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ORGANIZATION OF OXYGEN THERAPY USING A NASAL TUBE AND VENTURA MASK IN PATIENTS WITH ACUTE RESPIRATORY FAILURE *(literature review)*

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✓ ***Resume***

Oxygen is transported into the blood by simple diffusion across the alveolar-capillary membrane along a partial pressure gradient. If the oxygen content in atmospheric air is about 21%, the partial pressure of oxygen in the atmosphere is about 150 mm Hg, and in the blood it is about 100 mm Hg. Oxygen is transported by the blood in two forms: dissolved in plasma and bound to hemoglobin. 0.31 ml of O2 dissolves in 100 ml of blood, which is not enough to saturate the tissues with oxygen. Oxygen is mainly transported in red blood cells together with hemoglobin: 100 ml of blood is carried by 200 ml of oxygen. The most important parameter by which the amount of oxygen bound to hemoglobin can be determined is the oxygen saturation of hemoglobin - SaO2 or saturation. The partial pressure of oxygen is 100 mm Hg, and in arterial blood, the oxygen saturation of hemoglobin is about 97%.

Key words: mitochondria, nasal cannulas, anatomical features.

ОРГАНИЗАЦИЯ КИСЛОРОДНОЙ ТЕРАПИИ С ИСПОЛЬЗОВАНИЕМ НАЗАЛЬНОЙ ТРУБКИ И МАСКИ ВЕНТУРЫ У ПАЦИЕНТОВ С ОСТРОЙ ДЫХАТЕЛЬНОЙ НЕДОСТАТОЧНОСТЬЮ *(обзор литературы)*

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✓ ***Резюме***

Кислород транспортируется в кровь путем простой диффузии через альвеолярно-капиллярную мембрану по градиенту парциального давления. Если содержание кислорода в атмосферном воздухе около 21%, то парциальное давление кислорода в атмосфере около 150 мм рт.ст., а в крови — около 100 мм рт.ст. Кислород транспортируется кровью в двух формах: растворенный в плазме и связанный с гемоглобином. В 100 мл крови растворяется 0,31 мл O2, чего недостаточно для насыщения тканей кислородом. Кислород транспортируется в основном в эритроцитах вместе с гемоглобином: 100 мл крови переносят 200 мл кислорода. Важнейшим параметром, по которому можно определить количество кислорода, связанного с гемоглобином, является насыщение гемоглобина кислородом - СаО2 или сатурация. Парциальное давление кислорода составляет 100 мм рт.ст., а в артериальной крови насыщение гемоглобина кислородом составляет около 97%.

Ключевые слова: митохондрии, носовые канюли, анатомические особенности.

Relevance

Pulse oximetry, based on the differences in the absorption of light by hemoglobin depending on the oxygen saturation of hemoglobin, has become a common method for determining SaO2 and detecting hypoxemia. When the amount of oxygen in the blood decreases, the cells of the carotid body of the carotid arteries first react (within milliseconds), which increases pulmonary ventilation and cardiac output. Many compensatory mechanisms are involved in adapting to hypoxia: pulmonary ventilation, cardiac output, stroke volume, hemoglobin concentration, systemic microvascular bed dilation with spasm of the pulmonary bed, an increase in alveolar volume, and spasm of arterioles in the hypoventilation zone to redistribute blood to the lung areas with good ventilation. The development of molecular biology has made it possible to understand the relationship between the physiological physiology of diseases and the cellular response to hypoxia [1,3]. Different tissues have different oxygen requirements; nervous tissue is the most sensitive. The mechanisms leading to hypoxia are different: ischemia (reduced blood supply to tissues), carbon dioxide poisoning, asphyxia, sleep apnea, severe anemia, altitude sickness, and impaired ventilation and perfusion. However, the consequences of hypoxia for tissues are the same. At the cellular level, 80% of oxygen is used by mitochondria, 20% by other organelles [2,5]. At the same time, its partial pressure in mitochondria is very low - 1-3 mm Hg. Oxygen is used as an electron donor at the end of the electron transport chain, in complex IV, in cytochrome-C oxidase, for the synthesis of adenosine triphosphate. When oxygen and its electrons are deficient, the electron chain undergoes compensatory modifications. At the same time, due to a decrease in the flow of carriers under conditions of cellular hypoxia, electrons are directly transferred to the electron chain, thereby increasing the active forms of oxygen and nitrogen [4]. Free radicals are highly toxic and cause cell death. It should be remembered that oxygen therapy is aimed at treating hypoxemia, not dyspnea, and therefore, if the oxygen content in the blood is normal, then dyspnea cannot be expected to be treated in the event of a normal level of oxygen in the blood [6]. In addition, oxygen therapy does not eliminate the cause of hypoxemia. Pulse oximetry should be performed in all patients with shortness of breath or in critical condition to monitor the fullness and timely detection of hypoxemia. Approximately 14% of patients with novel coronavirus infection have a severe form of the disease, the main criterion for severity is a decrease in oxygen saturation in the blood, requiring hospitalization and oxygen therapy. About 5% of all patients (and about 25% of those hospitalized) need to stay in the intensive care unit, which is often associated with the development of acute respiratory distress syndrome[10]. The mechanisms of hypoxemia development in COVID-19 are still being studied, one of the main of which is thrombosis in the microcirculatory bed associated with endothelial damage, which leads to a decrease in blood flow, the development of alveolar atelectasis. In the case of a stable course of the disease, the target values of SaO2 exceed 90%. In the case of severe disease, respiratory failure, shock - the target value of SaO2 exceeds 94%. In this case, oxygen therapy through nasal cannulas or a mask is usually not sufficiently effective, and high-flow nasal therapy or non-invasive positive pressure ventilation with a Ventura mask is preferable. These methods, which were introduced in a timely manner before the COVID-19 pandemic, can reduce the need for intubation and mechanical ventilation (ventilation), and high-flow ventilation through cannulas has advantages over traditional methods. oxygen therapy through cannulas and high-pressure ventilation. Given the shortage of ventilators and intensive care unit beds during the epidemic, the importance of these methods cannot be overestimated. An additional adjunct to oxygen therapy is the prone position (lying on your stomach) [11]. This method improves oxygenation and outcomes in patients with moderate to severe respiratory distress syndrome. The mechanism is likely to be related to improved ventilation-perfusion ratio and opening of collapsed alveoli in the lower basal parts of the lungs. Both pre-epidemic studies in spontaneously breathing hypoxemic patients and studies in patients with novel coronavirus infection receiving oxygen therapy have shown improved oxygenation and reduced intonation requirements. The prone position is well combined with oxygen therapy through cannulas and satisfactorily with mask. It is used in patients who can lie on their stomach for a long time and can independently change body position [8,14]. It is not used in hemodynamically unstable patients with recent abdominal surgery, spinal instability. There is currently no reliable data on the effect of the exact position on the long-term outcome of COVID-19. Given the toxicity of oxygen with a concentration of more than 60%, an air mixture of 40-60% oxygen is used for long-term oxygen therapy. Pure oxygen, when inhaled for more than 30 minutes, has a damaging effect on the mucous membrane of the respiratory tract (tracheitis), in addition, due to the formation of surfactant and impaired resistance, adsorption atelectasis occurs in the alveoli, followed by blood shunting, which does not allow to adequately eliminate hypoxemia. Thus, high concentrations of oxygen are used for a short time in terminal conditions: apnea, hypoxic coma, cardiac arrest, carbon monoxide poisoning. Oxygen therapy is well tolerated, but occasionally dryness and irritation of the nasal and pharyngeal mucosa occur, which can lead to discomfort, limited mobility, and difficulty eating [12,15]. To reduce the drying effect of the oxygen-air mixture on the mucous membrane of the respiratory tract, the oxygen mixture is moistened by passing it through water, and then fed under a pressure of 2-3 atmospheres. The advantage of masks is that they have the ability to overcome the flow of oxygen through the mouth. With the help of valves, exhaled air is released, which allows you to maintain the required oxygen concentration. When using a simple face mask, the oxygen flow can be up to 15 l / min, which provides a higher concentration (50-60%) than cannulae [13,19]. With high levels of lung ventilation, the use of masks and catheters may be ineffective. The mask is the most common method of oxygen delivery. There are different types of masks: Ventura valve mask - a mask with a different valve provides a stable concentration of oxygen regardless of the patient's breathing pattern. The oxygen concentration achieved is 24-60%, depending on the type (color) of the chest valve used, and the flow rate for it is also determined by the type of valve [16,17]. It is often used for COPD, as it allows you to give oxygen in the required concentration, avoiding hypercapnia; Non-return masks (return mask). This allows you to achieve the maximum concentration of oxygen in the mixture you breathe, using a tank bag that is constantly filled with oxygen breathing mixture and, due to the presence of a valve, works only for breathing. Mask valves allow you to exhale, but do not allow outside air to enter the mask. This allows you to achieve an oxygen concentration of 85-90% at a rate of 15 l / min, and is not used for long-term oxygen therapy. Non-invasive ventilation reduces the need for invasive ventilation. It avoids tracheal intubation, thereby minimizing the risk of upper airway injury, avoids the introduction of sedatives, and provides: greater safety and comfort for the patient; preservation of spontaneous breathing; reduction of the risk of ventilator-associated pneumonia; preservation of patient contact; and economic benefits. However, this method is more complex and time-consuming for the physician, as it requires constant adjustment of various parameters to the patient's constantly changing respiratory function [10,11,12,13]. There are also limitations: it cannot be used with a low level of consciousness, anatomical features of the patient; prolonged use of mask ventilation can damage the skin of the face; insufficient humidification and heating of the gas mixture can lead to damage to the mucous membrane of the upper respiratory tract, aerophobia, nausea, burning, individual intolerance (claustrophobia). If non-invasive ventilation is ineffective, timely tracheal intubation and invasive (artificial) ventilation of the lungs are necessary. Consideration of this method is beyond the scope of this review. At home, with a stable course of chronic diseases of the bronchopulmonary system or in the absence of access to a central source of medical oxygen in a hospital (high quality), a medical oxygen concentrator can be used for long-term oxygen therapy. Oxygen cylinders are also used - usually for transporting a patient with hypoxemia to an ambulance team or within a hospital, the duration of inhalation of 40% of the required oxygen concentration is limited to about 20 minutes. Thus, oxygen therapy, despite its centuries-old history of use, continues to develop actively, occupying an important place in the treatment of cardiovascular and bronchopulmonary diseases. Its importance cannot be overestimated - it often allows saving the patient's life, as it is one of the main methods of treating patients with a new coronavirus infection [7,9]. Various aspects of the use of oxygen are described in detail in modern recommendations, indications and application algorithms have been developed. At the same time, a number of controversial issues remain; in some cases, studies are ongoing to confirm the effectiveness of oxygen therapy, while in others it shows its ineffectiveness and even negative effects. Further study of oxygen utilization, including advances in molecular cell biology, as well as the ongoing development of technologies for the production of new devices for oxygen therapy, will help to establish a solid place for oxygen therapy in everyday medical practice [1,3,6].

Conclusion

Oxygen is transported into the blood by simple diffusion across the alveolar-capillary membrane along a partial pressure gradient. If the oxygen content in atmospheric air is about 21%, the partial pressure of oxygen in the atmosphere is about 150 mm Hg, and in the blood it is about 100 mm Hg. Oxygen is transported by the blood in two forms: dissolved in plasma and bound to hemoglobin. 0.31 ml of O2 dissolves in 100 ml of blood, which is not enough to saturate the tissues with oxygen. Oxygen is mainly transported in red blood cells together with hemoglobin: 100 ml of blood is carried by 200 ml of oxygen. The most important parameter by which the amount of oxygen bound to hemoglobin can be determined is the oxygen saturation of hemoglobin - SaO2 or saturation. The partial pressure of oxygen is 100 mm Hg, and in arterial blood, the oxygen saturation of hemoglobin is about 97%.

It is necessary to organize scientific research into the organization of oxygen therapy using a nasal tube and ventura mask in patients with acute respiratory failure.

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