

THE EVOLUTION OF ARTIFICIAL LUNG VENTILATION

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Artificial lung ventilation (ALV) is an essential medical intervention for patients experiencing acute respiratory failure, enabling them to maintain adequate oxygen levels and reducing stress on their breathing muscles. The evolution of ALV exemplifies ongoing advancements in bioengineering and medicine, driven by the desire to enhance patient care and well-being. From rudimentary and cumbersome devices, modern ALV machines have evolved into sophisticated systems capable of personalized and precise respiratory support. This progress is not only a testament to technological innovation but also reflects a deepening understanding of lung function, respiratory diseases, and the physiological effects of mechanical ventilation. Key milestones in medical history, such as polio epidemics, wartime injuries, and the emergence of resuscitation medicine, have directly influenced the development and refinement of ALV technologies. By examining the historical context and key stages of ALV evolution, we can better appreciate current achievements and identify promising avenues for future research in this critical field [1].

Initial attempts to create mechanical ventilation devices were associated with the development of devices operating on the principle of negative pressure. The most famous example is the “iron lung” device, which appeared in the early 20th century [2]. This device created negative pressure around the patient's chest, simulating the natural process of inhalation. “Iron lungs” were widely used during the polio epidemic to support the breathing of patients with paralysis of the respiratory muscles. Despite their effectiveness, these devices had a number of significant drawbacks, such as bulkiness, discomfort for the patient, and limited access to the body for medical procedures. In addition to the basic principle of creating negative pressure, the design of artificial lung ventilation devices (ALVs), known as “iron lungs”, evolved, offering different models

such as the Drinker and Emerson. These models differed in the materials used (mainly steel and rubber) and the mechanisms of the valves and pumps that provided rhythmic pressure changes. The use of these devices went beyond the treatment of poliomyelitis, also covering cases of botulism and other neuromuscular diseases leading to paralysis of the respiratory muscles. The care of patients with a tracheostomy on an ALV was a complex task, requiring constant attention and specialized skills of medical personnel. It is necessary to note the significant social and psychological impact of prolonged stay in an “iron lung”, which could lead to isolation and depression in patients. In the history of medicine, there are cases of patients who spent decades in them, adapting to unusual living conditions. In parallel with the use of AVL, manual ventilation methods were used, but they were labor-intensive and not suitable for long-term life support. Attempts to modernize the design of the “iron lungs” were aimed at increasing the comfort and efficiency of patients, but no significant breakthroughs were achieved in this area.

The emergence of positive pressure ventilators (PPVs) was a significant breakthrough in the field of respiratory support [3]. These devices deliver air directly to the airways, creating positive pressure in the lungs and ensuring their expansion. The first positive pressure devices were developed during World War II to treat wounded patients with chest and lung injuries. In the 1950s, more advanced models such as the Bird Mark 7 appeared, which became widely used in clinical practice. As technology and understanding of respiratory physiology advanced, ventilators became more sophisticated and functional. In the 1970s, volume-controlled ventilators emerged, allowing more precise control of air delivery to the lungs, as well as modes such as Intermittent Mandatory Ventilation (IMV), which facilitated weaning of the patient from the ventilator.

In the 1980s, the advent of microprocessors ushered in a new era in ventilator development [4]. Microprocessor control allowed for more flexible, precise, and functional devices. Today’s ventilators from leading manufacturers such as Hamilton Medical, Dräger, GE Healthcare, Philips, ResMed, and Mindray are high-tech systems that can precisely adapt to individual patient needs. In recent years, there has been a focus on developing lung-protective strategies to minimize ventilator-induced lung injury (VILI). Modern ventilators actively use artificial intelligence and machine learning to automatically adjust ventilation parameters,

predict complications, and adapt to changing patient needs. Artificial intelligence algorithms allow you to analyze large amounts of data and make decisions aimed at optimizing respiratory support.

Modern ventilators are complex and multifunctional systems that can precisely adapt to the individual needs of the patient and provide optimal respiratory support [5].

In conclusion, it should be noted that the evolution of ventilators demonstrates a continuous desire to improve respiratory support. From bulky “iron lungs” to modern high-tech systems equipped with artificial intelligence and protective ventilation strategies, each stage of development brought new opportunities and solutions to existing problems, which led to a significant improvement in the treatment outcomes of patients with respiratory failure.

Future research is aimed at developing more advanced lung protection strategies and personalized approaches to respiratory support. Prospects for the development of ventilators are associated with the integration of artificial intelligence, the creation of non-invasive methods and portable devices for providing care to patients outside the hospital. This will expand the possibilities of respiratory support and improve the quality of life of patients with respiratory failure.

References

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