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History of Mechanical Ventilation

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Review Article

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Abstract

Background: In neuromuscular diseases, mechanical ventilation can be used to assist weakened respiratory muscles or compensate for a loss of respiratory control. A return on History may let understand the different strategies for using non-invasive and invasive of mechanical ventilation.

Methods: A literature review was carried out from the PubMed, google scholar and the archives of the medical library of Descartes in Paris with the following key words "history" "mechanical ventilation" and "neuromuscular diseases".

Results: France has played a major role in the development of mechanical ventilation at home. It was one of the first countries to set up a truly organized and efficient charging system. Today, the French system allows care to be taken care of at home, with genuine coordination between the hospital department, the equipment distribution network, the attending physician, the nurses, the physiotherapists, the patient and his family.

Conclusion: Despite improved respiratory care, especially with the introduction of mechanical ventilation, there is a disparity in the management of respiratory care in the world.

Keywords: History; Neuromuscular Diseases; Respiratory care; Mechanical ventilation

Abbreviations: ALLP: Association lyonnaise de logistique post-hospitalière; HMV: Home mechanical ventilation; MV Mechanical ventilation; NMD: Neuromuscular diseases; PEP: Positive expiratory pressure; ANTADIR: Association nationale pour les traitements à domicile, les innovations et la recherche

Introduction

In neuromuscular diseases, the degenerative muscular involvement causes a mechanical alteration of respiratory pump, bringing into may be the death [1]. Mechanical ventilation can be used to assist weakened respiratory muscles or compensate for a loss of respiratory control in these patients [2]. Actually, mechanical ventilation is the gold standard for the management of respiratory problems in patients with NMD [1,2]. It allowed has improved the life expectancy of certain diseases [3-5]. Cough assistance tools are also proposed for change to facilitation of the expectoration of secretions [6-8]. Two methods of long-term HMV can be distinguished: non-invasive ventilation (NIV) which encompasses all ventilation methods which use interfaces with the upper airways and invasive ventilation (IV), which requires

tracheostomy [9-11]. Switched to IV is appropriate when non-invasive methods are inefficient, or if they are highly dependent on the ventilator and have bulbar dysfunction, requiring aspiration despite adequate cough assistance [10-12]. However, invasive ventilation as a strategy for long-term ventilation remains discussed. This is may be partly due to a lack of knowledge on the history of ventilation and its introduction. The aim of this study was to describe the history of mechanical ventilation and methods in patients with neuromuscular diseases requiring MV.

Historical-Chronological Context

En 1907, Henrich Dräger, un fabricant allemand crée «le Pulmotor» (Figure 1), un appareil de ventilation dédié aux personnes asphyxiées [13]. This apparatus is supplied by a bottle of compressed air, in which the increase of the pressure inside the inspiratory circuit actuates a system of connecting rods animated by a bellows and closes at more than 20 cm H_2O the arrival of the gas enabling thus expiration [14]. At the beginning of the XXth century, poliomyelitis epidemic affected the United States, particularly to 1916 New York, causing more than 27,000 victims, including 6,000 deaths [15].

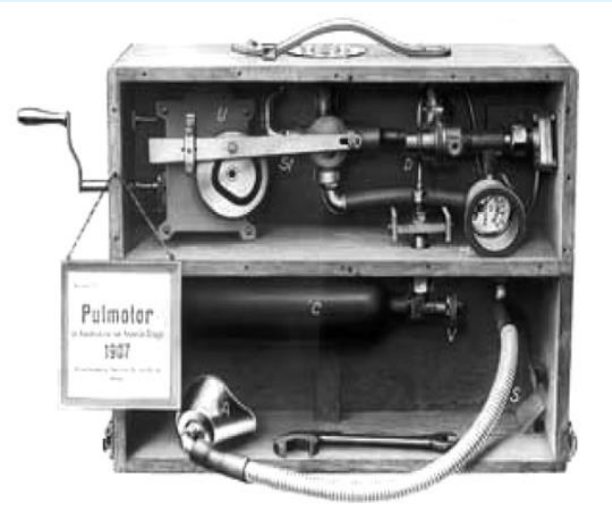

Figure 1: Pulmator of HenrichDräger, 1907.

In 1929, Phillip D & Louis S [16] of Children's Hospital in Boston invented and used a non-invasive mechanical ventilation machine called the "Iron Lung" for the first time in a child with respiratory failure (Figure 2). This device reveals some immediate clinical benefit, with improvement of vital functions and survival in these children [16]. The Iron lung is a sealed metallic cylinder capable of causing the respiratory movements of the patient by creating a negative pressure inside the cylinder. The patient was to enter completely into this cylinder, leaving only the head out. However, effectiveness of this ventilation technique was limited in the case of pharyngolaryngeal paralysis or in the absence of control of airway secretions. About 80% of the cases, which mainly concerned children and young adults, did not survival.

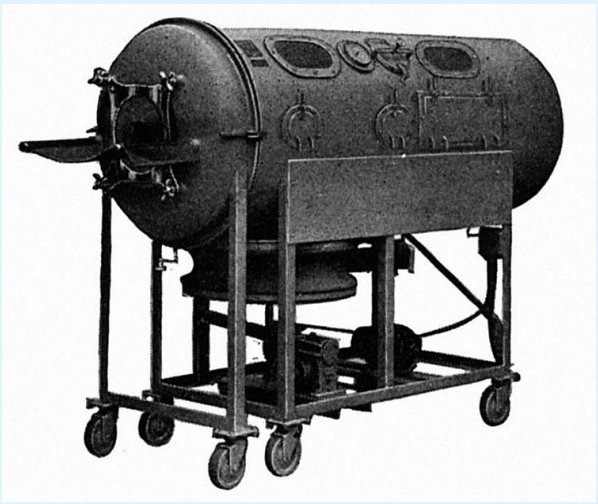

Figure 2: Irong lung of Drinker & Shaw, 1928.

During the 1950s, the polio epidemic spread to Europe. In front of this disease, which is cause for permanent respiratory paralysis leading to death, terror and fear had spreaded at all sections of the population, whether in Europe or the United States [17]. In 1949, a French center for the treatment of polio sequelae was created at the Raymond Poincaré Hospital, headed by André G [18]. Patients were described with lung involvement leading to respiratory assistance by lung of steel or with a cuirass [18].

In 1952, doctors Henry L [19] and Bjørn Ibsende of the Copenhagen hospital decided to use a technique that had already proven itself in heavy surgery [19]. This technique involves introducing a tube into the patient's trachea to bring air into the lungs by manual pressure on a ventilation balloon with a mixture of air and oxygen. This technique had as main advantage the management of the airway secretions by the tube, but two major disadvantages, the patients had to be assisted 24/24H (i.e. medical staff, they had to take turns, for manually ventilate the patients) and there was a risk of infection. Thereafter, doctors used an old technique: tracheotomy which is a surgical incision of the trachea in which a cannula is inserted (Figure 3).

Figure 3: Tracheotomy in pigs, Andréas Vésalius, *De Humanicorporisfabrica*, (1515-1564).

The advantages were the management of airway secretions by endo-tracheal aspiration and the introduction of a cannula over a long period. With the introduction of penicillin, the risk of infection by the opening of the airways change to was considerably decreased. From then on, efforts focused on the development of more sophisticated artificial respirators via the tracheotomy cannula. In 1954, the team of Engström CG [20] developed the first electric fan called "Engström 150". This technique allowed ventilation through the tracheostomy cannula with predetermined air-flow with frequency between into 10 and 30 cycle/min [20]. This rather restrictive technique rapidly imposed the development of apparatuses to ensure a continuous ventilation. In addition, these devices were only usable in hospitals. So, the first works to transfer the respiratory support technologies from the hospital to the home were carried out. At the same time, two poliomyelitis vaccines were developed: Jonas Salk in 1955, developed an inactivated vaccine administered intramuscularly, and one vaccine from Albert Sabin in 1961, an oral attenuated vaccine for eradicated this epidemic [21]. However, the sequelae and urgency of the patients still affected by this pathology, still facilitated research into new ventilators Directed by Professor Paul S [22], the first fully mechanical ventilators, were manufactured by Drs. Vincent and Jandeau from an electric wiper motor of Citroën 2 CV [21]. These new devices envisaged the return patients at home. The East Radcliffe, in England, also operated with an electric motor and a weight for the compression of the air blown into the lungs. Despite the great progress, the adaptation of these two techniques to the home of the patients was still problematic. In particular, in terms of monitoring, oxygen supply, autonomy and airway secretions management.

To address at problem of the patient's return home, the Lyons Association for the Control of Poliomyelitis (ALLP) are created in 1954, under the guidance of Professor Paul Sédaillan [22]. As a result of hospital treatment, several patients were transferred to their homes with these devices. As the month progressed, doctors, patients and their famailies realized that mechanical ventilation at home was a more economical and they also contributed to improvement the vital prognosis (absence of nosocomial infections in the home) and quality of life of affected subjects. Subsequently, many technological advances have been made: the introduction of positive expiratory pressure (PEP) and barometric ventilation modes. The introduction of electronics has improved the performance of the devices, a better cycle, improved tolerance, but also better monitoring with using alarms of ventilator. The addition of batteries also allowed greater mobility and autonomy for the patient. Other devices has allowed to embarked the ventilator on a wheelchair and so to allowing the patient to leave their home.

In view of the increasing number of respiratory inadequacies and a more organized management, a convention was signed with the Social Security in 1974. This agreement consists in providing the patients with a refund on the basis of a daily fee. In 1981, the National Association for the Treatment of Respiratory Injuries (ANTADIR) was created, in order to extend the associative model to all regions [22]. However, in the same year, a prospective study by Stauffer and Al examined the risks associated with tracheotomy and suggested a significant rate of comorbidity (for example, with hemorrhage and infections higher than 30% and of tracheal stenosis rates above 50%) and the high mortality rate due to these complications [23]. To compensate for this, in the early 1980s, the nasal mask of ventilation was created. This revolutionary non-invasive technique allows the use of a respirator without having to introduce foreign material into the patient's body. These non-invasive methods have contributed to the increased of use to mechanical ventilation at home, to compensate for sleep disorders. In particular, it has been extended to patients with sleep apnea syndromes from the late 1980s [24,25]. Since 1990, mechanical ventilation at home has been strongly established in Europe. The effectiveness of home ventilation techniques and their socio-economic relevance have largely contributed to their development in France but also throughout Europe.

Conclusion

Despite improved respiratory care, especially with the introduction of mechanical ventilation, there is a disparity in the management of respiratory care in the world. In France, for these patients, medical care is free and caregivers can be trained in endotracheal aspiration. This simplifies the return at home of tracheotomized patients. Unlike the Anglo-Saxon countries, where non-invasive ventilation techniques are preferred, including in the most dependent patients because they are need a 24 hours a day, of nurse at home of the patient.

Author Contributions

G. Boussaïd designed the study, wrote the manuscript, and are the guarantors of the paper. All authors critically revised the manuscript, read the final version, and approved its submission for publication.

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