Continuous Positive Airway Pressure (CPAP) Devices to Provide Oxygen to Patients with CoViD-19 Pneumonia, Part 2

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Continuous Positive Airway Pressure (CPAP) devices are widely used in the treatment of hypoxemia characterizing CoViD-19 pneumonia: in this scenario, also due to different regional epidemiological and clinical pandemic features, CPAP is currently debated and has so far been heterogeneously appliced with a predominantly empirical approach.

Every Severe Acute Respiratory Infection (SARI) case requires early supplemental oxygen to correct hypoxemia: oxygen target saturation range is > 90% (≥ 95% in pregnancy, > 94% in critically ill children, > 90% in other conditions). Given the pathophysiological characteristics of interstitial pneumonia, dyspnoea and respiratory distress occur belatedly in the clinical picture, but sometimes suddenly. To detect early signs of failure and identify prognostically negative evolution, monitoring must be simple and essentially based on pulse oximetry, respiratory rate (RR), ventilatory pattern and PaO2/FiO2 ratio: each of them should be interpreted as a single datum, but even more on the basis of the evolution over time.

A main priority must never be forgotten: to guarantee adequate personal protective equipment in all circumstances when handling any oxygen therapy device in patients known or suspected for CoViD-19. Given the risk of aerogenic dispersion of droplets from high flow devices, it is recommended to limit their use to isolated environments with negative pressure. The high number of suspected or positive cases, the scarce logistical availability of these environments in Emergency Departments (ED), as well as the need for treatments lasting several days, have made this principle scarcely applicable.

CPAP devices are well known and their use is increasingly spreading in the Emergency Medicine landscape. CPAP devices in this scenario can be summarized as follows: high-flow ones with an external or a stand-alone Venturimeter (Venturi-type flow generator system), or "Boussignac"® type (pressure generator system based on the acceleration and collision of oxygen molecules). Their performances (mainly in terms of flow and FiO2) and the pathophysiology of the underlying medical condition to be treated must be taken into consideration when choosing between these devices.

Venturi systems provide high flows (mainly those with external Venturimeters) and guarantee better performance by maintaining constant pressure: this allows the inflamed lung parenchyma to be spared from the traumatizing phenomenon of recruitment and derecruitment. On the other hand, every system based on the Venturi principle ensure incremental flows only by paying the price of lowering FiO2. Boussignac and Boussignac-like CPAP devices are less effective in maintaining constant pressure

throughout the whole respiratory cycle, but they guarantee the highest FiO2, however often inaccurate, in a wide range of patient minute ventilation.

The ideal CPAP device should combine all these features when treating hypoxemic inflammatory conditions also requiring alveolar recruitment, even in the presence of moderately preserved lung compliance and slight respiratory distress. However, only a few high-flow Venturi systems are able to guarantee flows such as to maintain a constant pressure level up to 12-15 cm H2O as recommended in CoViD-19 pneumonia.

With regard to interfaces, we can consider three main types, offering a decreasing degree of tolerance for longer treatment: helmet, total-face mask, oro-nasal mask. To significantly reduce droplets dispersion, an anti-viral / anti-bacterial filter can be mounted in series between the mask and the valve on total-face and oro-nasal masks, using a special fitting. Filters can also be inserted on some helmet models with an interchangeable PEEP valve. Now more than ever, filters must be certified and checked to prevent contamination by a variety of bacterial and viral species and particles of various sizes.

Downstream of these considerations, we then recommend the use of a Venturi system with a helmet, without precluding the advantages that, in selected cases, can be offered by other devices.

To date, no experiences regarding CPAP provided by a mechanical ventilator have been published. This method would allow, at least in theory, the graphic monitoring of parameters, the humidification of the circuit, the stability of FiO2 for a wider range of minute ventilation, the achievement of high PEEP values and a low dispersion of droplets.

On the ventilatory side, in case of acute hypoxemic respiratory insufficiency due to residual functional capacity reduction (as for cardiogenic pulmonary edema), CPAP does not actively perform any form of respiratory work: on the other hand it is able to reduce work of breathing due to respiratory distress, improving the compliance of the thoraco-pulmonary system, increasing the percentage of ventilated alveoli and reducing the degree of hypoxemia, even in cases refractory to conventional oxygen therapy.

The use of CPAP is therefore recommended for hemodynamically stable patients, with preserved neurological status (Kelly - Matthay scale = 1), whole respiratory dynamics, RR ≥ 28 bpm, unresponsive to standard O2 therapy, where monitoring is guaranteed thanks to the availability of human and instrumental resources, experience of medical and nursing staff, and with quick access to invasive ventilation without any delay in case of failure.

The use of CPAP, as well as that of non-invasive ventilation (NIV), in respiratory pandemics is reported in the literature in quantitatively and qualitatively scarce studies; its effectiveness is therefore too limited to allow any type of widespread recommendation and rather involves serious caution. The relationship between the potential benefit in mild to moderate acute hypoxemic respiratory failure cases, and the risk of inappropriateness, wasting of resources and of time in the application of invasive and intensive measures, is extremely weak. The clinical and ventilatory picture is, about NIV, in the middle ground between that of pneumonia and that of ARDS (acute respiratory distress syndrome), thus representing a very high risk of failure, even if in expert hands and in a semi-intensive environment.

In the current state of knowledge, which is constantly evolving, it seems rational to recommend the early use of CPAP for patients with CoViD-19 with SARI, at a moderate stage of the clinical course, in clinical phenotypes 3 and 4, when refractory to conventional O2, with a PaO2 / FiO2 ratio of almost

250 during standard O2 therapy with high FiO2, keeping the attention focused on the respiratory pattern and the trend of PaO2 / FiO2.

The use of high continuous positive pressure values, between 8 and 15 cm H2O, and high FiO2 is recommended to achieve the 94-99% oxygen taget saturation range. As usual, the target is lower (90-92%) in patients at risk of hypercapnia. The impact of positive pressure on the hemodynamic and perfusional side rarely makes a difference in these cases, but extreme and continuous attention even to these aspects is mandatory.

As physiopathologically known for pneumonia or mild ARDS, the response to CPAP cannot be rapid even for COVID-19 cases: the monitoring of vital parameters must therefore first of all confirm the stability of the condition, since the first hour, but in the same way in the following days, promptly detecting any sign of deterioration. In the interval phases in which the CPAP is temporarily suspended, even more careful monitoring will be necessary to understand the stability of the clinical condition, or to early identify the deterioration and the appearance, more or less rapidly, of a decrease in SpO2 or an increase in RR. In the intervals it is possible to consider the use of high flow nasal cannulas (HFNC).

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