J Bras Pneumol. 2020;46(4):e20200282
https://dx.doi.org/10.36416/1806-3756/e20200282

EDITORIAL

COVID-19 pandemic and mechanical ventilation: facing the present, designing the future

Marcelo Alcantara Holanda[1,2], Bruno Valle Pinheiro[3,4]

Mechanical ventilation (MV) is essential for sustaining life in cases of severe respiratory failure. The origins of MV date back to the 16th century, when Vesalius described the technique in the book *De Humani Corporis Fabrica*. Negative pressure ventilators were developed in the late 19th century, whereas invasive MV, as we know it, emerged in response to the 1952 poliomyelitis pandemic in Denmark. At that time, anesthesiologist Bjorn Ibsen used tracheostomy and manual positive pressure ventilation in patients with severe forms of the disease and respiratory muscle paralysis, reducing the lethality from 97% to 40%.[1,2] Thereafter, MV came to be recognized as a life-saving technique, and its history is comingled with that of ICUs.[1,2] It has since evolved from a support basically aimed at normalizing gas exchange to a technique capable of doing so, without damaging the lungs, without compromising the physiology of the cardiovascular system or that of other organs, and without causing diaphragmatic dysfunction, thus ensuring the resolution of the underlying disease, providing good patient-ventilator synchrony, and reducing the need for sedation.[1] After almost 70 years, MV is now facing its biggest challenge: the new coronavirus disease 2019 (COVID-19) pandemic. Poliomyelitis was accompanied by respiratory acidosis due to neuromuscular failure, whereas pneumonia by the new coronavirus causes severe damage to the lung parenchyma and severe hypoxemia, which is often refractory to usual interventions, in 10-20% of the cases.[3]

A few months after the first case of COVID-19 was reported in China, the disease was declared a pandemic, and more than 6.9 million confirmed cases and 400,469 deaths had been reported as of June 8, 2020.[4] By that same date, 645,771 confirmed cases and 35,026 deaths had been reported in Brazil, which thus came to rank third in terms of absolute number of deaths worldwide.[4] These numbers, which had been reached in such a short time, show the high contagiousness of the virus that causes COVID-19, designated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Although severe forms of the disease occur in only a small fraction of patients, the absolute numbers of such patients are considerable and could eventually cause the collapse of health care systems. The most critical structural limitation is the shortage of ICU beds and mechanical ventilators, ventilatory support being at the heart of the problem. In addition, there are restrictions on the use of noninvasive ventilation and high-flow nasal cannulas due to the risk of aerosolizing the virus into the environment and infecting members of the multidisciplinary team or other patients. Patients with COVID-19 can require MV for two to four weeks. In addition, complications, such as ventilator-associated pneumonia, pulmonary thromboembolism, delirium, and patient-ventilator asynchrony that is difficult to resolve, can increase morbidity and mortality.[3,5] The challenges for providing MV safely include maintaining the supply of materials, such as personal protective equipment, MV accessories (such as filters and circuits), and medications (for sedation, analgesia, and neuromuscular blocks), as well as the need for support from clinical engineering services.

Errors in adjusting the mechanical ventilator can cause serious iatrogenic complications and increase the risk of death, whereas the use of MV with the appropriate settings reduces mortality, the occurrence of complications, the number of days on MV, the length of ICU stay, and hospital costs.[6] In recent decades, technological advances, including the emergence of equipment incorporating microprocessors, different ventilation modes, and advanced features, have led to significant improvements in mechanical ventilators, although such ventilators have human-machine interfaces that are more complex, which has complicated their use.[7] Along with these advances, the learning process and management of these machines have become more difficult for students, residents, and other health professionals.[7,8] Because of the COVID-19 pandemic, thousands of new ICU beds have been created and similar numbers of new ventilators have been acquired throughout the country. Consequently, there is a shortage of staff specialized to work in that context. Although recent graduates have been called in to work on the front lines, they lack the necessary knowledge, training, and experience to manage different types of ventilators in complex cases. It is to be expected that inexperienced professionals feel insecure and have difficulty applying the best evidence-based practices and interventions recommended in protocols and guidelines by the major medical societies. Therefore, there is a high risk of deviations from established practices.[3,8]

Coping with this wartime scenario is characterized by a set of measures taken in order to mitigate the risks and reduce the lethality of COVID-19. Such measures include promoting broad access to digital training (courses and virtual simulators) on using MV[9]; enabling access to telemedicine; supporting the development and manufacture of mechanical ventilators with technology that is more accessible, making them easier to use, and that are not dependent on components and materials

1. Disciplinas de Pneumologia e de Terapia Intensiva, Universidade Federal do Ceará, Fortaleza (CE) Brasil.
2. Escola de Saúde Pública do Ceará Paulo Marcelo Martins Rodrigues, Fortaleza (CE) Brasil.
3. Disciplina de Pneumologia, Universidade Federal de Juiz de Fora, Juiz de Fora (MG) Brasil.
4. Coordenação da UTI, Hospital Universitário, Universidade Federal de Juiz de Fora, Juiz de Fora (MG) Brasil.

Figure 1. A physiotherapist wearing a prototype of a helmet-type system developed specifically for coping with COVID-19. The helmet allows the application of positive pressure around the head by means of a mixture of high flows of compressed air and oxygen, enabling an FiO_2 of up to 100% and continuous positive airway pressure of up to 18-20 cmH_2O, minimizing the risk of air leakage into the environment. Source: Personal archive of Holanda MA.

that must be acquired from the international market; making efforts to restore old, inoperative ventilators and to adapt portable ventilators or ventilators used in anesthesiology; creating safe hospital environments for the use of noninvasive ventilation and high-flow nasal cannulas in negative-pressure isolation rooms, if possible; and searching for alternatives to noninvasive ventilatory support, reducing the risk of infection of the health care team and the pressure for indicating tracheal intubation as the first treatment option in the event of oxygen therapy failure (Figure 1).[10] Research funding agencies, universities, industry sectors, medical societies, and other entities have united around these measures, quite often in a supportive and altruistic way, and that is commendable.

This is a historical moment because awareness has been raised and there have been paradigm shifts regarding the role of mechanical ventilatory support in health care systems. Accessibility, expertise, technology, innovation, usability, training, excellence, safety, effectiveness, low cost, equity, and universality are some of the concepts that permeate the role of MV in health care policies worldwide.[11,12] It is certain that there will be new catastrophes and pandemics in the future and that the health of millions, perhaps billions of people, will be seriously affected. Contingency plans for current and future threats to global health, especially infections and respiratory diseases, should guide and enable universal access to safe, high-quality ventilatory support, even in regions with limited financial resources.[11,12] The challenges have been set; it is up to us to face them in the present as we build the foundations for a promising future for MV in Brazil and in the world.

REFERENCES

1. Slutsky AS. History of Mechanical Ventilation. From Vesalius to Ventilator-induced Lung Injury. Am J Respir Crit Care Med. 2015;191(10):1106-1115. https://doi.org/10.1164/rccm.201503-0421PP
2. LASSEN HC. A preliminary report on the 1952 epidemic of poliomyelitis in Copenhagen with special reference to the treatment of acute respiratory insufficiency. Lancet. 1953;1(6749):37-41. https://doi.org/10.1016/S0140-6736(53)92530-6

3. Berlin DA, Gulick RM, Martinez FJ. Severe Covid-19 [published online ahead of print, 2020 May 15]. N Engl J Med. 2020;10.1056/NEJMcp2009575. https://doi.org/10.1056/NEJMcp2009575
4. World Health Organization [homepage on the Internet]. Geneva: World Health Organization; [cited 2020 Jun 8]. Coronavirus disease (COVID-19) pandemic [about 9 screens]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019?gclid=Cj0KCQjww_f2BRC-ARIsAP3zarGPN3jVnt36qWvYS5TZ54HLi_8KsVwBpxNq4sEQsXCJ6_Vb7b_zsRoaArIBEALw_wcB
5. Richardson S, Hirsch JS, Narasimhan M, Crawford JM, McGinn T, Davidson KW, et al. Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area [published correction appears in doi: 10.1001/jama.2020.7681]. JAMA. 2020;323(20):2052-2059. https://doi.org/10.1001/jama.2020.7681
6. Mechanical Ventilation Committee of the Brazilian Intensive Care Medicine Association; Commission of Intensive Therapy of the Brazilian Thoracic Society. Brazilian recommendations of mechanical ventilation 2013. Part I. J Bras Pneumol. 2014;40(4):327-363. https://doi.org/10.1590/S1806-37132014000400002
7. Kacmarek RM. The mechanical ventilator: past, present, and future. Respir Care. 2011;56(8):1170-1180. https://doi.org/10.4187/respcare.01420
8. Tallo FS, de Campos Vieira Abib S, de Andrade Negri AJ, Cesar P Filho, Lopes RD, Lopes AC. Evaluation of self-perception of mechanical ventilation knowledge among Brazilian final-year medical students, residents and emergency physicians. Clinics (Sao Paulo). 2017;72(2):65-70. https://doi.org/10.6061/clinics/2017(02)01
9. Lino JA, Gomes GC, Sousa ND, Carvalho AK, Diniz ME, Viana Junior AB, et al. A Critical Review of Mechanical Ventilation Virtual Simulators: Is It Time to Use Them?. JMIR Med Educ. 2016;2(1):e8. https://doi.org/10.2196/mededu.5350
10. Patel BK, Kress JP, Hall JB. Alternatives to Invasive Ventilation in the COVID-19 Pandemic [published online ahead of print, 2020 Jun 4]. JAMA. 2020;10.1001/jama.2020.9611. https://doi.org/10.1001/jama.2020.9611
11. Guérin C, Lévy P. Easier access to mechanical ventilation worldwide: an urgent need for low income countries, especially in face of the growing COVID-19 crisis. Eur Respir J. 2020;55(6):2001271. https://doi.org/10.1183/13993003.01271-2020
12. World Health Organization. Medical devices: managing the mismatch: an outcome of the priority medical devices project. Geneva: World Health Organization; 2010.