MODERN TECHNOLOGIES AND MANAGEMENT OF AIR_OXIGEN MIXTURE FORMATION IN CPAP DEVICES

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Modern medicine faces unprecedented challenges, in particular, in the field of treatment of diseases of the respiratory system, which are among the most common causes of hospitalization and death in the world. In this context, innovative approaches to lung ventilation are becoming critical for improving patients' quality of life. One of the most effective solutions is the use of CPAP (Continuous Positive Airway Pressure) devices, which maintain constant positive airway pressure. These devices are indispensable for treating obstructive sleep apnoea syndrome and supporting respiratory function in cases of cardiopulmonary failure or other acute conditions.

The operation of CPAP devices is based on the principle of the formation of a stable flow of air-oxygen mixture, which is delivered to the patient. Proper adjustment of the composition of this mixture is extremely essential to ensure the effectiveness of the therapy, prevention of complications and optimal use of resources. Thanks to the rapid development of medical technologies, modern solutions not only enhance the precision of settings but also enable process automation, integration into the overall healthcare facility management system, and remote patient monitoring.

This publication addresses a highly relevant topic, encompassing a wide range of issues from the technical aspects of CPAP device operation to their integration into the digital infrastructure of hospitals and the training of medical personnel for effective use of these innovations.

A CPAP device creates positive airway pressure, preventing airway collapse during inhalation. The primary operational element involves delivering an air-oxygen mixture, which is formed by blending atmospheric air with medical oxygen in specified proportions. The mixture parameters are adjusted either manually or automatically, depending on the clinical case.

The main components of CPAP are the compressor that creates the airflow; oxygen dosing system for the formation of a mixture; filters for air purification; pressure and flow sensors for monitoring the operation of the device.

To form the air-oxygen mixture, proportional gas mixers are employed, which provide automatic oxygen dosing. This allows for highly precise oxygen concentration (FiO2) in the air-oxygen mixture and enables automatic parameter adjustments. Manual adjustment of the oxygen-to-air ratio is used in emergency situations or with portable devices, requiring a high level of expertise from medical personnel and careful monitoring of the patient's condition.

Intelligent dosing systems based on artificial intelligence (AI) algorithms are increasingly used today, offering adaptation to the patient's needs based on their condition. Artificial intelligence algorithms process large amounts of data, including medical history, previous ventilation parameters, blood oxygen level (SpO2),

respiratory rate, and other physiological indicators. Based on this data, the system creates a model that predicts how the patient's body may respond to various ventilation parameters. Sensors of the CPAP machine collect data on the patient's condition in real time, such as the level of blood oxygen saturation, airway pressure, respiratory rate, and the degree of airway openness. Artificial intelligence processes these indicators, analyses trends and determines the need to adjust parameters. The algorithm can automatically adjust the pressure in the airways to prevent them from closing (apnoea), the ratio of oxygen and air in the mixture to ensure the optimal level of oxygen saturation, the rate of air supply depending on the patient's activity level, allowing to avoid undesirable conditions such as hypoxia (lack of oxygen) or hyperoxia (excess oxygen). Artificial intelligence is able to detect patterns that indicate approaching critical conditions, for example, sudden deterioration of respiratory function or sleep apnoea. Based on these forecasts, the device can warn medical personnel in advance or independently activate the necessary operating mode. IoT technologies allow remote control of CPAP machines using web interfaces or mobile applications used to monitor and adjust parameters. Cloud services can send notifications about technical malfunctions, reduced performance or the need for device maintenance. Patients using CPAP at home can be monitored remotely by doctors, which is especially important for patients with chronic conditions.

Hospital Management Systems (HMS) automate key processes for real-time monitoring of CPAP device operations, including the storage of operational parameters (pressure, flow, oxygen concentration) and their transmission to a unified hospital database. This functionality enables medical staff to respond promptly to changes in patient conditions. The systems also ensure the automatic recording of CPAP usage data for each patient, facilitate therapy efficiency analytics to identify optimal treatment protocols, and optimize device utilization. The integration of CPAP devices into hospital management involves the implementation of technologies that enhance the efficiency of CPAP usage, synchronize them with the overall healthcare facility infrastructure, reduce patient service time, ensure personalized treatment, and promote effective resource utilization. This integration improves the quality of medical services, reduces costs, and creates a comfortable environment for both patients and medical staff. Modern technologies in CPAP devices provide high treatment efficacy for patients with respiratory disorders and open new opportunities for innovation in healthcare.

References: 1. Shevchenko A.I. (2023) Strategy for the Development of Artificial Intelligence in Ukraine: Monograph / Ed. by A.I. Shevchenko. Kyiv: IPSHI, 2023. 305 p.