The Journal of Critical Care Medicine 2020;6(3):143-145

EDITORIAL

DOI: 10.2478/jccm-2020-0027

Mechanical Ventilation – A Friend in Need?

Bianca-Liana Grigorescu*

Department of Pathophysiology, George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Targu Mures, Romania

Received: 14 July 2020 / Accepted: 17 July 2020

The development of modern medicine has imposed a new approach both in anaesthesiology and in intensive care. This is the reason why, in the last decades, more and more devices and life-support techniques were improved in order to achieve the highest medical outcomes.

Key features of the critically ill patient are severe respiratory, cardiovascular or neurological derangements, often in combination, reflected in abnormal physiological observations. All these changes converge towards the establishment of pulmonary or extrapulmonary respiratory failure requiring mechanical ventilatory support. In the current conception, mechanical ventilation does not represent a curative method for respiratory pathology, however, it represents a bridge therapy ensuring the rest and preservation of respiratory muscles, improves gas exchange and assists in maintaining a normal pH until the recovery of the patient [1].

Despite decades of research, there are limited therapeutic options directed towards the underlying pathological processes and supportive care with mechanical ventilation remaining the cornerstone of patient management.

Mechanical ventilation is one of the most used short-term life support techniques worldwide for a broad spectrum of pathologies, from surgical to nonsurgical critically ill patients or multiple organ failure [2,3]. The underlying pathophysiological mechanism leading to multiple organ failure is mitochondrial disfunction secondary to oxygen delivery impairment. In critically ill patients heart-lung interactions, hemodynamic and respiratory imbalance are the leading causes for tissue hypoxia and oxidative phosphorylation impairment. The consequence is an important decrease in ATP production with deleterious effects on cell metabolism leading to organ failure, including respiratory muscle weakness. This is a vicious cycle, which, in the absence of appropriate supportive measures, leads to death.

Oxygen delivery impairment and hypoxia were the most important targets in respiratory management for decades. The first attempt for intubation and mechanical ventilation was attributed to Vesalius, in the 16th century. However, the golden era for this life-saving advanced support was inaugurated in early 1950^{s} during the poliomyelitis epidemics. The development of the first mechanical ventilators and blood gas analyzers, represented a giant step forward in intensive care, with a remarkable decrease of mortality in poliomyelitis patients from 87% to 40% [1,2]. Shortly after, a major development in mechanical ventilation was the use of positive end-expiratory pressure (PEEP) and the use of new pressure modes of ventilation (pressure-controlled ventilation and pressure support ventilation). The aforementioned modes of ventilation remain preferred by intensivists worldwide to the present day. In other terms, we can say "this was the beginning of a beautiful friendship between man and machine". Nowadays, we cannot imagine a modern ICU without performant, user-friendly ventilators with advanced monitoring functions, which are able to provide mechanical support as close as possible to respiratory physiology.

An epidemiological study reveals that in the United States approximately 310 persons out of 100,000 undergo invasive mechanical ventilation for nonsurgical indications, meanwhile in Israel 8,4% of the population in Jerusalem area received respiratory support [3]. The most common indications were neurological status impairment, hypoxemic and/or hypercapnic respiratory failure, severe trauma, cardiac failure, acute respiratory distress syndrome (ARDS) and chronic obstructive pulmonary disease (COPD) exacerbation. Mechanical ventilation supports gas exchange, maintains acid-base balance, and alleviates the work of breathing associated with an acute pulmonary or systemic injury, without being considered a unimodal treatment for acute respiratory failure [1]. It represents only a small part of

* Correspondence to: Bianca-Liana Grigorescu, Department of Pathophysiology, George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Targu-Mures, Romania. E-mail: biancagrigorescu20@yahoo.com

a complex life support strategy related to etiological treatment, sedation management, minimizing complications, avoiding ventilator associated pneumonia and sarcopenia. In recent decades, a better understanding of the physiology of mechanical ventilation, its associated hemodynamic consequences and the development of an advanced cardio-pulmonary monitoring system, changed the idea that the main goal of this respiratory supportive therapy is to normalize blood gas levels and their alveolo-capillary exchange. For many years, intensivists were focused on hypoxia related to respiratory failure and mitochondrial disfunction leading to multiple organ failure. Mechanical ventilation allows for an increase in the fraction of inspired oxygen from 0.21 to 1.0 leading to an improvement in tissue oxygen supply.

Although the improvement in tissue oxygenation has been remarkable, high oxygen levels have toxic effects. Even if hyperoxia rapidly corrects arterial oxygenation in patients without large shunt, it has some harmful hemodynamic effects like decreasing cardiac output and parasympathetic tone, increasing vascular resistance with cerebral and coronary vasoconstriction. These hemodynamic changes have the potential to aggravate an underlying cerebral or cardiac disease, resulting in poor outcomes in critically ill patients. In pulmonary regions with low ventilation-perfusion ratio, hyperoxia can lead to reabsorption atelectasis, which imposes higher levels of PEEP followed by a negative impact on right ventricular afterload [2]. Some studies revealed that mechanical ventilation and PEEP application could negatively affect coronary perfusion, but high PEEP levels do not worsen myocardial contractility and stroke volume [4].

An important goal in the early phase of mechanical ventilation is adequate sedation with or without muscular blockade, to avoid “fighting with the ventilator”; lung-protective ventilation can be aided by using neuromuscular blockers [1]. Patient-ventilator dyssynchronies were frequently associated with poor outcomes [2]. One of the most important issues related to sedation is when, how long and what we use to achieve the best outcomes. The use of sedatives with long half-lives or their slow metabolism may prolong the duration of mechanical ventilation, leading to respiratory muscle disfunction and atrophy, followed by a difficult weaning.

Prolonged mechanical ventilation injures the respiratory muscles and the diaphragm. Ventilator-induced diaphragm disfunction (VIDD) is a pathological condition that occurs in critically ill patients secondary to diaphragm inactivity during mechanical ventilation, leading to its rapid atrophy and contractile dysfunction [1,5]. VIDD occurrence in mechanical ventilated patients represents a challenge for intensivists, due to difficulties related to weaning from the ventilator. After years of research in this field, muscle protective ventilation strategies represents the best choice for maintaining optimal levels of inspiratory muscle effort and preventing patient-ventilator dyssynchronies [1,5].

A major challenge for intensivists remains the mechanical ventilation of patients with ARDS, for which low lung compliance requires high ventilation pressures accompanied by a high risk of barotrauma. Current protocols recommend protective and ultraprotective mechanical ventilation using low tidal volumes and optimal PEEP [2]. An important step in the history of mechanical ventilation was represented by the ventilatory assistance of COPD patients, where air-trapping phenomena prevail. Aggressive mechanical ventilation of COPD patients could lead to vitally impactful respiratory and hemodynamic imbalances. Recent studies found that these same protective and ultraprotective methods of mechanical ventilation should also be applied in patients without ARDS, in the ICU or undergoing major surgical procedures, even in brain-dead potential donors [2]. Thus, the concept of mechanical ventilation receives a new meaning, that of ”a friend in need is a friend indeed”, accompanying the intensivist towards assisting the critically ill patient to functional recovery.

The year 2019 represented a turning point in re-evaluating the importance of invasive mechanical ventilation in the context of the current SARS-CoV-2 pandemic. With a faster pace than the previous severe acute respiratory syndrome (SARS) in 2012 and Middle East respiratory syndrome (MERS) in 2013, the Coronavirus disease 2019 (COVID-19) took the world by storm. Its clinical spectrum is wide, with patients developing severe respiratory imbalances, as well as other organ dysfunctions [6]. The challenge was and still is represented by the insufficient number of mechanical ventilators, as well as, adaptation of the protective and ultraprotective ventilation protocol to an extremely vulnerable category of patients suffering from an insufficiently known pathology. A recent study describing Wuhan's experience with the COVID-19 pandemic suggests using the same protective ventilation protocol from ARDS [6]. A question in need of a solution from intensivists reffers to microcirculatory blood flow. Microcirculatory alterations induced by severe inflammation concur with alterations in oxygen extraction capabilities by tissues and contribute to imbalances between ventilation and perfusion relationships, thus to development of multiple organ dysfunction [7].

The advantages and disadvantages of invasive mechanical ventilation opened the way for researching towards wider recommendations regarding noninvasive ventilation, as well as, personalised mechanical ventilation.

Taking into consideration the current context, mechanical ventilation is best described by ”a friend in need is a friend indeed”, coming along on the professional path ”for better, for worse”.

Conflict of interest

None to declare.

Bibliography

1. Gologher E.C., Ferguson N.D., Brochard L.J., et al. Clinical challenges in mechanical ventilation, Lancet 2016; 387: 1856-66.
2. Tài Pham, Brochard L.J., Slutsky A.S., Mechanical Ventilation: State of the Art, Mayo Clin Proc. 2017;92(9):1382-1400.
3. Zisk-Rony R.Y., Weissman C., Weiss Y.G., Mechanical ventilation patterns and trends over 20 years in an Israeli hospital system: policy ramifications, Israel Journal of Health Policy Research, 2019; 8:20.
4. Grubler M.R., Wigger O., Berger D., et al., Basic concepts of heart-lung interactions during mechanical ventilation, Swiss Med Wkly. 2017; 147:w14491
5. Schepens T., Dres M., Heunks L., et al., Diaphragm-protective mechanical ventilation, Curr Opin Crit Care. 2019 Feb;25(1):77-85.
6. Lingzhong Meng, Haibo Qiu, Li Wan, et al., Intubation and Ventilation amid the COVID-19 Outbreak, Wuhan's Experience, Anesthesiology, 2020; 132:1317-32.
7. Ospina-Tascón, G.A., Bautista, D.F., Madriñán, H.J. et al. Microcirculatory dysfunction and dead-space ventilation in early ARDS: a hypothesis-generating observational study. Ann. Intensive Care 10, 35 (2020). https://doi.org/10.1186/s13613-020-00651-1.