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Peculiarities of Cerebral Blood Circulation and Cognitive Function Disorders in Chronic Lung Diseases

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Abstract

The priority direction is the study of various risk factors for the development of cerebrovascular diseases, one of which is chronic obstructive pulmonary disease (COPD). The current stage of development of angioneurology is characterized by a significant increase in the role of fundamental research in the study of pathogenetic mechanisms of development of cerebrovascular accident.

Keywords: *Cerebrovascular Disease, Chronic Obstructive Pulmonary Disease, Clinical Practice, Cognitive Impairment.*

1. Introduction

Chronic obstructive pulmonary disease is characterized by the development of a chronic inflammatory process of the respiratory tract, lung parenchyma and blood vessels, in which an increased number of neutrophils, macrophages and T-lymphocytes is detected in various anatomical structures of the respiratory system [3, 12].

According to international studies, COPD occurs in 4-6% of the adult population, there is a tendency to increase. According to the forecast data of the World Health Organization, the damage from COPD will increase in the coming decades, and by 2020 these diseases will take the 5th place in the world in terms of socioeconomic damage and the 3rd place in terms of mortality [5, 12].

According to modern concepts, one of the important links in the pathogenesis of COPD is the brain. Due to the high activity, the brain has a high demand for oxygen. Unlike other organs, the brain has practically no reserves of oxygen, which it consumes for energy. This explains the high sensitivity of the nervous tissue to hypoxia. Hypoxia is a leading factor in the mechanism of brain damage, therefore, for the normal functioning of the central nervous system (CNS), its adequate blood supply is of great importance [9]. A feature of cerebral circulation is its self-regulation. An important regulator of cerebral blood flow is the vascular endothelium. Vasomotor activity of blood vessels is the main marker of the functional viability of local mechanisms for maintaining circulatory homeostasis. Violation of the vasodilation apparatus of intracerebral arteries is accompanied by cerebral ischemia [3]. A feature of cerebral circulation disorders in COPD is diffuseness with the involvement of significant areas of the brain.

On the basis of experimental studies, it was found that in COPD there is endothelial dysfunction of the vessels of the cerebral and main basins, characterized by a significant increase and predominance of arterial constrictor activity, which leads to inadequate perfusion of the brain and, as a result, to CNS dysfunction [13]. Endothelial dysfunction can be defined as an imbalance between relaxing and constrictor factors, anti- and procoagulant mediators, growth factors and their inhibitors [1, 2].

However, there is no data on what structural changes in COPD occur in the vessels of the brain, how pronounced they are and how they change depending on the stage of the disease. It is known that during exacerbation and progression of the disease, increasing hypoxia, intoxication, the impact of infectious factors on the vascular wall and nerve cells, as well as dyscirculatory disorders of a congestive nature

due to right ventricular failure lead to a significant disruption of the CNS [7]. Thus, in patients with decompensated cor pulmonale and severe respiratory failure, severe encephalopathy occurs [5]. The severity of cognitive impairment, the nature and severity of the neurological deficit determine the patient's ability to continue working, the preservation of the ability to self-service. The study of structural changes in the arteries supplying the brain, the identification of the relationship and the degree of their severity in COPD at different stages of the formation of chronic pulmonary heart is of great interest to clinical medicine [11]. This will help timely prescribe corrective therapy to these patients, improve the quality of life and prognosis of the disease [6].

In this regard, the purpose of this work was to study the features of cerebral hemodynamics in patients with COPD depending on the stage of COPD and to correct these disorders.

2. Materials And Methods

During the research, we examined 65 patients. The mean age was 61.0 ± 5.6 years (from 45 to 72 years).

Inclusion criteria: diagnosis of COPD, verified by a pulmonologist on the basis of a spirographic study; absence of cerebrovascular pathology, blood pressure (BP) less than 140/90 mm Hg.

All patients underwent cerebral hemodynamics using color duplex scanning of extra- and intracranial vessels using the SA-8000 EX device (Medison). Doppler ultrasound of the cerebral vessels was performed in the following volume: internal carotid artery (ICA), vertebral artery (VA); anterior cerebral artery (ACA), middle cerebral artery (MCA), posterior cerebral artery (PCA). During visual assessment of the state of the vascular bed, the patency of the vessel was assessed (passable, occluded), the direction of its course (the presence of deformations - bends, tortuosity, loops), the mobility of the vascular wall (rigidity, hyperpulsation), the state of the intima-media complex (density, thickness, surface shape, uniformity). The study of venous blood flow was carried out by determining the speed of blood flow through the vein of Rosenthal. The main indicators were calculated according to quantitative characteristics. Quantification of blood flow in the arteries was based on directly measured Doppler parameters (amplitude, frequency, frequency distribution, impulse variations) and calculated various indices. These indicators were: peak systolic velocity (PSV), mean systolic velocity (SVR), Gosling pulsation index (PI). A hypercapnic test was also performed by holding the breath for 30 seconds.

The venous outflow was corrected using diosmin. The drug was administered at a dose of 600 mg (1 tablet) in the morning for a month. Cerebral hemodynamics was assessed before and after treatment.

The obtained results were statistically processed using the Microsoft Excel package, Statistica 6, with an estimate of the mean values of M, the mean square error m, and the Pearson correlation coefficient. Significance of differences between groups was assessed using Student's t-test, non-parametric Mann-Whitney test.

During the study, all patients were divided into groups.

1. The main group - patients with COPD stage I-III. Depending on the stage of COPD, the main group was divided into 3 subgroups: I — patients with COPD stage I (27 subjects), II — patients with COPD stage II (21 subjects), III — patients with COPD stage III (17 subjects).

2. Comparison group — patients with dyscirculatory encephalopathy (DE) of the 1st stage (15 subjects).

3. Control group - 10 practically healthy people of the same sex and age composition.

The groups did not differ in gender, age, and mean BP values.

3. Results and Discussion

The obtained results of Doppler examination indicate that in patients with COPD stages I-III, compared with patients suffering from stage 1 DE and the control group, there were significant changes in a number of indicators.

During duplex scanning of the extracranial parts of the brachiocephalic arteries, the thickness of the intima-media complex was studied.

When examining the thickness of the intima-media complex, there is a direct correlation between the thickness of the intima-media complex and the stage of COPD.

In 51% of the studied patients, there are local hyperechoic hemodynamically insignificant plaques in the bifurcation of the common carotid artery with a degree of stenosis of the vessel diameter up to 64%. At the same time, in subgroup I, plaques are present in 36%, in subgroup II — in 56%, in III — in 57%, which indicates an increase in atherogenesis processes as the stage of COPD develops.

In the study of cerebral arteries, there were significant changes in a number of indicators. Characteristics of the vessels of the brain are reflected in table. 1.

Table 1. Indicators of cerebral hemodynamics

Vesselsofthebrain	**Maingroup, n = 65**			**Comparisongroup, n = 15**	**Control group, n = 10**
	I subgroup, n = 27	**II subgroup, n = 21**	**III subgroup, n = 17**		
internalcarotidartery					
ПСС, см/с	69,4 ± 8,2	65,3 ± 7,3	62,0 ± 4,1*	69,0 ± 5,2	72,0 ± 4,0
Vertebralartery, segmentV4					
ПСС, см/с	49,0 ± 7,6	44,6 ± 10,9	32,0 ± 6,1*, л,	46,2 ± 6,5	50,6 ± 6,5
ССК, см/с	32,7 ± 5,9	31,7 ± 6,1	23,8 ± 5,9*	29,2 ± 9,5	35,2 ± 6,4
PI	0,7 ± 0,1	0,8 ± 0,1	0,90 ± 0,07#	0,8 ± 0,1	0,8 ± 0,1
Middle cerebralartery					
ПСС, см/с	101,0 ± 7,3	84,9 ± 8,8	81,0 ± 7,1*, л,	99,4 ± 6,4	100,7 ± 7,4
ССК, см/с	65,3 ± 9,3	60,7 ± 7,9	60,3 ± 8,3	65,7 ± 9,7	67,5 ± 8,5
PI	0,70 ± 0,08	0,9 ± 0,1	0,9 ± 0,1#	0,80 ± 0,06	0,90 ± 0,09
Anteriorcerebralartery					
ПСС, см/с	84,6 ± 9,9	78,1 ± 5,6	75,4 ± 9,1	83,6 ± 9,2	86,7 ± 8,3
ССК, см/с	56,8 ± 9,7	53,2 ± 8,7	52,0 ± 9,5	53,3 ± 9,3	57,0 ± 9,5
PI	0,70 ± 0,08	0,80 ± 0,09	0,9 ± 0,1#	0,9 ± 0,1	0,90 ± 0,09
Posteriorcerebralartery					
ПСС, см/с	65,8 ± 10,7	60,5 ± 5,6	59,0 ± 5,8	62,5 ± 5,0	66,0 ± 9,7
ССК, см/с	44,5 ± 8,8	36,8 ± 3,5	35,8 ± 3,5*	37,7 ± 2,8	44,5 ± 3,7
PI	0,80 ± 0,08	0,80 ± 0,07	0,9 ± 0,1	0,9 ± 0,1	0,8 ± 0,1

Analysis of the results of the study showed that as COPD develops, there is an increase in hemodynamic disturbances. According to a number of indicators of Doppler ultrasound, a statistically significant difference between the groups was revealed. There is a significant decrease in blood flow velocity in the internal carotid, vertebral, middle cerebral, posterior cerebral arteries with the progression of the stage of COPD compared with the control group and the comparison group.

Thus, for patients with hypoxic encephalopathy against the background of COPD, the following change in hemodynamic parameters is characteristic: with a decrease in blood flow velocity, an increase in indices characterizing the resistance of the vascular wall occurs (as the pathology increases).

Assessment of the regulation of cerebral blood flow was carried out using a hypercapnic test. The test is based on arbitrary breath holding, which leads to an increase in the content of carbon dioxide in the blood plasma, irritation of the receptors of the carotid sinus zone and smooth muscle elements of the vascular wall occurs, resulting in expansion of the terminal arteries and arterioles, which is accompanied by a general decrease in peripheral resistance and an increase in blood flow in large intracranial arteries.

During the test in subgroup I, the speed indicators increased by 11%, in II - by 6%, in III - by 4.8%. Thus, with the progression of the underlying disease, a decrease in cerebrovascular reserve is noted.

The state of venous blood flow is presented in table. 3. When examining the blood flow velocity in the Rosenthal vein, significantly significant changes were revealed — the velocity increased with the aggravation of COPD. It is known that an increase in the rate of venous outflow through the veins of Rosenthal indicates a difficulty in outflow from the cranial cavity as a whole. The main way of venous outflow is carried out through the superficial veins, when the blood flow through them becomes difficult, the blood flow through the deep veins increases compensatory.

Against the background of the above hemodynamic disorders, as part of complex therapy in the treatment of COPD, the drug diosmin was used, which has a venotonic, angioprotective and anti-inflammatory effect. By increasing the tone of the veins and reducing their extensibility, it contributes to the reduction of venous congestion. Diosmin also enhances the resistance of capillaries, reduces their permeability, naturally improves microcirculation, lymphatic drainage. There is also evidence that the drug diosmin has an evidence base for improving arterial blood flow [4, 8].

Changes in cerebral hemodynamics while taking diosmin are shown in Table. one.

As follows from Table. 1, after treatment with diosmin, patients showed statistically significant dynamics of Doppler ultrasound parameters in the form of improved blood flow in all vascular pools, mainly in the carotid one, indicators of impaired venous outflow, and a decrease in the increased pulsation index.

Thus, against the background of the presence of COPD in a patient, the development of hemodynamic disorders takes place. From the data obtained, it can be seen that the severity of hemodynamic disorders of the brain directly depends on the severity of COPD, while changes are characteristic of both the arterial and venous channels. Against the background of the use of the drug diosmin as part of complex therapy in the treatment of encephalopathy, an improvement in hemodynamics is observed - the blood flow velocity in the carotid and vertebrobasilar pools increases, the velocity in the Rosenthal vein decreases, which proves the possibility of its use as part of therapy in the treatment of encephalopathy against the background of COPD.

4. Conclusion

1. In patients with COPD, there is a violation of cerebral hemodynamics against the background of the progression of the underlying disease.

2. Against the background of the progression of the underlying disease, there is a significant decrease in speed indicators in the intracranial arteries, an increase in blood flow in the deep veins (Rosenthal's vein), thickening of the intima-media complex compared to the control and main groups.

3. When using the drug diosmin to correct cerebral hemodynamics, positive results were obtained - an improvement in arterial blood flow, a decrease in speed indicators in the deep veins of the brain, which helped to level neurological symptoms.

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