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Clinical Application of Intelligent System of Weaning from Mechanical Ventilation

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Abstract. Long-term mechanical ventilation is associated with many complications. Intelligent weaning from mechanical ventilation system benefits patients with mechanical ventilation, especially those who have difficulty in weaning from ventilation. It is another great progress in the application of artificial intelligence in medical practice.

1. Introduction

Mechanical ventilation is the important measure to support patients in intensive care to ensure the safety and patients in general anesthesia. It is also the treatment of chronic obstructive pulmonary disease (COPD) such as respiratory failure and myasthenia gravis, but prolonged mechanical ventilation can bring many patients with physical and mental damage, and increased mortality, prolonged hospitalization, increased hospitalization expenses and medical resources. Most patients who receive mechanical ventilation therapy have postoperative acute respiratory failure, pneumonia, congestive heart failure, sepsis, trauma or acute respiratory distress syndrome, etc [1]. Therefore, timely identification of offline indicators and early separation from mechanical ventilation support are of great significance. However, inappropriate early weaning can also increase the respiratory burden of patients, which may lead to respiratory failure and require re-intubation.

Therefore, how to evacuate mechanical ventilation in time, safely and effectively is a highlight issue in the field of critical care medicine. The traditional process of weaning from mechanical ventilation is decided by doctors. Due to the influence of personal experience, ability, preference and other factors, the criteria for doctors to identify and judge offline and the offline methods adopted by doctors vary. The sensitivity and specificity of predicting successful off-line outcomes were also low. A recent systematic evaluation by Blackwood et al. shows that compared with the conventional offline mode, the mechanical ventilation time, offline time and ICU hospitalization time of the planned offline unit all decrease significantly [2]. Programmatic intelligent weaning, as a method of planned weaning, has its effects on the weaning process of patients with mechanical ventilation. This article discusses the basic principle and clinical application of intelligent weaning system.

2. Ventilator and Weaning from Mechanical Ventilation

Ventilator is a device that can replace, change or control normal physiological respiration of human beings, improve respiratory function, provide oxygen and remove carbon dioxide by adjusting respiratory frequency, tidal volume, airway pressure and other respiratory parameters, and reduce respiratory work consumption and heart reserve capacity [3]. It not only plays an important role in



major hospitals, as a necessary respiratory support equipment for clinical practice, but also walks into the home of patients with respiratory diseases as a representative. Ventilator off-line refers to the process of gradually lowering the level of mechanical ventilation, so that patients can gradually recover their independent breathing and finally get out of the ventilator. The current understanding of weaning is not that of the strict sense of weaning in the past, that is, the patient is completely separated from the ventilator, but the whole process from the lowering of ventilator support conditions to the complete offline extubation is understood as offline, which is more in line with the pathophysiological process [4].

3. Predictors of Weaning from Mechanical Ventilation

The timing of weaning is now quite arbitrary. The first text book on mechanical ventilation, published in 1965, stated that clinicians needed clinical experience and made a lot of judgment to understand the appropriate timing of ventilator withdrawal. As a rule, evacuation should begin as soon as possible [5]. Timely off-line treatment can significantly reduce the mortality of hospitalized patients in intensive care unit, reduce the risk of complications of mechanical ventilation, shorten hospitalization time and reduce medical costs. Therefore, clinicians should actively minimize the duration of mechanical ventilation. According to research statistics [6, 7], about 15% of patients who stop mechanical ventilation need to be reintubated within 48 h, and the failure rate of extubation in ICU varies greatly. The average failure rate of extubation in surgical ICU is 5%~8%, while that in medical or neurological ICU can be as high as 17%. However, 40 to 60 percents of patients who unexpectedly extubate themselves prematurely do not require re-intubation, so finding the time to go offline is particularly important. Currently, the commonly used weaning criteria include: controlled etiology of respiratory failure, stable hemodynamics, oxygenation index > 200 when positive end-expiratory pressure ventilation is less than or equal to 5 cmH₂O (1 cmH₂O = 0.098kpa), and no sedative or opioid receptor drugs were applied [8]. Clinically, it is difficult to specify the starting time of weaning. In the past, only auxiliary/control mode was used, and weaning was simple to stop auxiliary/control ventilation. Therefore, the starting time of weaning is very clear. In the past 10 years, pressure support, synchronous intermittent command ventilation and other auxiliary breathing modes have emerged. Both respiratory therapy and weaning from ventilation can adopt the auxiliary breathing mode, so it is very difficult to determine the starting time of weaning from ventilation. Theoretically, it can be considered that the primary pathogenesis requiring respiratory treatment is basically controlled, and auxiliary respiration can be considered as an offline process, but there is no physiological or clinical indicator as the limit [9, 10].

4. Principles of Intelligent Weaning from Mechanical Ventilation

The intelligent offline machine USES closed-loop control principles for basic operations, such as detection of respiratory signals, generation of inspiratory pressure and inspiratory flow, and more complex functions, such as adjusting inspiratory pressure through breathing to achieve the set tidal volume (dual control mode). These ventilators can also provide patterns or strategies for incorporating patient responses into ventilator management using more advanced closed-loop systems. Closed loop control and respiratory tact can feedback patients' vital signs and adjust selected parameters to meet the needs of individual patients [11]. At the same time, the closed-loop system is expected to improve the tolerance of mechanical ventilation, reduce respiratory work, and improve the synchronicity between ventilator and patients. The intelligent ventilator modifies the ventilator parameters by operating the predetermined algorithm, and adjusts the ventilator output by comparing the measured value (actual value) of specific parameters with the target value (ideal value). The closed-loop system can reduce or amplify the difference between the measured value and the target value by negative feedback. Patients who need ventilator support will be transferred from control mode to support mode. Automatic weaning from mechanical ventilation will be realized gradually. The schematic diagram is as follows. (Figure 1)

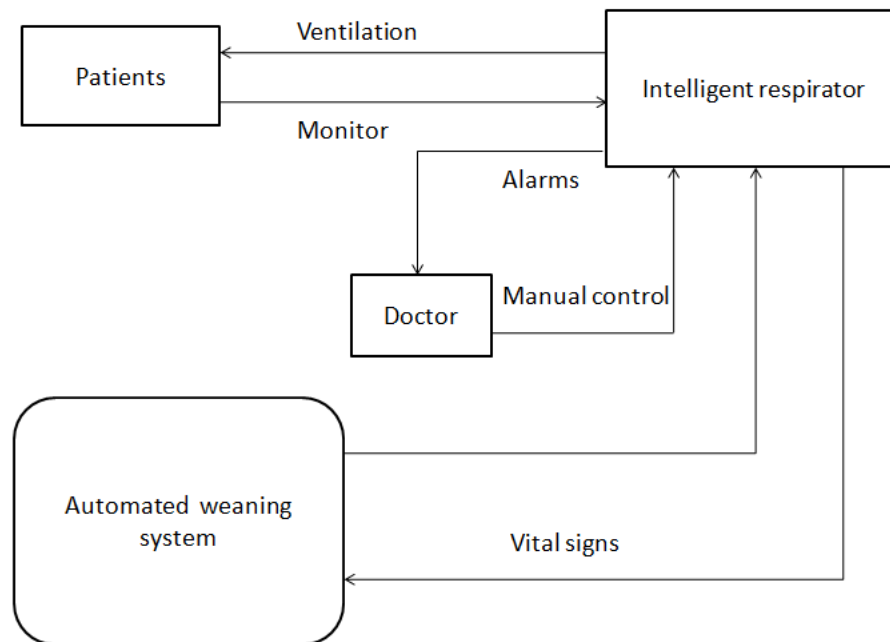


Figure 1. The mechanism of intelligent system of weaning from mechanical ventilation

5. Conclusion

In recent years, the use of mechanical ventilation has increased significantly, weaning from mechanical ventilation has been the focus and highlight of mechanical ventilation research, and the number of clinicians skilled in nursing these patients (mainly intensivists, anesthesiologists, respiratory doctors) has stagnated. Projections for 2020 indicate that the number of long-term mechanical ventilation (96 hours) will more than double compared with 2000. At the same time, prolonged mechanical ventilation accounts for one-third of adult mechanical ventilation and two-thirds of hospital resources. In fact, mechanical ventilation has recently proved particularly costly [12, 13]. Studies have shown that the prognosis of patients in ICU is directly related to the workload of staff [14]. Intelligent offline greatly reduces the burden of medical staff, such as it can adjust the support level according to the patient's end-expiratory carbon dioxide situation, so it greatly reduces the number of medical staff to collect arterial blood gas analysis.

Studies show that intelligent offline system can shorten the hospitalization time, save manpower and material resources. In addition, difficulties in implementing knowledge in clinical practice are recognized and decreased, and promoting automation is also conducive to solve this problem [15]. For some patients, offline is very difficult, mainly including COPD, chronic heart function, etc. Inappropriate opportunity of extubation makes breathing burden heavier, leading to fatigue and respiratory failure again, which may lead to re-intubation. Delayed weaning off ventilator may produce a variety of complications. The intelligent ventilator can make a series of feedback adjustments according to the specific conditions of patients, so that mechanical ventilation can be as close to physiological respiration as possible. The damage to patients can be reduced. All in all, intelligent weaning from mechanical ventilation is the inevitable trend in the future, the system is not very perfect at present, but the research has been carried out and will be widely used in the future.

6. References

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