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SHORT REVIEW
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Mechanical ventilator support and prone positioning in COVID-19 related pneumonia

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ABSTRACT:

COVID-related acute respiratory distress syndrome (CARDS) is the most severe form of COVID pneumonia, which causes high morbidity and mortality. Theoretically, there are 2 types of CARDS including L-type and H-type, that was classified by the level of alveolar elastance. The mechanical ventilator support and oxygen supplement will be different between the types of CARDS. Low tidal volume ventilation and optimal positive end expiratory pressure (PEEP) remain the essential management in this severe form of COVID-19, who required intubate and ventilated.

Keywords: COVID-19, CARDS, Prone positioning, Mechanical ventilator

Introduction

COVID-19 is currently a global pandemic that causes high morbidity and mortality, particularly in critical cases. The common presentation is among the common respiratory symptoms and could be deteriorated to multiple organ failure. From the previous epidemiologic study, approximately 15% of cases developed pneumonia, and 5% required intensive care admission [1]. The optimal respiratory care including oxygen support is the key for hypoxic respiratory failure from severe COVID-19. Several devices have been practically suggested for respiratory symptoms included high flow nasal cannula (HFNC), non-invasive positive pressure ventilator (NIV) via either a common facial mask or helmet [2]. However, some patients did not improve with those devices, which become more respiratory distress and eventually required intubation and mechanical ventilator support. In this brief review, the author will pay attention to the mechanical ventilator support and prone positioning for COVID-19 pneumonia.

When should the patient be intubated?

Although previous reports from several countries during the first wave of pandemic demonstrated that intubation may relate to the higher mortality in COVID-19 pneumonia [3]. According to the proposed theory of the two different phenotypes of COVID-related acute respiratory distress syndrome (CARDS) included L-type and H-type, which later one significantly lower alveolar compliance [4]. Therefore, the intubated and mechanically ventilated patients will develop extensive patient-self-inflicted lung injury (P-SILI), which subsequently lead to mortality, especially in L-type and vigorously uncontrolled spontaneous breathing. Some experts suggested cautiously intubate the patients with CARDS to reduce ventilator-associated complications [5]. Then, HFNC and NIV would initially consider improving hypoxemia in particular patients. However, both HFNC and NIV may delay intubation and eventually be related to mortality too [6]. From the reason, the timing for considering intubation is debatable.

A recent meta-analysis found that neither early intubation within 24-hours of admission or delay intubation related to the mortality difference. The wait-and-see approach was recommended [7]. Several recent studies also demonstrated that intubation did not relate to mortality [8, 9]. In the patients who required HFNC and NIV, the caregivers must closely monitor the clinical pictures of failure to therapy by using the ROX index or work of breathing scale (WOBS). The ROX index is calculated by the ratio of

SpO_2/FiO_2 divided by respiratory rate.[10] WOBS consisted of 4 common clinical parameters including respiratory rate, nasal flaring, sternocleidomastoid contraction, and abdominal muscle function [11]. ROX index < 5 or WOBS > 4 are indicated the failure of NIV or HFNC. Intubation must essentially be performed to rescue the patients.

Therefore, the reasonable indications for intubation for COVID-19 patients are (1) alteration of consciousness, (2) risk of aspiration, (3) severe decompensate acidosis with pH <7.2, (4) severe hypoxemia despite maximal non-invasive management, (5) signs and symptoms of severe respiratory distress, and (6) VA ECMO implantation [12]. Although above recommendation suggested to intubate for the patients with severe acidosis with pH< 7.2, I would consider alerting at pH <7.3 for curiosity.

What is the mechanical ventilator setting in intubated-COVID patients?

According to the different pathophysiology between L-type and H-type of CARDS, the L-type is a high alveolar compliance model. Therefore, the low tidal volume ventilation and higher PEEP are unnecessary and those may increase dead space and impair pulmonary blood flow [13]. From the concern of ventilator induced lung injury (VILI) in H-type of CARDS, the initial ventilator setting is similar to standard lung protective strategies included low tidal volume ventilation (6-8 mL/kg), high positive end expiratory pressure (PEEP), keep driving pressure (Dp) less than 15 cmH_2O or plateau pressure less than 28-30 cmH_2O [14]. According to mechanical power equation [15], respiratory rate must be adjusted to the optimal level to prevent acute respiratory acidosis. The higher respiratory rate also induces lung injury, however, the highest respiratory rate could be around 35 breaths/minute, according to the ARDSnet recommendation, if refractory respiratory acidosis occurred [16]. The target or gas exchange also similar to ARDS, which PaO_2> 55 mmHg or SpO_2 88-95% with arterial pH > 7.3 regardless of $PaCO_2$ level.

Recruitment maneuver is another debatable issue due to the risk of barotrauma and hemodynamic disturbance [17]. In the recruitable lung, this maneuver will improve gas exchange in both oxygenation and ventilation. To test the recruitability of the lung, the recent evidence in COVID-19 suggested using the recruitment-to-inflation (R/I) ratio > 0.5 to indicate the recruitability of the lung [18]. This procedure requires only a single breath test with a low risk for aerosol contamination, that is eligible to perform at the bedside [19]. Although, recruitment will improve gas exchange, the mortality outcome remains unchanged [20]. The method to determine recruitability is embedded at https://crec.coemv.ca/.

Regarding P-SILI, the main pathophysiology is uncontrolled transpulmonary pressure and its variability. Changing intrapleural pressure from uncontrolled spontaneous breathing will harm the injured alveoli and induced further lung injury. Therefore, controlled ventilation in a patient with vigorous work of breathing with neuromuscular blocking agents is suggested. The application of neuromuscular blocking agent in a patient with moderate to severe ARDS have shown the mortality benefit [21].

From the current pieces of evidence, the author, therefore, suggest the ventilator management algorithm in figure 1.

KEY MESSAGES:

- The appropriated decision on intubation in CARDS may not depend on oxygenation and ventilation. Clinically of increased work of breathing might be a clinical indicator for endotracheal intubation.
- High flow nasal cannular is one of the best devices to improve gas exhanges in CARDS, but it could delay endotracheal intubation. The closed monitoring with ROX index may be useful to reduce delay intubation.
- Awake prone position or paralytic prone position is the best position to improve the oxygenation of CARDS.

Awake prone positioning and paralytic prone positioning in COVID-19 pneumonia

In ARDS patients, being ventilated in a supine position may induce further lung injury particularly in the dependent lung area. Furthermore, the inhomogeneity change of injured alveoli will lead to the mismatching of ventilation and perfusion. To prone the ventilated patient, the gravitational force that causes collapse of dependent lung area will be diminished and improved the matching of ventilation and perfusion of alveoli [22].

Several recent clinical studies demonstrated the improvement of oxygenation and lung compliance in an intubated patient with a paralytic prone position. In addition, the mortality benefit has been confirmed in moderate to severe ARDS cases who have PaO_2/FiO_2 ratio less than 150 and were in a prone position for 16 hours/day [23]. The process to prone intubated and ventilated patient needs a team approach and appropriate drill before application to the real situation. The prone method can be viewed at https://criticalcarethai.org/2021/05/04/.

In a non-intubated patient with COVID-19, several small studies reported that awake self-prone positioning will improve oxygenation, reduce tachypnea, and work of breathing. Although awake prone positioning will improve gas exchange, the intubation rate is unchanged [24-26]. Therefore, the author also suggests performing this procedure in every non-intubated hypoxemic patient from COVID-19. The awake prone position is to ask the patient to actively cyclic rotate every 30 minutes to 2 hours in a supine position, lateral decubitus position in both sides, and eventually prone position [27].

The contraindication of prone positioning has been published elsewhere [28]. So, prone positioning should be performed in every patient with COVID-19 pneumonia in both intubated and non-intubated if there is no contraindication. However, close monitoring of respiratory deterioration must be done, particularly in non-intubated patients to avoid delayed intubation. In addition, the drill must be performed until all caregivers feel comfortable rotating the intubated patients to avoid the dislodgement of the tube and line.

Conclusion

The mechanical ventilator support in COVID-19 patients is essentially similar to ARDS from the other causes. The current lung-protective study is the mainstay of treatment as well as prone positioning. The prevention of VILI and P-SILI also need to be aggressively emphasized in every intubated COVID-19 case.

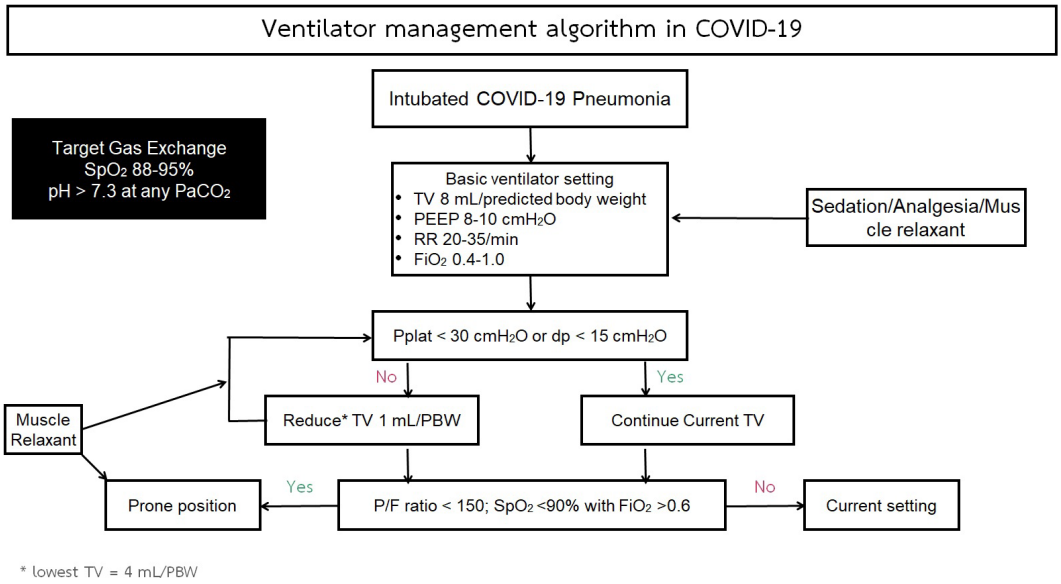

Figure 1. Ventilator management algorithm for COVID -19

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AUTHORS' CONTRIBUTIONS
Rungsun Bhurayanontachai drafted, approved, and submit the manuscript, and serves as the corresponding author.

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none

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