



Intubated BiPAP Use to Delay Mechanical Ventilation in COVID-19

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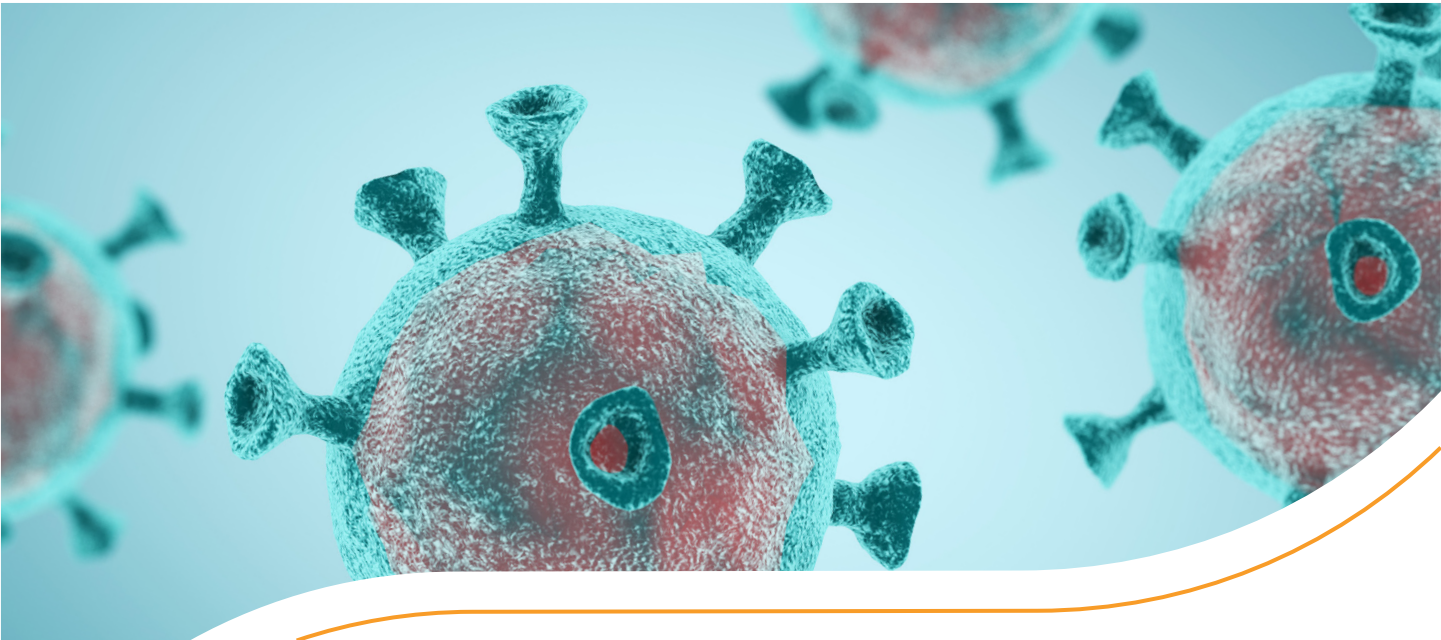


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Summary

A critical shortage of mechanical ventilators is anticipated in many countries, including the United States, because of the ongoing COVID-19 pandemic. A potential emergency solution would be the use of bi-level positive airway pressure (BiPAP). BiPAP may be used in the hospital setting with appropriate precautions for intubated COVID-19 patients experiencing Acute Respiratory Distress Syndrome (ARDS). Use of BiPAP on an emergency basis may delay or obviate the need for mechanical ventilation in appropriate COVID-19 patients.

Background

The world is currently experiencing the 2019-nCoV (COVID-19) pandemic. There are no vaccines or approved treatments for this virus, which infects its host, causes pneumonia, and leads to acute hypoxic respiratory failure. As COVID-19 spreads around the world, it is likely the availability of mechanical ventilators will be insufficient to meet the needs of the general population (WHO 2020). Some estimates by the CDC predict that 160 million in the US could be infected during the current pandemic, resulting in 2.4 million hospitalizations (CDC COVID-19 Response Team 2020). At last estimate, there are only 62,000 full-featured ventilators and approximately 99,000 older ventilators in hospitals nationwide (Centers for Disease Control 2020) (Ramsey 2020).

Need for Ventilators for COVID-19

An estimated 1-3% of those infected by COVID-19 will develop Acute Respiratory Distress Syndrome (ARDS) requiring mechanical ventilation. ARDS is a lung condition that results in hypoxic respiratory failure and can be mild, requiring only increased oxygen concentration via nasal cannula, to severe, necessitating oral tracheal intubation with mechanical ventilation. The Berlin Criteria define ARDS based on radiographic bilateral infiltrates, normal heart function, and a partial pressure of arterial oxygen over oxygen concentration ratio ($\text{PaO}_2/\text{FiO}_2$) of less than 200 (Fan, et al. 2017). Defined within the management of ARDS is maintaining oxygen PaO_2 above 55 mmHg, oxygen saturations better than 88%, and blood pH above 7.25 (Fan, et al. 2017). ARDS severity is based on the $\text{PaO}_2/\text{FiO}_2$ ratio while the patient receives 5 cmH_2O of continuous positive airway pressure (CPAP) (Fan, et al. 2017). Mild ARDS is a ratio of 200-300, moderate 100-200, and severe <100 . Most patients with ARDS are placed on a mechanical ventilator when any of these parameters cannot be maintained with supplemental oxygen delivery or if the work of breathing index is high, placing the patient at risk of respiratory fatigue and failure. The only treatment found to improve survival in ARDS is a low tidal volume strategy on ventilator support (6cc/kg ideal weight) (Ramsey 2020) (WHO 2020) (Patel, Wolfe and Pohlman 2016).

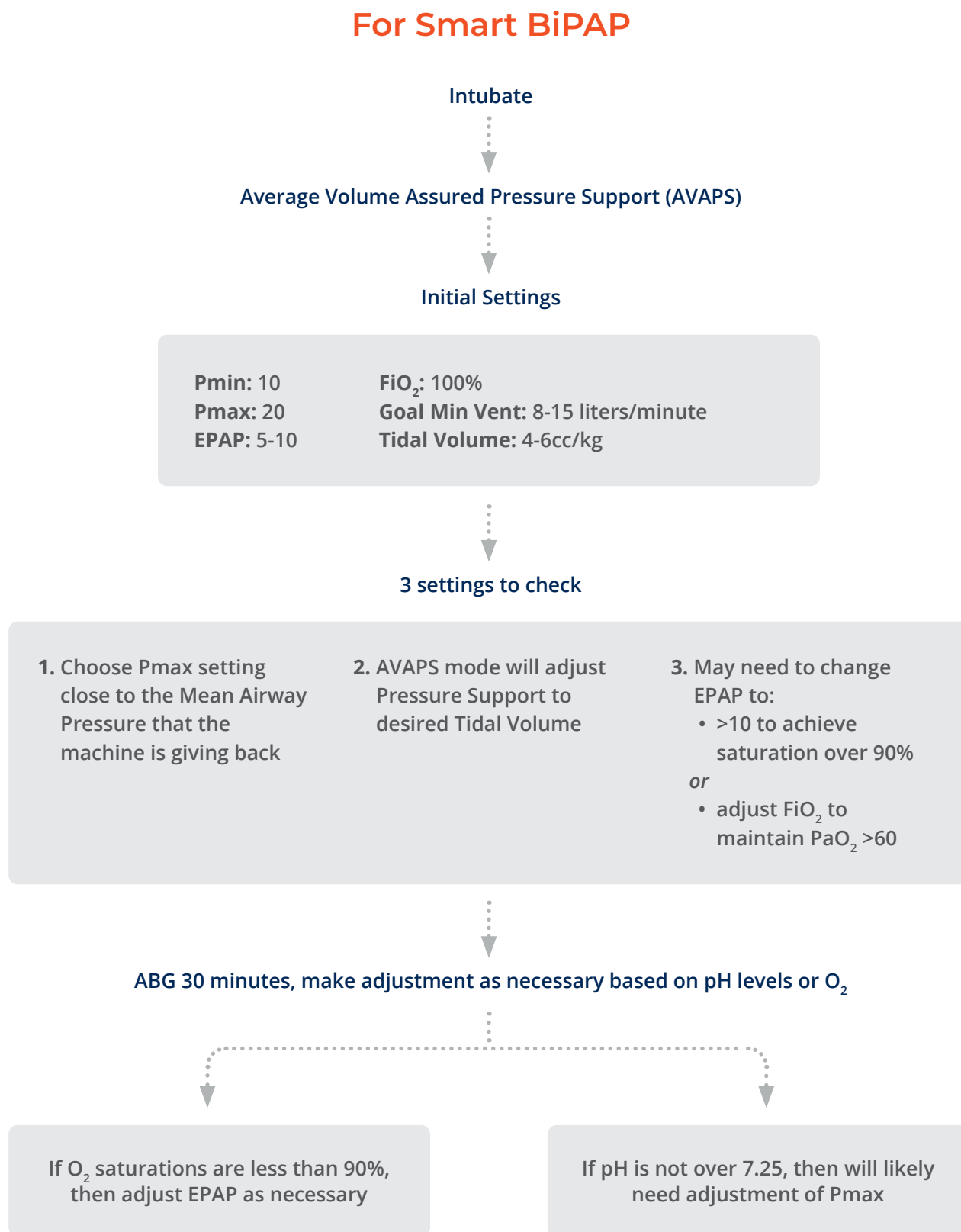
Non-invasive Ventilators to Delay Use of Standard Mechanical Ventilators Under Emergency Conditions

The dearth of mechanical ventilators (Ramsey 2020), the increased morbidity associated with prolonged mechanical ventilation, and barotrauma to the airways of the lung have ushered in the return of non-invasive ventilators (NIV) as part of management in hypoxic respiratory failure (Siegel and Hyzy 2019).

A recent trial comparing standard oxygen therapy, high-flow nasal cannula, and NIV demonstrated that the use of NIV devices, after intubation, has not lead to increased morbidity or mortality when compared to HFNC and standard noninvasive management strategies (Akhter and Rizvi 2017).

Lessons learned from developing countries with limited ICU resources conclude NIV is 8.75 times less expensive an intervention with no increased mortality associated with use (Rawat, et al. 2012) (Akhter and Rizvi 2017). While NIV via a face mask or helmet interface is recognized as a bridge supportive mode in ARDS, using an endotracheal tube has not been evaluated in COVID-19 subjects and, as such, is the clinical call of the physician. We suggest continued NIV use, after intubation, may be feasible due to worsening respiratory status and provides a means to ventilate/oxygenate patients until a standard ventilator becomes available or in lieu of a standard ventilator if all are in use. Hospitals and clinicians should continue best practices locally when undergoing NIV with intubation. A helmet interface would be preferable to a face mask to minimize air leak, improve outcomes, and provide support for patients in need of positive pressure ventilations. See algorithm (Figure 1).

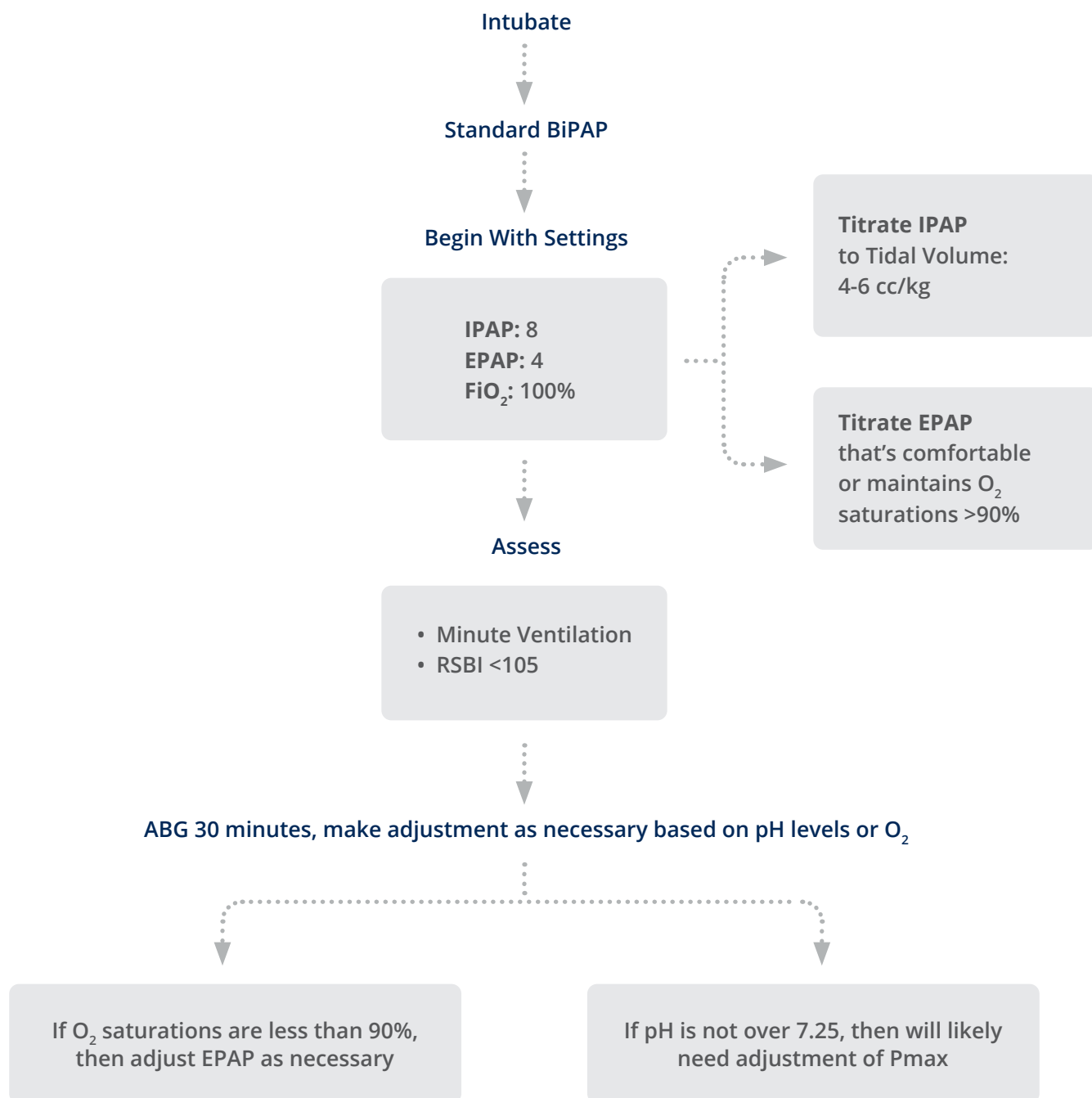
Figure 1



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Figure 1, continued

For Standard BiPAP



Use of BiPAP in Intubated Patients

Average Volume Assured Pressure Support (AVAPS) is an algorithm-based BiPAP mode found on newer standard NIV devices used in the hospital setting. The ability to set a tidal volume (average), respiratory rate, expiratory positive airway pressure level, and higher concentration of oxygen provided makes AVAPS plausible in patients with respiratory failure (WHO 2020). Further, AVAPS use in disease states with poor lung compliance, similar to ARDS, is an added benefit of the algorithm. There is limited literature on its use with oral tracheal intubated patients. Recently, at the CHEST International Convention 2019, an abstract from China—during the onset of COVID-19—found endotracheal intubation with AVAPS ventilation improved dyspnea and gas exchange and reduced relative adverse events caused by positive pressure ventilation (Han, et al. 2019). In another landmark paper, BiPAP with endotracheal tube connected via T-tube also demonstrated improved gas exchange in responders, decreased work of breathing, lower ventilation days, and improved mental status (GCS score ≥ 8) with the added benefit of lower cost of care (Akhter and Rizvi 2017).



Emergency Use While Minimizing Aerosolization

Previous experience with SARS has shown that BiPAP with a coronavirus may be used without excessive risk to the healthcare provider in an emergency setting. “Despite concern about potential aerosol generation, non-invasive ventilation (NIV) has been reported to be efficacious in the treatment of SARS-related ARF without posing infection risks to healthcare workers” (Yam, Chen and Zhong 2003). In small-sample-size studies with ARDS, BiPAP mask adjustment may be associated with aerosol generation risk (odds ratio 6.2, 95% confidence interval 2.2-18.1) as is NIV (study 1 OR 2.6, 95% CI 0.2-34.5; study 2 OR 3.2, 95% CI 1.4-7.2); however, this risk is not significantly different from that of mechanical ventilation (Tran, et al. 2012).

Nonetheless, COVID-19 aerosol formation during BiPAP should be minimized and managed in the emergency setting to the extent practical. The CDC has provided guidance for the potential precautions to use for BiPAP for COVID-19 patients. “EMS clinicians should exercise caution if an aerosol-generating procedure (e.g., bag valve mask (BVM) ventilation, oropharyngeal suctioning, endotracheal intubation, nebulizer treatment, continuous positive airway pressure (CPAP), bi-phasic positive airway pressure (BiPAP), or resuscitation involving emergency intubation or cardiopulmonary resuscitation (CPR) is necessary.

- BVMs, and other ventilator equipment, should be equipped with HEPA filtration to filter expired air.
- EMS organizations should consult their ventilator equipment manufacturer to confirm appropriate filtration capability and the effect of filtration on positive-pressure ventilation.” (CDC 2020)

The US FDA has released guidance that reads “...wherever possible, healthcare facilities should use FDA-cleared conventional/standard full-featured ventilators to treat patients who develop respiratory failure or respiratory insufficiency. However, for the duration of the public health emergency, to help foster the wider availability of devices for patients in need of ventilatory support, FDA does not intend to object to modifications to the FDA-cleared indications, claims, or functionality of these devices, without prior submission of a premarket notification where the modification will not create an undue risk in light of the public health emergency. Examples of circumstances where FDA currently believes a modification would not create such undue risk include: ... The use of devices indicated for sleep apnea (including noncontinuous ventilators delivering continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP) to treat patients with respiratory insufficiency, provided that appropriate design mitigations are in place to minimize aerosolization” (FDA 2020).

Additional recommended measures to reduce risk include the use of exhalation ports with round-the-tube airflow rather than jets, placement of a viral-bacterial filter between the mask and the exhalation port, and a negative-pressure environment (Yam, Chen and Zhong 2003).

Conclusion

To date, no ERS/ATS recommendation has been made (positively or negatively) for NIV in either *de novo* ARF or ARF in a viral pandemic (Rochwerg, et al. 2017). Nonetheless, COVID-19 appears to be an extraordinary event that may stress limited ventilator resources such that they may be unavailable for some ARDS patients. Although a full evidentiary package is not available, what evidence we have suggests AVAPS via endotracheal tube, in the right setting, can work as a bridge of support until a conventional ventilator becomes available.

Physician education will be needed in the immediate term to inform of appropriate BiPAP procedures in COVID-19. Nearly half (48%) of acute care hospitals have no intensivists, which implies doctors without ICU training will be left to care for the critically ill. Proactive education of these clinicians to the benefit of BiPAP/AVAPS, up to and/or after intubation, will be needed to prevent poor outcomes related to lack of an adequate number of ventilators. Further, any off-label use of a device by this physician population will require training to ensure the correct patient selection, device allocation, and BiPAP titration (CDC COVID-19 Response Team 2020).

Note: Syneos Health is coordinating with BiPAP manufacturers to prepare training materials in multiple media to be available for healthcare providers at COVID-BiPAPinfo.com.

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