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# Oxygenation and Brain Diseases

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***Abstract:*** *Oxygen therapy has made great development in the fields of prevention, treatment, and rehabilitation of diseases, and its clinical application is also very extensive. It has been found that oxygen inhalation can treat a variety of brain diseases from various aspects such as blood, metabolism, and cells. In this paper, we will review the previous studies and propose future research ideas based on the potential mechanism of oxygen inhalation through brain structure and brain metabolism in the treatment of various brain diseases.*

***Keywords:*** *oxygen absorption; hypoxia; brain structure; brain diseases*

## 1. Introduction

Oxygen is one of the four elements (sunlight, air, food, and water) that sustain human life, and is not only an energy substance required by the human body but also a raw material necessary for the body to carry out the process of life activities. When individuals are exposed to a particular environment, their oxygen intake cannot reach the basic amount required to maintain the health of the organism (i.e. hypoxia). For high oxygen consumption, the brain with low oxygen reserves has a very weak tolerance to hypoxia. Therefore, a normal supply of oxygen must be maintained to ensure normal physiological functions of the brain. And most of the effects of hypoxia on the human body can be alleviated or completely resolved by oxygen inhalation.

In clinical practice, we classify oxygen into normobaric oxygen (NBO) and hyperbaric oxygen (HBO) according to different pressures. both HBO and NBO can increase blood oxygen content, improve oxygen partial pressure and diffusion rate, improve the body's aerobic metabolic capacity, maintain the integrity of neurons in ischemic brain tissue, rescue acute ischemic brain tissue, reduce lesion volume[1], protect It also improves the safety of delayed thrombolysis with tissue fibrinogen activator in ischemic stroke .

Compared with NBO, HBO not only increases the oxygen penetration capacity, allowing oxygen to reach tissue cells that NBO cannot reach. It also has a bactericidal ability that is unmatched by NBO. Therefore, HBO is widely used in the clinical treatment of various physical and mental diseases and has achieved remarkable results in the treatment of brain diseases. In this paper, we will discuss the relationship between oxygen and the brain from three aspects: brain structure, brain metabolism, and brain function.

## 2. Effects of hypoxia on brain structure

### *2.1. Brain damage due to pathological hypoxia*

Pathological hypoxia includes the following four causes: (1) hypoxia due to the reduced partial pressure of alveolar oxygen or shunt flow of venous blood into arteries; (2) hematologic hypoxia due to reduced oxygen carried by the blood and reduced oxygen content of blood so that hemoglobin-bound oxygen is not easily released; (3) circulatory hypoxia due to impaired blood circulation and reduced blood supply to tissues; (4) Tissue hypoxia due to by impaired oxygen utilization by tissue cells.

### *2.2. Brain damage due to hypoxic environment*

The increase of carbon dioxide concentration in the mine will cause the oxygen concentration to decrease. When the concentration of carbon dioxide reaches 3 ~ 8%, people have obvious discomforts, such as headaches, nausea, and vertigo. When carbon dioxide concentration exceeds 10%, lightning-like ventricular rest occurs. Carbon monoxide poisoning mainly refers to the human body inhaling a large amount of carbon monoxide in a short period, which will lead to a lack of oxygen in human tissues and

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brain without timely treatment, resulting in death in serious cases. As the altitude rises, the atmospheric pressure drops, the partial pressure of oxygen decreases, and the oxygen storage in the body decrease at this time. Compared with the normal population in the plain, the compliance and elasticity of cerebral arteries of people living on the plateau for a long time are reduced, and the peripheral resistance is increased. The high viscosity of blood in plateau people, the slowing down of blood flow, the phenomenon of early aging of cerebral hemodynamics, and the tendency of lumen obstruction and vascular wall damage.

## 3. The effect of oxygen inhalation on brain structure, brain function, and brain metabolism

The two types of oxygen absorption, HBO and NBO, have different characteristics and indications, and different oxygen absorption methods can be selected for symptomatic treatment according to the characteristics of different types of diseases.

### *3.1. Effect of oxygenation on brain structure*

Cerebrovascular disease occurs when circulation is impaired. Cerebral hemorrhage is non-traumatic bleeding caused by the rupture of blood vessels in the brain parenchyma, which occurs mainly due to the lesion of cerebral blood vessels and is the most serious kind of cerebrovascular disease. HBO can decrease the blood flow to the brain tissue around the hematoma, increase the cerebral blood oxygen content, blood oxygen tension and oxygen partial pressure at the capillary arterial end, reduce blood cell and endothelial cell adhesion, and improve microcirculation and blood perfusion at the damage site. Even in the absence of erythrocytes in completely occluded vessels, HBO increases the amount of dissociated oxygen in the plasma and releases oxygen through plasma osmosis. Previous studies have also shown that HBO can promote neovascularization, constrict blood vessels, and accelerate the absorption of hematoma. More animal experiments have shown that HBO can promote the expression of VEGF mRNA, thus increasing the density of neovascularization in the hippocampal region of animals and alleviating brain tissue injury[7] favoring the establishment of collateral circulation in ischemic tissues and promoting faster capillary regeneration, thus promoting the recovery of brain tissue function.

Platelets are extremely important for the hemostatic function of the body, and enhanced platelet aggregation leads to the narrowing of cerebral blood vessels, which is an important cause of ischemic cerebrovascular disease. It has been shown that the platelet aggregation rate, whole blood viscosity, and hematocrit are significantly reduced in elderly people who have undergone HBO, and these changes are beneficial for improving brain function in the elderly. Plasma β-thrombomodulin (β-TG) and platelet factor 4 (PF4) are specific indicators of platelet activation[8], both of which are closely associated with a hypercoagulable state of blood[12][6]. Some investigators have found that HBOT can effectively reduce plasma levels of β-TG and PF4 in patients with early acute cerebral infarction, thereby reducing early neurological deficits in patients [13][10].

The blood-brain barrier (BBB) allows brain tissue to be less or even not damaged by harmful substances in circulating blood, thus maintaining the basic stability of the internal environment of brain tissue, which is biologically important for maintaining the normal physiological state of the central nervous system. Recent studies have shown that the integrity of the BBB plays a crucial role in maintaining the stability of the CNS internal environment[9]. Connexin37 (Cx37) is the most important membrane protein that constitutes the gap junction (GJ), the channel between cells and the fine structure of the BBB, and is important for maintaining the stability of the BBB internal environment. The alteration of BBB permeability after vasogenic brain edema is closely related to the abnormal changes of GJ channels on neuronal cells[2].HBO reduces the permeability of BBB by increasing the expression of GJ protein[14], which achieves the purpose of reducing vasogenic brain edema.

### *3.2. Effect of oxygenation on brain metabolism*

Brain metabolic regulation depends on local metabolites. When the cerebral microcirculation is disturbed, the obstruction of oxygen utilization in brain tissue will lead to the accumulation of H+ in lactic acid, and then the increase of intracellular Na+ will also cause brain cell swelling; at the same time, the increase of Na+ will also activate the intracellular Na+-Ca2+ exchange, resulting in intracellular Ca2+ overload, which will then cause a series of neuronal cell damage, and may even form the edema-hypoxia-edema vicious circle. HBOT can firstly increase the tissue oxygen supply reserve and the number of microvascular openings, and then increase the oxygen uptake rate of brain cells in the acute

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phase, and increase the blood oxygen content in the body, which can rapidly improve the hypoxic state of brain tissues, inhibit the inflammatory response and the impaired energy metabolism, and increase the body's oxygen uptake. energy metabolism disorders, increase the body's oxygen uptake and storage capacity and correct oxygen supply disorders, thus improving metabolic levels .

### *3.3. Effect of oxygenation on brain function*

For patients with traumatic brain injury, oxygenation can improve blood viscosity, restore microcirculation and capillary degeneration in the focal area, and facilitate the removal of hematoma in the focal area; it can also significantly improve the blood supply to the reticular activating system and brainstem, stimulate the excitation of the reticular activating system, restore brain function, and promote the recovery of cognitive function. Previous studies have found that HBO not only improves the brain-somatic physiological capacity of high altitude migrants in human caused by high altitude environments but also improves the attention orientation function of migrants. And long-term NBO also improves the cognitive abilities of individuals [3]-[5][11].

In people without brain injury, oxygenation helps to slow down and delay the process of internal cortical inhibition, which has a role in delaying the onset and development of brain fatigue.

## 4. Conclusions

Although the effects of oxygen therapy on brain disorders have been extensively studied, there are still some shortcomings. First, the current oxygen therapy mainly uses HBO, and fewer studies are using NBO, as well as fewer studies on the combination of the two treatment modalities. Second, at present, oxygen inhalation is mainly applied to the treatment of various diseases in the clinic, and there are fewer studies on healthy people, and future studies can strengthen the research on healthy people. Thirdly, there is less research on the optimal concentration, pressure, duration, and period of oxygen inhalation, and strengthening research on these aspects will help people to use oxygen more correctly and healthily.

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