

## The Use of Controlled Hardware Ventilation of the Lungs in the Pre- and Post-Covid Period

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The idea of using hypoxic mixtures in medicine was justified by the laureates of the Nobel Prize in Physiology and Medicine in 2019 William Kaelin, Peter Ratcliffe, Gregg Semenza [1]. According to the official wording of the Nobel Committee, the laureates are noted “for the discovery of mechanisms by which cells perceive the availability of oxygen and adapt to it.” As a result of the persistent creative work of engineers and doctors, the OXYTERRA apparatus appeared in Russia - an installation for producing hypoxic and hyperoxic gas mixtures (HYPO-OXY-1), with which it is possible to carry out  $DaO_2$  procedures in sick people - normobaric interval hypo-hyperoxic training. The technique of interval breathing training based on alternating phases with a low oxygen content in the inhaled air (hypoxia simulating high altitude) and phases with a high oxygen content (which increases the training effect of hypoxia, makes the procedure easily tolerable and safe) is implemented in many medical specialties. It is used in obstetrics and gynecology, allergology, respiratory and circulatory pathology, diseases of ENT organs, gastrointestinal tract. The course of treatment consists of 10 - 15 trainings with careful monitoring of the patient’s condition (interval training with reduced (9 - 16%) and increased (31 - 33%) oxygen content in the respiratory mixture). The procedure lasts about 40 minutes each, during which the patient breathes air with different oxygen concentrations through a breathing mask (on average 5 cycles of hypoxia and hyperoxia). The device automatically monitors the pulse and the level of oxygen in the blood. During these procedures, the researchers proved an improvement in the indicators of the functional respiratory system, an increase in the rate of oxygen delivery to the tissues at maximum load, a reduction in the recovery time of the respiratory and cardiac rhythm, an increase in overall performance and economization of respiratory and cardiovascular functions. It has also been proven to increase the oxygen distribution function of blood, the effective functioning of the mitochondrial apparatus of cells when performing a maximum intensity load with a lower pulse cost of pulmonary and systemic hemodynamics.

The method of respiratory training based on compensation of oxygen starvation of the body’s cells in order to enhance restorative functions has become effective for the rehabilitation of patients with pulmonary insufficiency that developed after pneumonia of various genesis, including COVID-19. At the same time, bronchial patency improves due to the removal of the bronchospasm component, the production of surfactant by alveolar cells increases, which prevents the occurrence of atelectasis in the lungs, improves the function of the atrial fibrillation of the bronchi. Increasing the oxygen capacity of the blood optimizes the function of the endothelium of the pulmonary vessels, the processes of oxygen use in the mitochondria, improves the state of myocardial contractility.

The term “post-ovoid states”, despite its manifestations in real clinical practice, is not included in statistical recommendations. According to researchers who have extensive experience in combating this infection, the term “postcovid syndrome” should denote the numerous consequences of the disease of coronavirus (COVID-19) pathology. The authors cite data that up to 20% of people who have had a coronavirus infection suffer from long-term symptoms lasting up to 12 weeks and 2.3% of cases longer [2]. Long-term symptoms include the following problems that occur in waves or on a permanent basis:

- Paralyzing weakness, shortness of breath, incomplete inhalation, apnea, heaviness behind the sternum;
- Headaches, myalgias, neurological and joint pains;
- Loss of sense of smell, phantosmia (possibly associated with damage to the cranial, in particular olfactory nerves), distortion of smell/taste;
- Hair loss, tooth loss, cystic formations in the jaw cavity;
- Vascular and vasculitis manifestations on the skin, other skin reactions (extensive urticaria, capillary nets);
- Sudden jumps in pressure and pulse, arrhythmias, mainly tachycardia (including orthostatic tachycardia), dizziness;
- Cognitive impairment (memory loss, “fog in the head”, disorientation in space, anxiety and panic attacks);
- Gastrointestinal disorder, diarrhea that occurs in waves and does not depend on diet or medication;
- Prolonged subfebrile temperature, sometimes hypothermia, or temperature spikes;
- In rare cases, Guillain-Barre syndrome (acute autoimmune inflammatory polyradiculoneuropathy);
- Numerous other specific symptoms.

The main target of SARS CoV-2 is the lungs. In the pathogenesis of the disease, two mechanisms should be distinguished that mutually burden each other and can lead to the development of acute respiratory distress syndrome, and pathomorphologically - diffuse alveolar damage:

1. Direct viral damage to alveocytes with the development of immuno-inflammatory syndrome;
2. The development of micro- and macrothrombosis of pulmonary vessels and obstructive thromboinflammatory syndrome. Therefore, this condition is called microCLOTS - microCOVID Lung Obstructive Thrombovascular Syndrome [3]. The COVID-19 pandemic has introduced new terms into the circulation of doctors that were not previously familiar. So, when describing radiographs obtained after computed tomography (CT) of the lungs, doctors drew attention to one feature - the effect of frosted glass that occurs in lung tissue affected by inflammation. This term refers to a vague pattern with white specks observed on CT scans of the lungs, which indicates their increased density. In essence, the “frosted glass effect” describes “gray options” between a normal lung scan and a scan of an extremely altered lung that is almost completely white because it is full of pus or fluid. The term originates from old films where scenes were shot through a glass lens, which made the film look hazy. In the pathogenesis and pathomorphology of lung lesions in patients with COVID-19, detected by CT in the form of “frosted glass syndrome”, there may be three processes: 1) inflammation of interstitial lung tissue with elements of vascular microthrombosis, fibrosis and compression of residual air in the alveoli; 2) exudate release into the alveoli with a complete lack of airiness according to the type of classical pneumonia; 3) massive bronchiolar obstruction with impaired ventilation of the alveoli [4].

All the above data indicate that the therapeutic approach to patients with the consequences of a COVID-19 infection should be multifaceted. The rehabilitation direction is of great importance to compensate for all functional damage to organs and tissues. Along with medical support for patients with manifestations of postcovid syndrome, a hardware method of treatment is needed with breathing a gas mixture with a reduced (from 9% to 16%), and then with an increased (37%) oxygen content. In a short period of use, the high clinical effectiveness of the technique used for the rehabilitation of patients with coronary postcovid pathology has been established [5]. Russian domestic medicine is equipped with an effective method of restoring many (including potentially life-threatening) lost body functions in people with complications after SARS-Cov-19 infection. Currently, several patients are conducting a training cycle on the OXYTERRA device to eliminate respiratory discomfort after a viral disease.

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