RM strength was reduced in all the examined patients in comparison with the normal indices. However, the indices varied significantly between groups (Table 2).

The RM strength of inspiratory effort was reduced in both experimental groups, without a significant difference between the indices. In patients belonging to the main group, with DM and DFS, a significant decrease of MIP index by 18.5 cm H_2O (34%) was found compared with data on patients with uncomplicated DM ($p_{I-II} < 0.01$), and by 17.3 cm H_2O (33%) compared with the indices in patients without DM ($p_{I-III} < 0.01$).

The expiratory effort revealed higher RM strength values in DM patients compared to the third group by 22.0 cm H_2O (25%) ($p_{II-III} < 0.05$). In patients with DM complicated by DFS, a significant decrease in the MEP index by 49.4 cm H_2O

Table 1. *Initial characteristics of patients*

Indices	Studied groups		
	Group I n=16	Group II n=29	Group III n=27
Mean age, years old	62,6±0,9	61,5±1,2	60,8±0,7
Men/Women, absolute number	7/9	15/14	13/14
Hypertension, percentage of patients, %	100	100	100
CHD, percentage of patients, %	56	50	65

Chart 2. *The respiratory muscles strength in the studied groups (M ± m)*

Studied groups	Indices of RM strength	
	MIP, cm H_2O	MEP, cm H_2O
Group I, n = 16	53,9±6,9	59,4±7,4
Group II, n = 29	72,4±4,8	108,8±6,4
Group III, n = 27	71,7±7,3	86,8±5,3
p	p_{I-II}<0,01 p_{I-III}<0,01 p_{II-III}>0,05	p_{I-II}<0,01 p_{I-III}<0,05 p_{II-III}<0,05

Note: p — the reliability of the difference between the studied groups

(83%) was found compared with data on patients with uncomplicated DM ($p_{I-II} < 0.01$), and by 27.4 cm H_2O (46%) compared with the indices in patients without DM ($p_{I-III} < 0.05$).

The analysis of the changes in the RM strength revealed various MIP and MEP in the groups of patients depending on gender. MIP and MEP indices in men were significantly higher than in women in all groups. Mean MIP indices were lower in men and women in all groups. The MEP index was determined within normal limits only in women belonging to the second group (97.9 ± 6.4 cm H_2O).

Among women, the smallest MIP index was found in the group of patients with DFS: compared with the second group, it decreased by 27.1 cm H_2O (66%) ($p_{I-II} < 0.01$), and compared with the third, it decreased by 23.3 cm H_2O (55%) ($p_{I-III} < 0.05$). Among men, the strength of inspiratory muscles is reduced by 13.9 cm H_2O (20%) in patients of the main group compared with patients with DM ($p_{I-II} > 0.05$) and by 17.7 cm H_2O (26%) compared with patients without DM ($p_{I-III} < 0.05$).

When assessing the strength of the expiratory muscles in men, there were no significant differences between the groups, unlike what was true of the women. Among women, the MEP index is reduced by 20.6 cm H_2O (41%) in patients with DFS compared with patients without DM ($p_{I-III} < 0.05$) and by 48.4 cm H_2O (98%) compared with patients with DM without DFS ($p_{I-II} < 0.01$).

Figure 1 shows the deviation of the RM strength during inspiration and expiration in the examined groups of patients, depending on gender (Fig. 1).

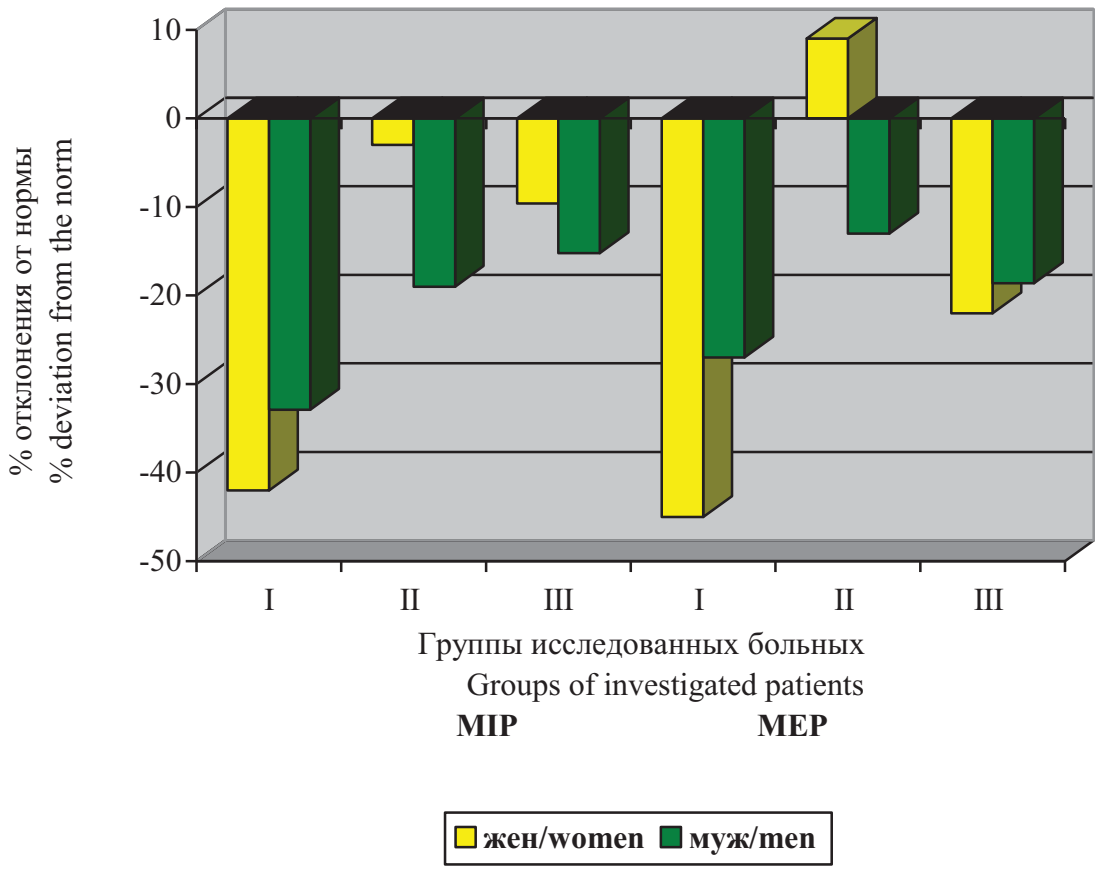

Figure 1. *Deviation from the norm of indices of the respiratory muscles strength in men and women in studied groups*

It is obvious that the most significant decrease relative to the normal values of the RM strength is observed on inspiration in women and in men in the group of patients with DFS. On expiration, the RM strength is reduced more significantly in the first group in women.

A significant decrease of the RM strength at rest is thus typical for patients with DM complicated by DFS, which confirms the RM weakness. It can be assumed that the causes of these changes are multifactorial, associated with the RM dysfunction because of the metabolic and degenerative processes, with a disorder of neuromuscular transmission, the impairment of circulation, morphofunctional characteristics of airways, and respiratory failure [11]. When DM is present before the development of late diabetic complications, it is necessary to monitor the RM strength to identify weakness and to implement the medical rehabilitation measures.

Conclusion:

1. Respiratory muscle weakness together with a decrease in inspiratory and expiratory muscle strength are observable in patients with diabetes mellitus complicated by the diabetic foot syndrome.

2. A more significant RM strength decrease in expiratory effort is observed in women with the diabetic foot syndrome compared to men with this pathology.

Conflict of interests

The authors declare no conflict of interests.

References:

1. Dedov I.I., Shestakova M.V., Vikulova O.K. Epidemiology of diabetes mellitus in Russian Federation: clinical and statistical report according to the federal diabetes registry. Diabetes Mellitus. 2017; 20 (1): 13-41 [In Russian].
2. Risman B.V., Chmyrev I.V., Gamolin S.V. Quality of life and function of feet patients with purulent-necrotic complications of diabetic foot. Vestnik VMA. 2011; 2(34): 87-96 [In Russian].
3. Sivozhelezova O.K., Ivanov K.M. The quality of the life of the patients with the chronic heart insufficiency and the destructive forms of the syndrome of the diabetic foot. Vestnik OSU. 2014; 6 (167): 229-232 [In Russian].
4. Hsia C.C.W. Lung function changes related to Diabetes Mellitus. C.C.W. Hsia, Ph. Raskin. Diabetes Technology & Therapeutics. 2007; 2(1): 73-82.
5. Zhautikova S.B., Sejsembekov T.Z., Kenzhina Z.Z. The state of respiratory organs in extrapulmonary diseases. J. Clin. Med. Kaz. 2013; 2 (28): 79-80 [In Russian].
6. Svetlakova N.V. State of ventilatory function of lungs and hemodynamics of lesser circulation in patients with type I diabetes mellitus during intensive insulin therapy. Perm Medical Journal. 2008; 4(25): 47-53 [In Russian].
7. Sokolov E.I. Demidov Yu.I., Dudayev V.A. The condition of external respiratory mechanics in patients with type I diabetes. Clinical Medicine. 2007; 9: 54-58 [In Russian].
8. Sokolov E.I. Demidov Yu.I. Gas exchange function of the lungs in patients with type I diabetes mellitus. Therapeutic archive. 2008; 3: 63-66 [In Russian].
9. Ospanova T.S., Zaozerskaya N.V. Clinical and pathogenetic features of respiratory disorders in patients with diabetic nephropathy and obesity. Belgorod State University Scientific Bulletin. 2014; 11 (182): 62-67 [In Russian].
10. Boulbou M. Diabetes mellitus and lung function. M. Boulbou, K. Gourgoulianis, V. Klisiaris [et al.] Med. Princ. Pract. 2003; 12(2): 87-91.
11. Avdeev S.N. Assessment of the strength of the respiratory muscles in clinical practice. Atmosphere. Pulmonology and Allergology. 2008; 4: 12-17 [In Russian].

Article received on 15.01.2018
Accepted for publication on 11.05.2018