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Changes in Cerebral Hemodynamics in Patients Suffering from Chronic Obstructive Pulmonary Disease

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Abstract
The article presents an investigation results of cerebral hemodynamics in 120 patients with Stage 2-4 chronic obstructive pulmonary disease were treated in hospital. It has been performed an ultrasound examination of the vascular system of the head. It has been revealed a decrease in the indices of arterial blood flow and cerebrovascular reserve, difficulty with venous drainage from cranial cavity progressing with the increase of the stage of chronic obstructive lung disease. Besides, the conducted research points to the necessity of an appropriate medicinal treatment administration.

Keywords: chronic obstructive pulmonary disease, cerebral hemodynamics, hypoxia, ultrasound dopplerography.

1. Introduction

Chronic obstructive pulmonary disease (COPD) is one of the most widespread human diseases and is an important medical and social and economic problem of the present time [1]. Recently, massive air pollution with motor transport and industrial emissions, smoking, unsatisfactory social conditions as well as the increase in the number of persons with genetic determination of respiratory organ pathologies have all contributed to avalanche-like increase of COPD incidence [4]. In particular, various researches held in different countries show that this pathology is on average diagnosed in 4-6 % of grown-ups: 14.2 % among smokers, 6.9 % among those having quitted smoking and 3.3 % among those having never been smoking. Nowadays, there are about 600 million people suffering from COPD worldwide [2]. In the period of 2003-2004 COPD sickness rate in Ukraine has increased by 4.8 %, making up 264.3 cases for 100 thousand of the citizens. According to the recent data, the average number of people with this pathology in our country is 10-14 % of the adult citizens of Ukraine that is about 3 million people [4].

In accordance with the modern concepts, one of the most important links of COPD pathogenesis is the brain. Because of its high activity the cerebrum needs much oxygen. In contrast to other organs, the brain has practically no oxygen reserves which could be used for energy production. It explains the fact of high susceptibility of nervous tissue to hypoxia. Hypoxia is a leading factor in the mechanism of cerebral affection that's why adequate blood supply of the central nervous system (CNS) plays a major role in its proper functioning [8].

Nevertheless, there are no data about structural deviations in the brain vessels of people suffering from COPD; any information about their expression and changes depending on the stage of disease is also absent. It is known that in the period of disease exacerbation and progression the increasing hypoxia, intoxication, infectious agent influence upon the vascular wall as well as dyscirculatory malfunctions of a congestive character because of right ventricle deficiency may significantly damage the CNS activity [7]. Thus, patients with decompensated cor pulmonale and severe respiratory failure develop expressed encephalopathy [5]. The extent of cognitive disturbances as well as the character and severity of neurologic deficiency determines the patient's possibility to go on labor activity and to maintain the self-service ability. Investigation of structural changes in arteries supplying the brain as well as detection of the degree of their expression in people suffering from COPD of various stages of chronic cor pulmonale formation are of great interest for clinical medicine [9]. It will assist in administering a proper modifying therapy to such patients, which in its turn will improve their quality of life and disease prognosis [6].

2. Materials and methods

We have examined 120 patients suffering from Stage 2-4 COPD:

- Group 1 comprised 60 patients with Stage 2 COPD (their mean age being 53.38 (±5.1); 20 women and 40 men among them);
- Group 2 – 40 patients with Stage 3 COPD (mean age 55.8 (±5.5); 4 women and 36 men);
- Group 3 – 20 patients with Stage 4 COPD (mean age 58.65 (±8.09); 1 woman and 19 men);
- Group 4 (Control Group) – 25 apparently healthy persons (mean age 54.36 (±3.12); 10 women and 15 men).

Cerebral hemodynamics of all of the patients has been investigated by means of ultrasound dopplerography (USDG) of extra- and intracranial vessels with the help of an apparatus Multigon 500 M (USA) by determining blood flow velocity characteristics (BFV) and pulsatility index (PI). Ultrasound dopplerography has been performed in the following volume: internal carotid artery (ICA), anterior cerebral artery (ACA), medial cerebral artery (MCA), posterior cerebral artery (PCA), vertebral artery (VA), Rosenthal vein (RV), tentorial sinus (TS). Besides, hypercapnia test has been performed by means of 30 seconds' breath-holding.

Statistical processing of the received data has been performed with the help of an application package Statistica 12.0. For evaluation of statistical significance of the index difference among groups, we have used non-parametric Kolmogorov-Smirnov's criterion for comparison of two independent variables; we have also conducted correlative analysis using gamma coefficient. Changes in indices were considered credible on condition that $p<0.05$.

3. Results

The results received in dopplerography examination confirm that the patients with Stage 2-4 COPD have significant changes in a series of indices in comparison with the control group.

Patients with Stage 2 COPD have been revealed to have credible differences in the following indices – left MCA ($p<0.05$), right MCA ($p<0.05$), left ACA ($p<0.05$), right ACA ($p<0.05$), left PCA ($p<0.05$), left VA ($p<0.05$), right VA ($p<0.05$) (Chart 1) in comparison with the control group.

BFV data in other cerebral vessels of the patients with Stage 2 COPD and those of the control group didn't differ considerably. The credible difference in venous blood flow indices in the patients of this group hasn't been revealed either.

The analysis of the investigation results showed an intensification of changes in hemodynamic indices in arterial and venous circulation of the brain with the intensification of respiratory disorders. Thus, blood flow velocity in the intracranial arteries has credibly decreased in patients with Stage 2 COPD in comparison with those of the control group: BFV indices in left ICA and right ICA has decreased in numbers by 1.08 and 1.08, left MCA and right MCA – by 1.01 and 1.04 correspondingly, left ACA and right ACA – by 1.05 and 1.05, left PCA and right PCA – by 1.06 and 1.06, left VA and right VA – 1.14 and 1.2 correspondingly. Against the background of COPD progression the indices of blood flow velocity in deep veins – left RV and right RV – increased in numbers by 1.33 and 1.35 correspondingly; TS – by 1.16. PI MCA increased by 1.13; PI ACA – by 1.16; PI PCA – by 1.1; PI VA – by 1.1 (Chart 1).

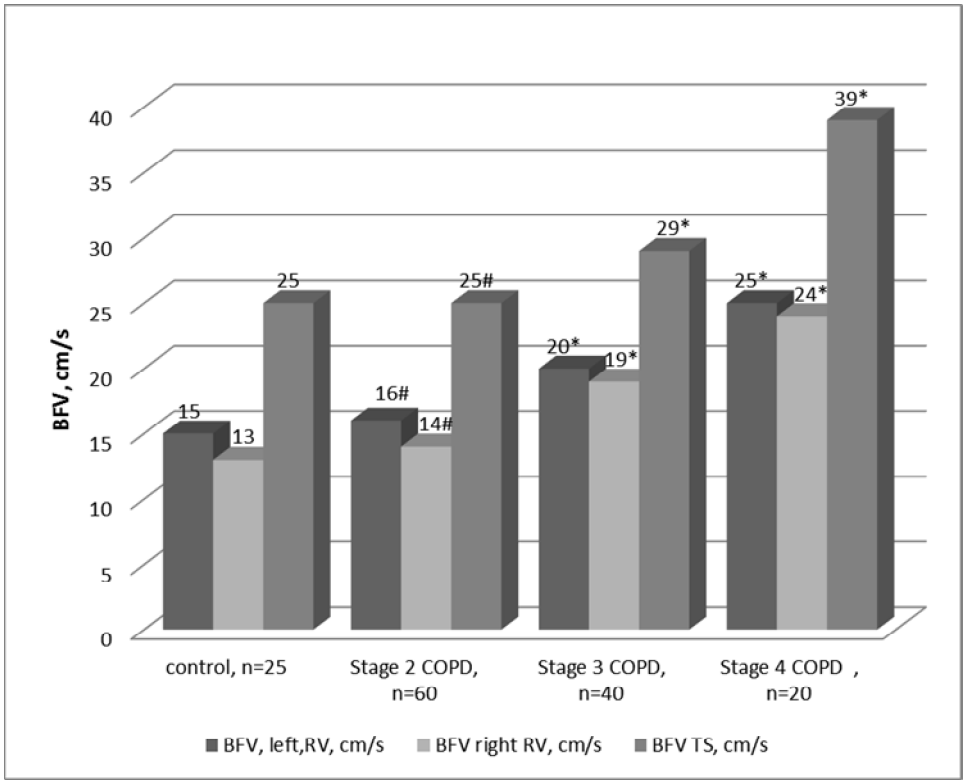
Patient with Stage 4 COPD showed even greater decrease of BFV in arterial bed: left ICA and right ICA decreased by 1.15 and 1.13 correspondingly; left MCA and right MCA – by 1.07 and 1.08; left ACA and right ACA – by 1.07 and 1.1; left PCA and right PCA – by 1.11 and 1.12; left VA and right VA – by 1.21 and 1.25. Blood flow velocity in the deep veins of the brain has credibly increased: left RV and right RV – by 1.66 and 1.66; TS – by 1.56. PI MCA increased by 1.2; PI ACA – by 1.2; PI PCA – by 1.15; PI VA – 1.15 (Chart 1).

The evaluation of cerebral blood flow regulation was conducted with the help of hypercapnic test. The basis of the test is formed by random breath-holding causing the increase of carbon dioxide content in blood plasma, in such a way there is receptor stimulation of sinus carotid area and smooth muscle elements of the vascular wall that results in dilation of the terminal arteries and arterioles which is accompanied by the general decrease of peripheral resistance and increase of blood flow in large intracranial arteries. While performing hypercapnic test linear blood flow velocity normally increases by 20-25%.

While conducting hypercapnic test velocity indices increased by 12% in Group 1, by 7% in Group 2 and by 4.5% in Group 3. Thus, cerebrovascular reserve decreases with underlying disease progression.

Chart 1: Hemodynamic indices of blood flow in intracranial arteries and veins

BFV, cm/s	Stage 2 COPD, n=60	Stage 3 COPD, n=40	Stage 4 COPD, n=20	Control, n=25
Left ICA	45 #	41.5 *	39 *	45
Right ICA	44 #	40 *	38 *	43
Left MCA	55 ^	52 ^	49.5 *	53
Right MCA	53 ^	50 *	48 *	52
PI	0.82 *	0.91 *	0.94 *	0.8
Left ACA	43 ^	40 ^	39 *	42
Right ACA	42 ^	39 *	37 *	41
PI	0.8 #	0.91 *	0.94 *	0.8
Left PCA	35 ^	31 ^	29.5 *	33
Right PCA	33 #	30 ^	28 *	32
PI	0.8 ^	0.9 *	0.92 *	0.8
Left VA	33 ^	27*	25.5 *	31
Right VA	31 ^	25 *	24 *	30
PI	0.8 ^	0.9 *	0.92 *	0.8
Left RV	15 #	20 *	25 *	15
Right RV	14 #	19 *	24 *	14
TS	25 #	29 *	39 *	25



Scheme 1: Comparison of BFV median in patients with various stages of COPD with that of the control group

Note: # - p>0.1 unreliability of the difference between investigation groups and the group of healthy persons, * - p<0.001 credibility of the difference between investigation groups and the group of healthy persons

USDG of intracranial vessels is a quite informative method of diagnostics of functional changes in the vascular blood flow in people suffering from COPD. Consequently, our investigation revealed that with Stage 3-4 COPD aggravation there is a reliable decrease of BFV in the arteries of carotid and vertebrobasilar beds and its increase in cerebral deep veins. It may be connected with the decrease of arterial blood afflux resulting from venous congestion and decrease of cardiac output resulting from the decrease of venous return to the heart because of a precapillary block in the lungs. The main route of venous outflow is made via superficial veins, if blood flow via them hinderds the blood flow via deep veins is compensatory increased.

4. Conclusions

1. Patients with COPD suffer from cerebral hemodynamics disorder against the background of the underlying disease aggravation.
2. Because of underlying disease progression there is a reliable decrease of BFV via intracranial vessels and blood flow increase via cerebral deep veins.

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