

# Obstructive Sleep Apnea, Obesity, and Noninvasive Ventilation: Considerations During the Coronavirus Disease 2019 Pandemic

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## GLOSSARY

**AHI** = apnea–hypopnea index; **ARDS** = acute respiratory distress syndrome; **BMI** = body mass index; **BPAP** = bilevel positive pressure ventilation; **BVM** = bag valve mask ventilation; **CI** = confidence interval; **COPD** = chronic obstructive pulmonary disease; **COVID-19** = coronavirus disease 2019; **CPAP** = continuous positive airway pressure; **EPAP** = expiratory positive airway pressure; **F<sub>IO<sub>2</sub></sub>** = inspiratory oxygen fraction; **FRC** = functional residual capacity; **H1N1** = influenza A; **HFNC** = high-flow nasal cannula; **ICU** = intensive care unit; **IPAP** = inspiratory positive airway pressure; **NIV** = noninvasive ventilation; **OHS** = XXX; **OSA** = obstructive sleep apnea; **PPE** = personal protective equipment; **SARS** = XXX; **SARS-CoV-2** = severe acute respiratory syndrome coronavirus; **SASM** = Society for Anesthesia and Sleep Medicine; **SDB** = sleep-disordered breathing; **TLC** = total lung capacity; **VC** = vital capacity; **WHO** = World Health Organization

As health care providers tackle the global coronavirus disease 2019 (COVID-19) pandemic, many questions have arisen regarding management of populations at increased risk and protection of health care workers. The number of cases continues to rise globally and is now in excess of 2 million worldwide with over 150,000 deaths.<sup>1</sup> The COVID-19 pandemic has placed an enormous burden on the global health care system with numerous repercussions.

## ARE PATIENTS WITH OBSTRUCTIVE SLEEP APNEA AT GREATER RISK OF SEVERE COVID-19 ILLNESS?

Recent data from Wuhan, China, found higher rates of comorbidities such as chronic obstructive pulmonary disease (COPD) (10.4% vs 0.5%), diabetes (26.9%

vs 6.1%), hypertension (35.8% vs 13.7%), and coronary artery disease (9.0% vs 2.0%) among COVID-19 patients who were admitted to intensive care unit (ICU), required mechanical ventilation, or died.<sup>2</sup> These characteristics are corroborated with preliminary data from the Italian COVID-19 outbreak which describe the typical COVID-19 patient as age 60–70, men, and obese.<sup>3</sup> Interestingly, these characteristics depict the demographic most likely to have coexisting obstructive sleep apnea (OSA). It is estimated that moderate–severe sleep-disordered breathing (SDB; ie, apnea–hypopnea index [AHI] ≥15 events per hour) affects 14% of men and 6% of women in the general population.<sup>4</sup> A significant proportion (up to 90%) of total cases are undiagnosed, which is a limiting factor in epidemiological study of this condition.<sup>5</sup>

By definition, OSA patients experience recurrent nocturnal intermittent hypoxemia, which has been linked to higher incidence of atrial fibrillation and sudden cardiac death.<sup>6,7</sup> Also, OSA can potentially exacerbate inflammation in COVID-19–related sepsis or acute respiratory distress syndrome (ARDS). Coexisting obesity alters baseline respiratory mechanics by reducing total lung capacity (TLC), functional residual capacity (FRC), and vital capacity (VC) as well as increasing pleural pressure and upper and lower airway resistance.<sup>8</sup> Obese patients are at risk of developing lung derecruitment and atelectasis, which are exacerbated by sedatives, supine positioning, and mechanical ventilation. The overlap of obesity and OSA, in the setting of obesity hypoventilation

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syndrome, is characterized by severe obesity (body mass index [BMI]  $>35$  kg/m<sup>2</sup>) and daytime arterial hypercapnia. Patients with comorbid disease phenotypes such as obesity hypoventilation syndrome are at increased risk of adverse outcomes with significant challenges in mechanical ventilation and cardiopulmonary interactions when infected with COVID-19.

During the influenza A (H1N1) pandemic in 2009, obesity was found to be an independent risk factor for complications related to influenza.<sup>9,10</sup> A retrospective analysis of BMI stratified by age in symptomatic patients with COVID-19 who presented to a large academic hospital system in New York has shown that patients aged  $<60$  years with a BMI between 30 and 34 kg/m<sup>2</sup> were 2.0 (95% confidence interval [CI], 1.6–2.6,  $P < .0001$ ) and 1.8 (95% CI, 1.2–2.7,  $P = .006$ ) times more likely to be admitted to acute and critical care, respectively, than those with a BMI  $<30$  kg/m<sup>2</sup>.<sup>11</sup> Likewise, patients with a BMI  $>35$  kg/m<sup>2</sup> and aged  $<60$  years were 2.2 (95% CI, 1.7–2.9,  $P < .0001$ ) and 3.6 (95% CI, 2.5–5.3,  $P \leq .0001$ ) times more likely to be admitted to acute and critical care than patients in the same age category who had BMI  $<30$  kg/m<sup>2</sup>.<sup>11</sup>

Currently, there is no direct evidence to support OSA as an independent risk factor for severe COVID-19 infection, but some inferences can be made from data on ARDS. Obesity was shown as an independent risk factor for developing ARDS among hospitalized patients.<sup>12</sup> In a large retrospective cohort study of over 6,000,000 cases, sleep apnea has been associated with an increased risk for the development of ARDS among patients undergoing orthopedic and general surgical procedures.<sup>13</sup> The majority of the clinical data do not support increased mortality due to ARDS in obese patients.<sup>14</sup> As well, patients with OHS who are hospitalized in general are at increased risk of mortality and morbidity, but the risk is mitigated among patients treated with noninvasive ventilation (NIV).<sup>15</sup>

### AIRWAY MANAGEMENT FOR OSA PATIENTS WITH COVID-19

Airway management for COVID-19 patients can be challenging as OSA is a predictor of difficult intubation and difficult bag valve mask (BVM) ventilation.<sup>16</sup> Factors such as coexisting obesity can lead to rapid oxyhemoglobin desaturation during rapid sequence induction in an already hypoxemic patient. This can put health care workers in a compromised position as rescue maneuvers such as BVM ventilation, supraglottic airway insertion, or cricothyroidotomy are all high-risk, aerosol-generating procedures. Weaning patients with COVID-19 and coexisting SDB mechanical ventilation may be challenging. OSA patients may be at higher risk of failing extubation due to upper airway obstruction compounded by rostral fluid shifts and sedatives and underlying

hypoxemia. The combination of upper airway collapse with high negative intrathoracic pressure can generate shear forces causing secondary lung injury. Thus, this patient population may be at higher risk of prolonged mechanical ventilation. In these cases, tracheostomy may facilitate weaning from mechanical ventilation and if adapted to apply NIV through the tracheostomy, it can potentially free up ventilators in resource-limited scenarios. While NIV such as continuous positive airway pressure (CPAP) and bilevel positive airway pressure (BPAP) or high-flow nasal oxygenation may be offered as a bridge to extubation under normal circumstances, weighing the benefits versus the risk of viral transmission via aerosol generation to health care workers warrants careful consideration. Alternatively, prophylactic nasal cannula may be applied at extubation in anticipation of hypoxemia with less risk of aerosolization but ultimately does not overcome airway obstruction.

### SAFETY OF NONINVASIVE VENTILATION

COVID-19 patients can develop acute hypoxemic respiratory failure rapidly, and most clinical guidelines advocate for early endotracheal intubation in a controlled setting in favor of NIV for hypoxemic respiratory failure.<sup>3,17</sup> Routine use of NIV can potentially delay recognition of decompensation and increase the risk transmission through aerosol generation. Currently, the World Health Organization (WHO) recommends a trial of NIV of no longer than 1 hour to avoid failed recognition of decompensation and delaying intubation.<sup>18</sup> A recent study reported  $>40\%$  rate of NIVs failure leading to invasive mechanical ventilation in patients with moderate-to-severe ARDS and association with increased mortality in patients with ARDS. In mild-moderate COVID-19-related hypoxemia, NIV may be considered as a temporizing measure.

A major concern regarding NIV is its potential for aerosolizing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) containing droplets and transmission to health care workers. The concern is not limited to confirmed and suspected cases of COVID-19 as up to 50% of SARS-CoV-2 infections can be asymptomatic or presymptomatic.<sup>19</sup> The high-flow rates and mask leak associated with NIV combined with coughing provide conditions conducive for aerosolization. The context for these concerns arose initially during the 2003 SARS pandemic.<sup>20</sup> Since then, Hui et al<sup>21</sup> conducted a series of studies to measure relative dispersion of exhaled air during several modes of oxygen delivery and NIV.<sup>22–24</sup> Interestingly, maximum exhaled air dispersion distance on oxygen via nasal cannula at 5 L/min was greatest (100 cm) and similar to BPAP with full facemask at settings of inspiratory positive airway pressure (IPAP) 18 cm H<sub>2</sub>O and expiratory

positive airway pressure (EPAP) 5 cm H<sub>2</sub>O (92 cm).<sup>21,24</sup> In fact, CPAP at 20 cm H<sub>2</sub>O via a well-fitting oronasal mask or BPAP via helmet with tight air cushion was associated with negligible air dispersion.<sup>21,22</sup> The findings are summarized in Table.<sup>25</sup> Unfortunately, helmet CPAP is not widely available in most countries and is more expensive than standard facemasks. These studies used smoke as the marker for air dispersion. Smoke particles are smaller in size compared to droplet particles and may, in fact, overestimate the dispersion of viral-borne droplets. However, these models may not replicate coughing or sneezing which further increase air dispersion. Some hospital infection control policies require isolation of patients receiving NIV in negative pressure rooms or other settings conducive to airborne isolation. In the midst of a pandemic, these resources may not be readily available, and therefore, exceptions should be considered to avoid withholding an otherwise beneficial therapy.

**PERIOPERATIVE CONCERNS FOR THE OSA PATIENTS DURING COVID-19 PANDEMIC**

In the perioperative setting, the COVID-19 pandemic has affected many operating room and recovery room processes and presents unique considerations for patients with OSA. Current guidelines from the Society for Anesthesia and Sleep Medicine (SASM) recommend continued use of CPAP through the perioperative period to prevent postoperative complications.<sup>26</sup> It is well established that postoperative OSA patients receiving anesthetics, sedatives, and opioids and even intravenous fluids are at risk of developing postoperative cardiopulmonary complications and are at

increased susceptibility if they remain untreated with CPAP/BPAP.<sup>27,28</sup> In patients with known or suspected COVID, the feasibility of this practice is threatened by the potential for viral transmission to health care workers. Thus, benefits and infection risk of administering NIV must be carefully considered in context of depleting resources for isolation areas on postanesthetic care units and surgical wards to safely administer NIV.

**RISK MINIMIZATION**

Given the increased demand and scarcity of resources during a pandemic, it is essential to identify strategies to minimize risk to the patient and health care workers. Clinicians should prepare for cases when OSA patients will not be able to continue CPAP/BPAP and to weigh the clinical benefit versus risk of transmission. For surgical patients, using regional anesthesia techniques whenever possible can avoid high-risk aerosol-generating medical procedures such as airway manipulation and intubation and reduce opioid consumption to minimize postoperative respiratory depression and exacerbation of OSA. For patients at increased risk, that is, moderate–severe OSA receiving opioids, we recommend obtaining a postoperative monitored bed with continuous pulse oximetry, ideally with capnography, to provide early warnings of hypoventilation and/or hypoxemia. Finally, for those who do receive NIV on wards, in addition to following institution-based infection control practices and donning appropriate personal protective equipment (PPE) to reduce the nosocomial spread of COVID-19, we recommend the following precautions:

1. Use of negative pressure rooms whenever possible with at least 10 air exchanges per hour. In the absence of negative pressure, patients receiving NIV can be placed in a closed neutral pressure room with air cycling of at least 6 air exchanges/hour.
2. Use of a nonvented mask (ensure that an exhalation port is placed in the circuit).
3. A viral filter should be placed between the face-mask and exhalation port. The filter should be changed every 24 hours as moisture from exhaled gas can increase resistance to flow.
4. Selection of masks should be considered with priority from least aerosol generating to most: Helmet > full facemask > well-fitting oronasal mask > nasal mask.
5. Sequence of events: place mask on before turning on ventilator and turn ventilator off before removing mask.
6. Strict use of PPE when entering the room. Airborne precautions with minimum PPE: N95 respirator, goggles or full face shield, gown, and gloves when NIV is in use.
7. Minimize number of entries of medical personnel.

**Table. Maximum Exhaled Air Dispersion Distance Via Different Oxygen Administration and Ventilatory Support Strategies**

Method	Maximum Exhaled Air Dispersion Distance
Oxygen via nasal cannula 5 L/min, cm	100
Oxygen via oronasal mask 4 L/min	40
Oxygen via venturi mask Fio <sub>2</sub> 40%, cm	33
Oxygen via nonrebreathing mask 12 L/min, cm	<10
CPAP via oronasal mask 20 cm H <sub>2</sub> O	Negligible air dispersion
HFNC 60 L/min, cm	33
	17 (62 cm sideways leakage if not tightly fixed)
NIV via full facemask: IPAP, 18 cm H <sub>2</sub> O; EPAP, 5 cm H <sub>2</sub> O, cm	92
NIV via helmet without tight air cushion: IPAP, 20 cm H <sub>2</sub> O; EPAP, 10 cm H <sub>2</sub> O, cm	27
NIV via helmet with tight air cushion: IPAP, 20 cm H <sub>2</sub> O; EPAP, 10 cm H <sub>2</sub> O	Negligible air dispersion

Abbreviations: CPAP, continuous positive airway pressure; EPAP, expiratory positive airway pressure; Fio<sub>2</sub>, inspiratory oxygen fraction; HFNC, high-flow nasal cannula; IPAP, inspiratory positive airway pressure; NIV, noninvasive ventilation.

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In summary, although OSA is not directly linked to adverse outcomes, we highlight several unique considerations that will be encountered during the COVID-19 pandemic. In the pre-COVID-19 era, NIV has been a useful therapy in management of patients with OSA. However, the current pandemic raises several issues with their use. Patients with COVID-19 can decompensate quickly and the use of NIV may mask pending decline. NIV also generates aerosol droplets increasing the risk of viral transmission to other patients and health care workers. Thus, careful consideration must be taken to balance the risk profile of the individual, evolving clinical status, and the risk of viral transmission according to the type of NIV, the patient-ventilator interface, and the available precautions. ■■

#### DISCLOSURES

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**Contribution:** This author helped conceptualize, design, and draft the manuscript.

**Conflicts of Interest:** None.

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**Contribution:** This author helped write the manuscript.

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