Ventilator management recommendations in COVID-19

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In December 2019, a new pandemic surfaced caused by a new virus known as severe acute respiratory syndrome coronavirus 2 and new disease COVID-19, reported at first in Wuhan, China. By April 27, 2019, according to data by the WHO, there were 2,878,196 confirmed cases worldwide, with the US being the most affected with over 1 million cases alone. In the same period of time, 198,668 deaths have been registered, and over 907,000 have recovered around the world. In Mexico, reports show 15,529 confirmed cases and 1434 deaths.

Coronaviruses are a very diverse group of viruses, of the RNA type. The clinical picture of COVID-19 is characterized by fever, headaches, cough, fatigue, myalgias, diarrhea, vomiting, and laboratory alterations such as lymphopenia, neutrophilia, elevated AST levels, troponin I, bilirubin, reactive protein C, ferritin, and D-dimer. Laboratory studies are linked to the development of an acute respiratory distress syndrome (ARDS). A high fever (39°C) and the use of methylprednisolone are associated with a lower mortality¹.

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Patients with a COVID-19 infection present data of hypoxemic acute respiratory failure, bearing in mind that of the different mechanisms of hypoxemia, the short circuit is the only one that does not respond to high FiO_2 , and this is the main pathophysiological mechanism of the hypoxemia caused by COVID-19. Next, there is an extensive pulmonary damage, observing pneumocyte desquamation and the formation of hyaline

membranes, pulmonary edema, and inflammatory mononuclear interstitial infiltration, mainly lymphocytes, all compatible with ARDS, and thus unresponsive to an oxygen supply. When beginning with high flow (PNAF or puritan) and a persistence of hypoxemia ($\text{SpO}_2 < 90\%$ and $\text{PaO}_2 < 60$ mmHg), orotracheal intubation ought to be taken into consideration over non-invasive mechanical ventilation due to the risk of droplet dispersion. Once intubated, I recommend the following initial parameters for ventilator management among these patients: assist-control volume ventilation (ACV), with tidal volume (TV) of 6 ml/kg or less predicted body weight ($[\text{size in cm} - 152.4 [0.91] + 45.5$ in female and $+ 50$ in male), positive end-expiratory pressure (PEEP) 10 cm H_2O , respiratory rate (RR), the closest to the RR before intubation, FiO_2 at 100%, and a peak inspiratory flow rate (V_{max}) necessary to maintain an I:E relation of 1:2. I recommend beginning with ACV since it is the only modality that in each breath delivers the predetermined volume, thus avoiding secondary damage from a volume > 6 ml. I suggest starting with a PEEP of 10 cm H_2O since it allows for better ARDS scrutiny and classification². After setting initial parameters in the ventilator, we ought to take arterial blood gas at 30 min and classify ARDS with the Berlin criteria³. If it is mild ($\text{PaO}_2/\text{FiO}_2 < 300$ and > 200), leaving PEEP at 8 cm H_2O , if moderate ($\text{PaO}_2/\text{FiO}_2 < 200$ and > 100) with the PEEP at 12 cm H_2O , and if it is severe ($\text{PaO}_2/\text{FiO}_2 < 100$) maintain PEEP at 16 cm H_2O ⁴. We must repeat this after 30 min with FiO_2 at 100%. In cases, in which the patients with severe and moderate ARDS, where $\text{PaO}_2/\text{FiO}_2$ stays at < 150 mmHg, the following actions should

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Figure 1. Algorithm 1. ACV: Assist control volume; DP: driving pressure; MP: mechanical power; PEEP: positive end expiratory pressure; Ppl: plateau pressure; RR: respiratory rate; TV: tidal volume.

be performed: place the patient in the prone position⁵ and begin infusion of a muscle relaxant (cisatracurium 50-100 mg in 100 ml of saline solution 0.9%) for 24 h and administer methylprednisolone at 0.5 mg/kg of pre-determined weight every 12 h at the moment of hospital admission or dexamethasone 8 mg through IV every 12 h. Moreover, these patients, despite the fact that they may have a low or high compliance, may become over-distended with PEEP; hence, we suggest that if PaCO₂ increases 5 mmHg, subsequent to setting the PEEP at a determined number due to the severity of ARDS despite maintaining RR, TV, and decrease PEEP at 2 cmH₂O like suggest the algorithm in figure 1 (Fig. 1).

There are other methods for PEEP titration, such as the FiO₂/PEEP adjustment, better compliance, EXPRESS protocol, and the stress index, which have been evaluated in comparative studies, without finding evidence that one study is better than the other. However, in a study conducted by me⁴, where we evaluated

these same methods of PEEP titration and the use of lung ultrasounds to assess overdistention, we found that a PEEP of 8, 12, and 16, depending on whether the ARDS is mild, moderate, or severe, respectively, correlated well with the overdistended areas and with better compliance. For these reasons, I consider this method to be ideal given the fact that we should limit our exposure time given our adjacent risk of infection to use conventional near-patient PEEP titration techniques.

Other parameters we must monitor, since they also impact survival rate, are plateau pressure (Ppl), under 27 cmH₂O⁴, PaO₂ > 60 mmHg, and PaCO₂ < 5 mmHg⁴. These three measures are together called "right ventricle-protective ventilation, to avoid acute cor pulmonale. In addition, we must watch for alveolar driving pressure (DP = Ppl-PEEP) under 15 cm H₂O and mechanical power under 12, which are obtained using the following formula: $0.098 \times RR \times TV (P_{pico} - [DP/2])$.

PEEP weaning

There are no articles on when to begin the reduction of PEEP or when patients can be considered for said action. This will depend on dependent and independent variables of mechanical ventilation according to the chosen ventilation modality, observing that the patient in ACV has the same volume tidal (VT) and PEEP as was determined, the Ppeak, Ppl, and DP will reduce, that is, there is alveolar recruitment, and pulmonary compliance will improve. On the other hand, if we use a pressure modality (assist-control pressure, BiLevel, and APRV), we are able to observe the changes in the VT and flow variables, and in this case, with the same Ppeak, Ppl, PEEP, and DP, we can see a gradual increase in flow/VT, even going over the alveolar protection goals (> 6 ml/kg predetermined weight). If we observe all this after 12-24 h of stability and $\text{PaO}_2/\text{FiO}_2 > 150$ mmHg, I suggest the following diagram for PEEP weaning: reduce the patient's FiO_2 by 10%, and if the SpO_2 does not decrease by 5%, reduce the PEEP by 2 cm H_2O , and reassess in 8 h. Repeat the same maneuver, reduce FiO_2 by 10% and if the SpO_2 stays steady, lower the PEEP 2 cm H_2O once again, and so on, every 8 h, until we accomplish at least a PEEP of 10 cm H_2O , enough to wake our patients up, and at that moment consider spontaneous modalities over-controlled ones.

It will always be preferable that the patient is awake and in spontaneous modalities to avoid VM-related diaphragmatic weakness as much as possible.

Conflicts of interest

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