Official journal of the Spanish Society of Chemotherapy

Update in SARS-CoV-2 pneumonia

Federico Gordo[1,2]
Laura Parro[1]
Mohamed Mohamed[1]

Ventilation support in SARS-CoV-2 pneumonia. Strategy and indications

[1]Intensive Care Unit. Hospital Universitario del Henares. (Coslada-Madrid), Spain. Study group of infections in critically ill patients (GEIPC-SEIMC).
[2]Grupo de Investigación en Patología Crítica. Facultad de Medicina. Grado de Medicina. Universidad Francisco de Vitoria (Pozuelo de Alarcón-Madrid), Spain

Revista Española de Quimioterapia
doi:10.37201/req/s01.12.2022

ABSTRACT

The SARS-CoV2 pandemic has generated a need for knowledge, new concepts in pathophysiology and an increase of the use of respiratory support in highly complex patients. This fact has provoked the need to evolve to the concept of personalized ventilatory support according to the patient's response to treatment.

Keywords: personalized mechanical ventilation, COVID-19, ARDS, protective ventilation.

INTRODUCTION

Ventilatory support in SARS-CoV2 pneumonia is not very different from ventilatory support in acute respiratory distress syndrome (ARDS) with different etiology. Although multiple controversies have been generated, what is clear is the need to evolve towards adequate high-level ventilatory support where we can manage patients in a personalized manner, applicable both to COVID-19 pneumonia and to any etiology of ARDS.

As in other pathologies, in ARDS the same treatment should not be indicated in all disease spectra, nor in different patients due to individual variability, nor in each patient throughout the time of disease progression. The concept of phenotypes and even chronotypes has been highlighted and the appropriate therapy should be assessed in each case. It is equally important to minimize management differences between prescribers and adopt homogeneous objectives and criteria by creating respiratory management protocols that ensure a common strategy.

The important idea to conveyed in this article is the evolution of mechanical ventilation towards high-level personalized respiratory support. This will consist of individualizing the application of ventilatory modes, parameters (not only PEEP), non-ventilatory therapies and oxygenation systems, evaluating changes in response without forgetting the critical patient on mechanical ventilation is a dynamic patient.

Correspondence:
Federico Gordo
Intensive Care Unit. Hospital Universitario del Henares. (Coslada-Madrid), Spain
E-mail: fgordo5@gmail.com

DEFINITION OF ARDS

Berlin's definition (2011) to categorize ARDS based on the degree of hypoxemia [1], showed by the PaO_2/FiO_2 ratio, has been widely used to guide the management of SARS-CoV-2 patients. However, this definition has been shown to be limited for the adequacy of respiratory therapies. This idea had been previously expressed by different authors who advocate redefining distress and establishing the ventilatory strategy, not only considering oxygenation but also stratifying severity by considering lung compliance and alveolar dead space [2]. In this way we can establish different treatment strategies, using the appropriate PEEP in each patient, the appropriate tidal volume, as well as noninvasive ventilatory support strategies and extracorporeal techniques.

PATHOGENESIS OF ARDS IN COVID-19

ARDS caused by SARS-CoV-2 behaves like a traditional acute respiratory distress syndrome (hyaline membranes, progression through pathologic stages...) with a key role in intravascular immuno-thrombosis [3] and alteration of the hypoxic pulmonary vasoconstriction reflex [4]. This means that hypoxemia is not only related to pulmonary mechanics and decreased compliance but also due to the imbalance in the ventilation/perfusion ratio (V/Q) that leads to situations of very severe hypoxemia difficult to manage.

A study shows how virus involvement in extrapulmonary areas can also affect gas exchange. COVID 19 infiltration of carotid body receptors [5] that stimulate the respiratory center in response to hypoxemia was evidenced. This could explain both the abnormal response to hypoxemia ("happy hypoxemia") and the increase in inspiratory drive.

Inspiratory drive increases transpulmonary pressure and could explain the phenomena of pulmonary rupture and mediastinal emphysema evidenced in these patients, generating lung damage and complicating the mechanical ventilation management.

PHENOTYPES

Stratification of patients into different phenotypes is necessary. Two phenotypes were initially established [6]: Type L (low) and Type H (high) referring to two forms of presentation of ARDS. Type L where the imbalance in V/Q ratio predominates, with a significant increase in alveolar dead space as a cause of hypoxemia. And Phenotype H characterized by alteration of respiratory mechanics with loss of pulmonary compliance and increased CT involvement. Each phenotype would require a different ventilatory strategy.

However, it could not be two different forms of presentation but different stages that may be produced by different reasons, for example, start or not of noninvasive support. According to a recently published article [7], phenotype is not the only important thing but also the pattern the patient will develop throughout the evolution of the disease.

MORTALITY IN MECHANICAL VENTILATION

The mortality of patients on mechanical ventilation has been high. Some studies [8] estimate an overall mortality of 52%, reflecting a large variability between different hospitals that cannot be explained by factors inherent to the patients themselves. It is postulated that factors such as the structural organization of the intensive care units, the availability of qualified personnel (nursing and physiotherapy care), the prevention of associated infections, as well as the adequate and early respiratory support with an early strategy of prone ventilation may have an influence.

HIGH-LEVEL PERSONALIZED VENTILATORY SUPPORT

We recommend a treatment using a strategy of pulmonary and diaphragmatic protection, individualizing and selecting the ventilatory parameters according to the mechanical characteristics of the lung. Adequate sedation strategy that allows optimal synchrony patient-ventilator, proper selection of PEEP and tidal volume offering protective ventilation. In this way we manage to avoid lung damage which could affect the prognosis of the patients.

There is a pyramid of respiratory support. In critically ill patients, invasive mechanical ventilation is essential. Moreover, there is a whole spectrum of respiratory support treatments with oxygenation systems (conventional and high flow), non-invasive mechanical ventilation and support with extracorporeal techniques such as extracorporeal membrane oxygenation (ECMO) and extracorporeal CO_2 extraction ($ECCO_2R$).

Based on evidence, we recommend developing a protocol where the first step is to provide noninvasive ventilatory support. We recommend using a combined strategy, high-flow nasal cannula (HFNC) associated with continuous positive airway pressure (CPAP), to reduce the problems of each technique and reduce the failure rate. Perkins et al [9] demonstrated the superiority of CPAP over HFNC to improve oxygenation. Many patients benefit from the use of both techniques with suitable monitoring using the ROX index [10] and the HACOR score as predictors of therapy failure. But the most important aspect is the monitoring of tachypnea and increased work of breathing in patients.

Early identification the patients who require endotracheal intubation and invasive mechanical ventilation is really fundamental. The classic criteria for intubation include hypoxemia with cardiovascular dysfunction, low level of consciousness and, perhaps the most important, inability to maintain the necessary work of breathing. The indication for intubation should be individualized, without forgetting the pulmonary collapse due to disease progression.

During invasive mechanical ventilation, it is essential to use a protective ventilation strategy that minimizes lung stress, strain and strain rate, looking for the minimum driving pressure with a homogeneous ventilation [11]. In this respect it is recommended to use a five-pillar protocol: first make a pulmonary mechanics diagnosis; PEEP titration to choose the most appropriate level based on the best global compliance, and in selected cases use Electrical Impedance Tomography (EIT) to monitor regional changes (Figure 1); then adjust ventilation to the minimum tidal volume and driving pressure. Work of breathing should be measured and alveolar dead space monitored using capnography; and finally assess the possibility of respiratory drive by closely monitoring of airway occlusion pressure (P0.1) [12].

A PEEP level should be selected according to the patient's need at each specific phase of the treatment. Based on the evidence, the level of PEEP will vary over time, depending on the phase of the disease and the treatment strategies employed.

All of that should be adjusted according to the patient's characteristics. In patients with morbid obesity or elevated intra-abdominal pressure these protective limits can be exceeded.

The protocol should consider early application of prone position to improve the oxygenation and also in situations of low pulmonary compliance. Prone is considered the treatment of choice for severe refractory hypoxemia [13] in patients with a PaO2/FIO2 ratio less than 150 mm Hg or decreased lung compliance, clearly improving patient mortality. Prone position is the great lung recruitment maneuver.

Prone awake has also been discussed as another option in the management of these patients, although there is still

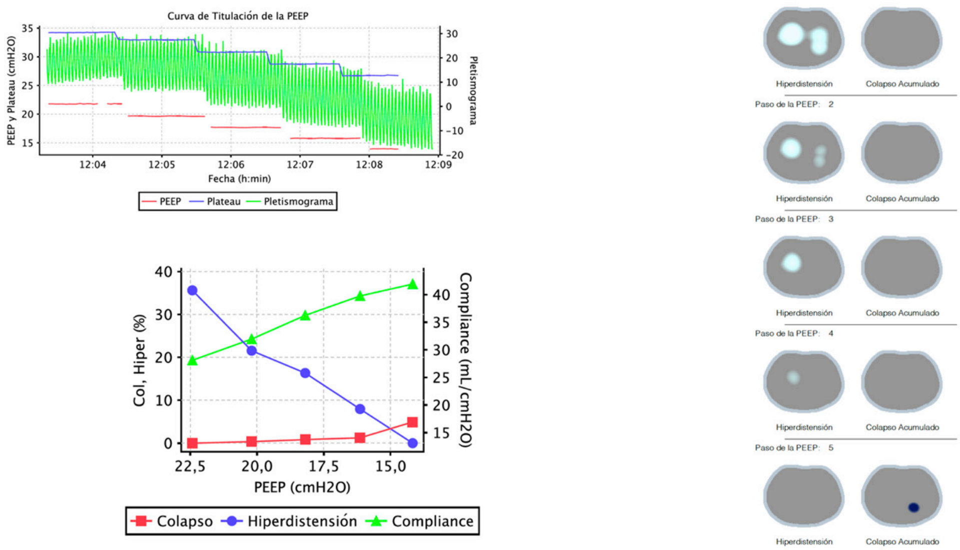

Figure 1 | **Pulmonary mechanics with PEEP titration by impedance tomography looking for the balance between pulmonary recruitment and overdistension.**

no high-quality evidence available to make a generalized recommendation. Ehrmann et al. [14] suggest it can improve oxygenation with a very low complication rate in selected patients with close monitoring. There are no clinical trials demonstrating that prone awake can truly decrease intubation rates and improve patient outcome and mortality.

If despite protective mechanical ventilation strategy and prone maneuvers we do not obtain the desired results, we have the option of ECMO. We must consider that patients who require ECMO are patients with high mortality because they did not respond to prone position. A Spanish case series study has been published [15] based on an observational cohort study that confirms a high mortality of patients receiving ECMO, up to 60%.

A promising technique in refractory cases is extracorporeal CO_2 extraction ($ECCO_2R$) [16]. It is a feasible technique using low blood flows that may represent a new therapeutic option combined with a protective and personalized ventilation strategy.

Another important aspect in the management of this type of patient is the work carried out by physiotherapists in ICU through respiratory rehabilitation and early mobilization, treatment by nursing staff in the prevention of infection, psychological support for patients, as well as treatment plans at discharge from ICU.

CONCLUSIONS

ARDS caused by COVID-19 pneumonia behaves similarly to distress of other etiology. Nevertheless, it presents particularities that require an individualized treatment strategy following a well-defined protocol. Mechanical ventilation conditions prognosis and mortality in these patients. It is recommended that the ventilatory strategy be dynamic during evolution and individualized to the requirements of each patient. It is essential to pay attention to the pillars of protective ventilation (tidal volume, lung distension pressure, respiratory drive...) avoiding pulmonary overdistension as a cause of avoidable damage. The treatment of lung collapse is basic, find the optimal PEEP at each moment and valuing the early prone as the main recruitment maneuver. To achieve this, measurements of pulmonary mechanics and continuous monitoring by capnography or impedance tomography are the basis for decision making.

In our clinical practice [17] all this should be included in a unit protocol that minimizes variability among professionals and ensures continuity of care. The protocol should also include as important aspects the high qualification of the nursing staff to avoid infections, respiratory physiotherapy, humanization and follow-up after discharge from ICU.

CONFLICTS OF INTEREST

Authors declare no conflicts of interest

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