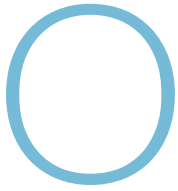


# THE ROLE OF CPAP IN *Treating Respiratory Distress in Patients With COVID-19*



By Regina Patrick, RPSGT, RST



On Dec. 31, 2019, the Municipal Health Commission of Wuhan, China, reported a cluster of cases of severe pneumonia of unknown

etiology.<sup>1</sup> On Jan. 12, China publicly shared the genetic sequence of the virus that caused the novel pneumonia.<sup>1</sup> On Feb. 11, 2020, the World Health Organization announced the official name for the disease: coronavirus disease 2019, commonly shortened to COVID-19.<sup>2</sup> Shortly thereafter, the International Committee on Taxonomy of Viruses officially named the virus causing COVID-19 as severe acute respiratory syndrome coronavirus (abbreviated SARS-CoV-2).<sup>3</sup>

COVID-19 quickly became a global pandemic. Many patients with COVID-19 developed pneumonia and required ventilators to assist their breathing. The need for ventilators soon overwhelmed the supply of ventilators. With the shortage of ventilators caused by the COVID-19 pandemic, early reports that continuous positive airway pressure (CPAP) therapy prevented or delayed some patients with COVID-19 from progressing to needing a ventilator and reduced chances of death were encouraging.<sup>4,5</sup> This news created an interest in developing CPAP devices that could provide noninvasive ventilation<sup>6</sup> or using less familiar forms of CPAP such as helmet CPAP and the Boussignac CPAP to counter the ventilator crisis. At the year anniversary of the pandemic, scientists are now aware that CPAP treatment may not be appropriate for all patients with COVID-19.

SARS-CoV-2 belongs to the Coronaviridae family, which consists of enveloped viruses that use ribonucleic acid (RNA) as its genetic material. A viral envelope consists of a lipid bilayer that closely surrounds a capsid (i.e., a shell of proteins that surrounds the viral RNA strand). The SARS-CoV-2 virus' envelope contains large club- or petal-shaped projections, commonly called "spikes" (the scientific name is peplomer [pronounced "PEH-ploh-mer"]), which appears as a crown (i.e., corona from the Latin for "crown") under a microscope.

When SARS-CoV-2 infects a cell, the virus' spike protein interacts with surface

receptors for angiotensin-converting enzyme 2 (ACE2) on the host cell's surface. Through this interaction, the virus enters the host cell. The host cell replicates the virus and is destroyed in the process. In the process of cellular death, the host cell releases various chemicals, as well as new virus particles. Nearby macrophages detect these chemicals and respond by producing proinflammatory cytokines (i.e., proteins that mediate

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intercellular activity such as the immune response; some examples of cytokines are interleukin 1, interleukin 6 and tumor necrosis factor alpha). These proteins attract other immune cells (e.g., monocytes, macrophages and T cells) to the site of infection, which further promotes inflammation and establishes a proinflammatory feedback loop (a process called "cytokine storm").

If a person's immune response is impaired, these immune cells may accumulate in the lungs and overproduce proinflammatory cytokines, which ultimately damages lung tissues. In a person with a healthy immune response, the initial inflammation attracts virus-specific T cells to the site of infection, where they eliminate SARS-CoV-2-infected cells before the virus can spread. Antibodies against the virus are produced, and the virus is neutralized. In the lungs, alveolar macrophages recognize neutralized viruses and dead host cells and clear them by phagocytosis.

SARS-CoV-2 infection in the lungs results in widespread alveolar damage and thickening of the alveolar wall.<sup>7,8</sup> The inflammatory chemicals increase capillary permeability so that blood plasma easily leaks out of capillaries and enters the interstitial spaces of the alveolar cells, which allows fluid to accumulate outside of the alveoli. These events ultimately cause alveolar collapse and impair gas exchange across the membrane of the alveoli.

In people with moderate or severe COVID-19, a ventilator is used to improve gas exchange in the lungs. A ventilator delivers air through an endotracheal tube or tracheostomy, both of which involve sedation of a patient to apply. Some drawbacks of ventilator use are ventilator-induced damage to pulmonary tissues that may already be weakened by a disease process, pneumothorax (i.e., collapsed lung) and ventilator-associated pneumonia caused by bacteria that has entered the body and lungs through the breathing tube or tracheotomy.

Unlike a ventilator, CPAP does not involve invasive procedures (i.e., endotracheal tube insertion, tracheotomy) to deliver pressurized air, and it does not involve sedation to apply. CPAP treatment continuously delivers slightly pressurized air through a mask that fits over the nose or nose and mouth. In CPAP, the pressure is the same for inspiration and expiration.

CPAP treatment is usually used to prevent upper airway collapse in people with obstructive sleep apnea. However, in people with pneumonia, the CPAP may prevent or reduce alveolar collapse, thereby improving ventilation in the lungs.<sup>9</sup> CPAP treatment may also improve ventilation by changing the ventilation and blood perfusion dynamics in the lungs.

On March 22, 2020, the U.S. Food and Drug Administration released guidelines permitting manufacturers and health care professionals to use CPAP machines to treat respiratory insufficiency,<sup>10,11</sup> owing to the difficulty in obtaining ventilators. Two methods that have

gained scientists' interest as a treatment for COVID-19 are the helmet CPAP and Boussignac CPAP. In 2016, a team of American researchers<sup>12</sup> demonstrated that helmet CPAP decreased the need for intubation and intensive care unit length of stay in patients with mild to moderate adult respiratory distress syndrome (ARDS), compared to mask CPAP. In another study, Armirfarzan et al.<sup>13</sup> demonstrated that approximately 30-50% of their patients treated with helmet CPAP were successfully managed without requiring intubation and mechanical ventilation. Therefore, Armirfarzan proposed that helmet CPAP could potentially prevent the need for or delay the need for more invasive ventilation.

In helmet CPAP, a transparent, bell-shaped helmet covers a person's entire head. The helmet has a collar neck seal at the bottom to prevent air leakage. Air and oxygen are delivered through ports by a tube connected to a wall flow meter, a high-flow oxygen delivery device or a ventilator. The helmet reduces the aerosolization of the virus because it covers the whole head. This factor reduces the risk of transmission of the virus to health care workers. Compared to a nasal or orofacial mask, a helmet mask does not become misplaced, thereby creating leakage, when a patient lies on the side or prone. Therefore, the helmet mask is more comfortable to patients.

In addition, some research indicates that the prone position combined with helmet CPAP may improve aeration in the lungs.<sup>14</sup> CPAP (especially at a high pressure) may divert blood flow from high-perfused areas

to low-perfused areas, thereby allowing the redistribution of aerated and nonaerated lung areas.<sup>14</sup>

In 1976, use of the prone position as a treatment to improve ventilation in patients with ARDS was first described.<sup>15</sup> The prone position modifies respiratory mechanics in that the front of the chest wall cannot expand because it is in contact with the surface of the bed. By decreasing movement of the front chest wall in the prone position, aeration in the lungs shifts from the front region to the back region where the alveoli may have become deflated or filled with alveolar fluid.

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## *This combined treatment avoids overdistension of the healthy lung areas, which would slow the progression of the disease.*

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Based on these findings, some researchers<sup>14</sup> suggest that certain COVID-19 patients may benefit from the combination of helmet CPAP at a moderate pressure level (i.e., 10 cmH<sub>2</sub>O) and prone position. This combined treatment avoids overdistension of the healthy lung areas, which would slow the progression of the disease.

The Boussignac CPAP system (Vygon, Écouen, France) consists of a full-face mask connected to the Boussignac valve, a short circular chamber that extends from the front of the mask. The circular chamber contains two lateral ports; the upper port is connected to tubing that is connected to an air or oxygen source. The chamber can also be attached to filters (e.g., high efficiency particulate air [HEPA] filter) that can help reduce (but not eliminate) SARS-CoV-2 exposure.

In the Boussignac valve, gas (i.e., air, oxygen, or air/oxygen mix) passes from the source through the tubing and enters the upper port of the circular chamber. The gas then passes through microchannels, which direct the gas toward the center of the chamber where the gas molecules collide with each other at a high speed. This collision creates turbulence and pressure within the chamber, thereby creating a virtual "valve." A patient breathes against the pressure produced by the virtual valve. The Boussignac CPAP system is capable of delivering a moderate level (10 cmH<sub>2</sub>O) of CPAP and requires only an oxygen source.

Few studies have been conducted on Boussignac and COVID-19 outcomes. Some findings are encouraging, although more research is needed. For example, in a recent case report of a woman with hypoxemia due to COVID-19, Mwenge and Rodenstein<sup>16</sup> noted that the patient's oxygen levels increased to >90% when she was on the Boussignac CPAP. However, the patient found it uncomfortable. The physicians switched her to conventional CPAP, which she well tolerated without any complications. Based on this experience, they encourage the use of CPAP in patients with COVID-19 pneumonia.

Wong and colleagues<sup>17</sup> reviewed the efficacy of Boussignac CPAP treatment for acute respiratory failure. Their review indicated that Boussignac CPAP significantly improved respiratory parameters and oxygenation values, and that the Boussignac CPAP was more effective than standard oxygen delivery and just as effective as bilevel positive airway pressure treatment (a treatment in which positive airway pressure is higher on inspiration and lower on exhalation) in improving patient oxygenation and respiration. They further found, based on one of the reviewed studies, that Boussignac CPAP reduced the intubation rate and hospital stay. However, these findings were based on the results of pre-COVID-19 pandemic studies.



Another study<sup>18</sup> indicated that a Boussignac CPAP may be adequate for patients breathing at a normal breathing rate with low air flow, but with high air flow, it does not maintain stable airway pressure, which could increase the work of breathing and cause respiratory fatigue. Thus, the Boussignac CPAP system may be less suitable for patients who are breathing at a higher frequency.

In the early days of the pandemic, the use of CPAP in COVID-19 patients with respiratory symptoms may have contributed to the spread of COVID-19 in Life Care Center of Kirkland (Kirkland, Washington) – CPAP treatment had been applied before the residents had been confirmed as having SARS-CoV-2 infection.<sup>19</sup> Therefore, greater information is critical to determine how best to use CPAP for people with COVID-19 (e.g., with or without the prone position), how to avoid aerosolizing the virus<sup>10</sup> in health care settings and which patients would benefit most from the treatment. For now, scientists continue gathering information regarding the impact of CPAP treatment on COVID-19 disease in patients with respiratory distress. 🌙

## References

1. World Health Organization (WHO). Archived: WHO Timeline—COVID-19. April 23, 2021. Accessed April 27, 2020.
2. World Health Organization (WHO). *Novel Coronavirus (2019-nCoV) Situation Report 22*. WHO: Geneva, Switzerland. February 11, 2020. Available at [https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200211-sitrep-22-ncov.pdf?sfvrsn=fb6d49b1\\_2](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200211-sitrep-22-ncov.pdf?sfvrsn=fb6d49b1_2)
3. Li H, Liu L, Zhang D, et al. SARS-CoV-2 and viral sepsis: observations and hypotheses. *Lancet*. 2020;395:1517-1520.
4. Sun Q, Qiu H, Huang M, et al. Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province. *Annals of Intensive Care*. 2020;10:33-36. doi:10.1186/s13613-020-00650-2
5. Radovanovic D, Rizzi M, Pini S, et al. Helmet CPAP to treat acute hypoxemic respiratory failure in patients with COVID-19: a management strategy proposal. *Journal of Clinical Medicine*. 2020;9:1191-1198. doi:10.3390/jcm9041191
6. Akhand MAH. Indigenously developed CPAP device to support Covid-19 patients. *Daily Observer*. March 14, 2021. <https://www.observerbdc.com/news.php?id=260379>

# Greater information is critical to determine how best to use CPAP for people with COVID-19.

7. China National Health Commission. Diagnosis and treatment of novel coronavirus pneumonia in China (trial version 7). 2020.
8. Yao XH, Li TY, He ZC, et al. A pathological report of three COVID-19 cases by minimal invasive autopsies. *Zhonghua Bing Li Xue Za Zhi [Chinese Journal of Pathology]*. 2020;49:411-417 (in Chinese).
9. Cosentini R, Brambilla AM, Aliberti S, et al. Helmet continuous positive airway pressure vs oxygen therapy to improve oxygenation in community-acquired pneumonia: a randomized, controlled trial. *Chest*. 2010;138:114-120.
10. US Food and Drug Administration (FDA). *Ventilator Supply Mitigation Strategies: Letter to Health Care Providers*. FDA: Silver Spring, MD. March 22, 2020. Accessed April 5, 2021. <https://www.fda.gov/medical-devices/letters-health-care-providers/ventilator-supply-mitigation-strategies-letter-health-care-providers>
11. US Food and Drug Administration (FDA). *Enforcement Policy for Ventilators and Accessories and Other Respiratory Devices During the Coronavirus Disease 2019 (COVID-19) Public Health Emergency: Guidance for Industry and Food and Drug Administration Staff*. March 2020. Accessed April 23, 2021. <https://www.fda.gov/media/136318/download>
12. Patel BK, Wolfe KS, Pohlman AS, et al. Effect of noninvasive ventilation delivered by helmet vs face mask on the rate of endotracheal intubation in patients with acute respiratory distress syndrome: A randomized clinical trial. *JAMA*. 2016;315:2435-2441.
13. Armirfarzan H, Shanahan JL, Schuman R, et al. Helmet CPAP: how an unfamiliar respiratory tool is moving into treatment options during COVID-19 in the US. *Therapeutic Advances in Respiratory Disease*. 2020;14:1-3.
14. Longhini F, Bruni A, Garofalo E, et al. Helmet continuous positive airway pressure and prone positioning: a proposal for an early management of COVID-19 patients. *Pulmonology*. 2020;26:186-191. doi:10.1016/j.pulmoe.2020.04.014
15. Piehl M, Brown RS. Use of extreme position changes in acute respiratory failure. *Critical Care Medicine*. 1976;4:13-14. doi:10.1097/00003246-197601000-00003
16. Mwenge GB, Rodenstein D. CPAP added to oxygen administration avoid intubation in acute respiratory distress in COVID-19 pneumonia. Case report. *SN Comprehensive Clinical Medicine*. Jun 18 2020:1-4. doi:10.1007/s42399-020-00349-2
17. Wong DT, Tam AD, Van Zundert TC. The usage of the Boussignac continuous positive airway pressure system in acute respiratory failure. *Minerva Anestesiologica*. 2013;79:564-570.
18. Sehlin M, Tornell SS, Ohberg F, et al. Pneumatic performance of the Boussignac CPAP system in healthy humans. *Respiratory Care*. 2011;56:818-826. doi:10.4187/respcare.01015
19. Hawryluk M. *CPAP Machines Were Seen as Ventilator Alternatives, but Could Spread COVID-19. Shots: Health News from NPR*. National Public Radio (NPR): Washington, DC. March 27, 2020. Accessed April 5, 2021. <https://www.npr.org/sections/health-shots/2020/03/27/822211604/cpap-machines-were-seen-as-ventilator-alternatives-but-could-spread-covid-19>



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