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# Proposal for Coronavirus Disease 2019 Management

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**Setting:** The coronavirus disease 2019 pandemic has raised fear throughout the nation. Current news and social media predictions of ventilator, medication, and personnel shortages are rampant.

**Patients:** Patients with coronavirus disease 2019 are presenting with early respiratory distress and hypoxemia, but not hypercapnia.

**Interventions:** Patients who maintain adequate alveolar ventilation, normocapnia, and adequate oxygenation may avoid the need for tracheal intubation. Facemask continuous positive airway pressure has been used to treat patients with respiratory distress for decades, including those with severe acute respiratory syndrome. Of importance, protocols were successful in protecting caregivers from contracting the virus, obviating the need for tracheal intubation just to limit the spread of potentially infectious particles.

**Conclusions:** During a pandemic, with limited resources, we should provide the safest and most effective care, while protecting caregivers. Continuous positive airway pressure titrated to an effective level and applied early with a facemask may spare ventilator usage. Allowing spontaneous ventilation will decrease the need for sedative and paralytic drugs and may decrease the need for highly skilled nurses and respiratory therapists. These goals can be accomplished with devices

that are readily available and easier to obtain than mechanical ventilators, which then can be reserved for the sickest patients.

**Key Words:** continuous positive airway pressure; coronavirus disease 2019; hypoxemia

## IMPORTANCE

The coronavirus disease 2019 (COVID-19) pandemic has raised founded, and unfounded, fear throughout the nation.

Current news and social media predictions of ventilator shortages are rampant. There have been suggestions that a single ventilator may be modified to ventilate two or more patients (N.H. was requested by the Department of Defense to participate in drafting a position article on ventilating more than one patient with a single ventilator) and that anesthesia and veterinary ventilators be commissioned to treat patients with respiratory distress. We believe that far greater challenges will become apparent long before ventilator shortages are a problem and suggest an alternative approach to treatment.

## CLINICAL PRESENTATION

Most patients with COVID-19 infection who present with early respiratory distress are hypoxemic, but not hypercapnic (1, 2). Atelectasis, diffuse infiltrates, disrupted lung architecture, and eventually, decreased lung compliance, increased work of breathing and rapid, shallow breathing are hallmarks of the disease. Early in the process, patients maintain adequate alveolar ventilation and normocapnia. Support of declining respiratory physiology in patients with acute respiratory distress syndrome (ARDS) has traditionally consisted of supplemental inspired oxygen, tracheal intubation, augmented tidal volumes from a mechanical ventilator and levels of positive end-expiratory pressure (PEEP) less than 15 cm H<sub>2</sub>O, unless inspired oxygen greater than 70% is required to maintain oxygen saturation greater than 80% (3–5). Additionally, augmented or controlled tidal volumes in patients who have normal or low arterial Pco<sub>2</sub>, will not reverse atelectasis, increase lung compliance, or reverse hypoxemia and may cause

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ventilator-induced lung injury (VILI), even with tidal volumes limited to 6 mL/kg (6). Ventilator-associated pneumonia (VAP) is a risk in all intubated and mechanically ventilated patients (7). Patients who are intubated often require sedation and occasionally paralysis to tolerate modes of ventilation recommended by the ARDS Network protocol (8).

## POTENTIAL PROBLEMS

For several years, anesthesia and critical care personnel have faced shortages of sedative and anesthetic drugs required for patient care, before the pandemic. As of April 20, 2020, the Food and Drug Administration reported shortages of propofol, midazolam, fentanyl, ketamine, etomidate, lorazepam, and flurazepam. The earlier reported shortage of rocuronium has resolved. An adequate supply of rocuronium likely is due to stoppage of most elective surgery, which shortly is to resume in many states (9). It is highly probable that such drugs will continue to be in short supply in the near future. Even with the establishment of compounding pharmacies within large hospitals, drug shortages will almost certainly persist.

Patients who are intubated and mechanically ventilated likely will require more healthcare personnel than are available to safely manage these patients. Such patients require physicians, and in some settings advanced practice professionals, and a minimum of 4:1 nursing care for safe, effective management. Currently, most ICUs maintain a ventilated patient to staff ratio of 2:1 and that ratio is mandated by law in California (10, 11). Critical care nurses are required to provide precise medication administration, reposition sedated patients between prone and supine positions, implement effective care plans, and identify changes in a patient's medical condition. Respiratory therapists are essential for the safe application of mechanical ventilation. A George Washington University researcher developed a novel tool to estimate the workforce shortfall of respiratory therapists and others skilled to manipulate the ventilator (12). These specially trained individuals are not available in sufficient numbers to care for the volume of patients currently predicted to need tracheal intubation and mechanical ventilation. It is likely that in some areas of the country, the shortage of critical care physicians, nurses, and respiratory therapists will occur as the equipment shortage is resolved by increased supply.

## CLINICAL MANAGEMENT

We propose an alternative approach to treatment of patients with COVID-19 infection who present with signs of respiratory distress. Continuous positive airway pressure (CPAP) is usually administered by facemask. It commonly is used in patients with sleep apnea but has been used for decades to treat patients with postoperative atelectasis (13–16), cardiogenic pulmonary edema (17), and respiratory distress (18, 19). CPAP applied with a facemask does not result in airway pressure change, does not provide ventilatory support, and should not be confused with noninvasive positive pressure ventilation (NIPPV), which does provide mechanical ventilatory support via a facemask. The remainder of this discussion will pertain to facemask CPAP only.

During the severe acute respiratory syndrome (SARS) epidemic in 2003, one report demonstrated a significant decrease in need for tracheal intubation and mechanical ventilation using facemask CPAP. Only 13 of 75 patients who received CPAP required tracheal intubation and mechanical ventilation. Cross-infection control measures were undertaken that were 100% effective at preventing transmission to medical and nursing personnel, in spite of lack of negative pressure rooms (20). Another report described a successful protocol for protecting more than 105 caregivers from contracting the virus from infected patients. The authors expressed hope that their experience would alleviate the anxiety of all healthcare workers caring for patients with SARS so that patients would not be deprived of an important treatment modality, while also obviating the need for tracheal intubation (21). Patel et al (22) treated ARDS patients with CPAP and pressure support, if needed, either through a helmet or by facemask and demonstrated a substantial drop in intubation requirement, mortality, and ICU length of stay. Risk of aerosolization of virus particles should be diminished with the helmet as well.

Antonelli et al (23) treated 147 patients with ARDS with PEEP titrated up to 12 cm H<sub>2</sub>O. Inspiration was augmented with pressure support necessary to achieve a tidal volume of 6 mL/kg. They concluded that tracheal intubation and mechanical ventilation were avoided in 54% of patients. Of patients intubated, 54% died and 20% had VAP, compared with 20% and 2%, respectively, who avoided intubation.

Even more worrisome, current published mortality data from New York for patients with COVID-19 who received mechanical ventilation was 76% for patients 18–65 years old and 97.2% for those older than 65 years (24). Despite mask-based strategies, some patients will require tracheal intubation and mechanical ventilation. In those situations, allowing patients to breathe spontaneously, minimizing sedation, and avoiding muscle paralysis will promote more normal cardiopulmonary physiology and may decrease the demand for skilled ICU nurses and respiratory therapists.

As stated earlier, CPAP should not be confused with NIPPV. NIPPV requires either a standard critical care ventilator or a specialized ventilator for facemask use and will not relieve the impending ventilator shortage. NIPPV and facemask CPAP are not physiologically equivalent. CPAP is designed to increase alveolar recruitment and resting lung volume while preserving spontaneous breathing. In contrast, studies employing NIPPV emphasize ventilatory support, with augmented tidal volumes. Generally, PEEP levels are less than 9 cm H<sub>2</sub>O, usually in the range of 5–8 cm H<sub>2</sub>O, and rarely is PEEP titrated to effect. NIPPV has been shown to provide benefit to patients with acute hypercapnic respiratory failure, but patients with severe alveolar collapse, as occurs with ARDS, have not been as responsive (25, 26). NIPPV is primarily a ventilation assist strategy. CPAP is designed to treat hypoxemia. CPAP results in augmented ventilation by improving lung compliance and decreasing work of breathing. With either technique, the end-expiratory pressure is most effective when titrated to a patient's need and almost always is greater than 10 cm H<sub>2</sub>O. There are a few published studies using as much as 15 cm H<sub>2</sub>O with a facemask early in treatment of patients with ARDS,

including patients with viral pneumonia with a  $P_{aO_2}/F_{iO_2}$  ratio less than 200 mm Hg. These reports suggest that early use of higher levels of CPAP may decrease the need for tracheal intubation and mechanical ventilation in patients with ARDS and SARS, with a decrease in attendant complications (VILI and VAP) (19–21).

There should be no reluctance to applying 10 to 20 cm  $H_2O$  CPAP with a mask to spontaneously breathing patients who may benefit. Currently, there is vast experience with the use of such levels of CPAP to treat patients with sleep-disordered breathing (obstructive sleep apnea), with no reported occurrence of acute lung injury, gastric distention, or patient discomfort secondary to its use. Thus, using these levels of CPAP we know is safe, as millions of patients currently are prescribed CPAP devices for home use in the United States, albeit with varying delivery mechanisms. Additionally, as opposed to sophisticated mechanical ventilators, mask CPAP systems are readily available on the market, simple to use, and far easier to obtain than mechanical ventilators, which can then be reserved for the sickest patients.

Instead of requiring mechanical assistance to improve ventilation, titrating CPAP will recruit alveoli, improve lung compliance, decrease the work of spontaneous breathing, decrease intrapulmonary shunting of blood, and reverse hypoxemia. Further, patients provided with CPAP by mask do not require the same level of ICU care with sedation, special monitoring, or specialized caregivers, as do intubated patients receiving typical mechanical ventilatory support. CPAP applied with room air ( $F_{iO_2} = 0.21$ ) may result in lower arterial blood oxygen saturation, but will permit more accurate assessment of lung function with either intermittent or continuous pulse oximetry (27). If patients with the same disease are isolated together, for example, in a large room with appropriate flow restriction and expiratory high-efficiency particulate air filters, cross-contamination between patients will not be an issue. By placing the same viral filters that we currently use on the expiratory limb of ventilators onto the expiratory limb of the mask CPAP equipment, concern for transmission to caregivers from aerosolization of infectious particles need occur only when the facemask is detached. To minimize particle aerosolization when the mask is removed from the patient for oral care, feeding, etc., flow from the CPAP generator can be terminated prior to mask removal.

## CONCLUSIONS

During a pandemic such as we face now, we should focus on providing the best and safest care for the most patients while protecting our caregivers and using the least amount of resources. Experimenting with ventilators designed for providing anesthetics, using advanced equipment designed for a single critically ill patient to provide care to multiple patients and using veterinary equipment for human patients may result in untoward complications. CPAP applied early and with a facemask to patients with hypoxemic, normocarbic respiratory distress may spare ventilator use. Titrating airway pressure to the individual's need and allowing spontaneous ventilation to persist will mitigate need for sedative and paralytic drugs and dramatically decrease the need for complex mechanical ventilators, highly skilled nurses, and respiratory therapists. These

goals can be accomplished with devices that are readily available and easier to obtain than mechanical ventilators, which then can be reserved for the sickest patients. If the early use CPAP administered with a facemask can decrease the need for intubation, the impending mechanical ventilator shortage should be significantly affected.

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Dr. Habashi has received reimbursement for travel to conferences sponsored in part by Dräger and has several patents in the area of mechanical ventilation and its application. To date, he has not received any royalties or payments for any patents. The remaining authors have disclosed that they do not have any potential conflicts of interest.

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