

Non-invasive respiratory support for COVID-19-related acute respiratory failure

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The European Respiratory Society/American Thoracic Society clinical practice guidelines, which are only recommendatory, suggest utilization of non-invasive respiratory support therapies (NRST) as a preventive strategy for avoiding intubation in hypoxemic acute respiratory failure (ARF).^[1] Theoretical concerns against the use of NRST are essentially related to safety reasons for the risk of the virus spreading among healthcare workers (HCW) and for the risk of delaying intubation in case of failure.

Recent experimental studies suggest that NRST are not “generating” bio-aerosols but more “dispersing” bio-aerosols farther away from the patient.^[2] Moreover, it has been recently suggested that early invasive mechanical ventilation (IMV) was associated with an increased risk of day-60 mortality.^[3]

NRST include continuous positive airway pressure (CPAP), bi-level positive-pressure ventilation (BLPPV), and high-flow nasal cannula oxygen (HFNCO), used in acute hypoxemic respiratory failure (AHRF) of different causes with different rates of success. HFNCO is beyond the scope of this article; however, it can be used sequentially or combined as an integrative NRST algorithm.^[4] In this article, we review the experience so far on the use of CPAP and BLPPV and discuss the indications that can be used to ascertain the ideal time to start and the ideal settings.

CPAP and BLPPV Experience in Coronavirus Disease 2019 (COVID-19)

Literature review of NRST in COVID-19-related ARF identifies 24 publications including 2159 patients.^[5-29] The average infection rate in HCW was 5%, less than the 12% reported in New York City among the staff not necessarily

working with NRST.^[30] Only two studies were performed in negative pressure rooms^[11,27] and the series with the highest HCW infection rates^[24] took place in Bergamo Emergency Department, in the high-stroke northern Italian town, during the first wave in Europe.

Only five series reported using advanced non-invasive ventilators,^[7,13,20,24,27] while in four portable home ventilators were used^[6,11,14,15] and in one intensive care unit ventilators.^[8] The only important outcome reported in all papers was the success rate in avoiding endotracheal intubation, achieved on average in 55% and 59% of patients with, respectively, CPAP and BLPPV.

Employed protocols, methodology, and data collected in the published studies were extremely heterogeneous. Considering the 15 studies using CPAP, three did not disclose the mean pressures applied.^[14,23,28] Mean CPAP pressures ranged from 10 cmH₂O^[10,22,26] to 15 cmH₂O.^[24] From the eight studies reporting BLPPV usage,^[5,7,9,13,15,20,24,27] only two^[7,27] reported mean pressure support and positive end-expiratory pressure (PEEP), respectively, 17.3/9.5 cmH₂O and 12/6 cmH₂O. In three, the indication to start BLPPV was the failure of HFNCO^[5,20,27] and the rest was due to availability,^[7] hypercapnia,^[13,15] acidosis,^[24] or CPAP failure.^[13] All the five series applying facemask CPAP^[8,6,11,15,28] used viral filters in the expiratory port of the circuit.

Helmet CPAP

With helmet CPAP, the advantage of less leakage conferred by the helmet may allow for more effective delivery of higher levels of positive end-expiratory pressure, potentially increasing alveolar recruitment and decreasing respiratory effort.^[31] Helmet CPAP—mainly using a flow

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generator—was applied in the majority of COVID-19 studies.^[7,10,12,16,22-24,26]

Non-invasive Positive Pressure Ventilation (NIPPV) and Risk of Self-Inflicted Lung Injury (SILI)

NIPPV in AHRF has been implicated in the risk of SILI.^[32] An observational study, including 62 patients (47 with non-COVID-19 [acute respiratory distress syndrome]) showed that generated tidal volume (a surrogate of the measurement of transpulmonary pressure) was a good predictor for NIV failure.^[33] So, to avoid SILI, a “protective-NIV,” with lower tidal volumes between 6 mL/kg and 8 mL/kg has been proposed.^[34] In the three studies that analyzed tidal volume levels^[35-37] included in a recent meta-analysis, only one^[35] showed a trend toward higher expiratory tidal volume in failure patients. None of the COVID-19 studies applying NRST refers to this topic.

CPAP or BLPPV in COVID-19: When to Start, When to Stop, and When to Wean

To decide when to start CPAP, there are three criteria: (1) If partial pressure of oxygen (PaO₂): fraction of inspired oxygen (FiO₂) ratios < 200 mmHg or PaO₂ < 60 mmHg or respiratory rate (RR) > 30 breaths/min (while on oxygen or HFNCO). (2) If PaO₂:FiO₂ ratio is < 300 mmHg or oxygen saturation (SpO₂) < 93% on O₂ > 5 L/min and the patient has body mass index > 30 kg/m² (optional).^[12] When starting CPAP, improvement in PaO₂:FiO₂ in 1 h should be analyzed. If improvement is ≥15%^[10] or ≥30%,^[16] consider the existence of lung recruitability. (3) When choosing CPAP with helmet or oro-nasal mask, start with 10 cmH₂O (do not exceed 12–13 cmH₂O to avoid barotrauma, SILI, or negative hemodynamic impact) to achieve SpO₂ > 93%^[10] or PaO₂ ≥ 60 mmHg.^[22]

Patients on helmet CPAP who do not show signs of respiratory distress (e.g., RR < 25 breaths/min) and maintain a SpO₂ > 94% with a FiO₂ < 50% and a PEEP ≤ 5 cmH₂O could undergo a weaning trial. Patients who maintain a PaO₂:FiO₂ ratio > 250 mmHg on Venturi mask with a FiO₂ < 40% for at least 24 h are considered successfully weaned from helmet CPAP.^[16]

It is suggested to reduce helmet CPAP level to the minimum possible (5–6 cmH₂O), maintaining a FiO₂ not higher than 50%. If de-recruitment is absent and the PaO₂/FiO₂ ratio is stable when compared with higher PEEP levels, the patient is ready to undergo a CPAP weaning trial.^[39] A weaning trial should be attempted every day to avoid a delay in CPAP removal.

The use of BLPPV as a first-line intervention should preferably be restricted to patients with COVID-19 who have hypercapnia (partial pressure of carbon dioxide [PaCO₂] > 45 mmHg), due to chronic obstructive pulmonary disease, cardiogenic pulmonary edema, or morbid obesity/obstructive sleep apnea.^[38] For patients with hypoxemic respiratory failure not responsive to conventional oxygen therapy, HFNCO should be preferred.

To start BLPPV, there are three criteria: (1) PaO₂:FiO₂ ratios < 100 mmHg and RR ≥ 30 breaths/min and/or respiratory distress under CPAP. (2) Suggested parameters: PEEP 12 to 16 cmH₂O and pressure support set with the aim of a tidal volume between 4 and 6 mL/kg and FiO₂ set to a target of SpO₂ 90% to 95%.^[40] (3) In patients with hypercapnic respiratory failure (PaCO₂ > 45 mmHg).

In the history of medicine, we have never had such a high influx of patients with similar presentations ready to be included in prospective studies. Even if NRST have been demonstrated to be effective tools in preventing IMV in COVID-19 ARF, further studies designed to address important neglected issues are needed to better tailor each treatment for each individual case performed by each individual team. Nosocomial infection preventive and control measures during non-invasive positive pressure ventilation should be carefully implemented.

Conflicts of interest

None.

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