

## Case Report

### Alternative CPAP Methods for Treating Severe Respiratory Failure Secondary to Pneumonia Resulting from Covid-19: Three Case Studies

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**Citation:** Rodríguez AM, Anselmi JO, González FJC, Lebrato JC, Saavedra MF (2020) Alternative CPAP Methods for Treating Severe Respiratory Failure Secondary to Pneumonia Resulting from Covid-19: Three Case Studies. Emerg Med Inves 5: 10100. DOI: 10.29011/2475-5605.010100

**Received Date:** 13 May, 2020; **Accepted Date:** 02 June, 2020; **Published Date:** 05 June, 2020

#### Abstract

The application of Continuous Pressure in the Airways (CPAP) has long shown an improvement in the evolution of different diseases, especially those that cause respiratory failure. On the other hand, the SARS-CoV-2 pneumonia has produced an explosive increase in patient's subsidiary to these devices and mechanical ventilation, both non-invasive and invasive. This has produced a shortage of these devices that has led to devising devices of fortune. We present here three cases of patients with acute respiratory failure secondary to Pneumonia due to COVID 19 treated with these alternative CPAP devices at the Hospital de Campaña de Ifema in Madrid.

#### Introduction

Applying Continuous Positive Airway Pressure (CPAP) results in the deployment or recruitment of partially or totally collapsed alveolar units, improves pulmonary compliance, and increases transpulmonary pressure and residual functional capacity. This implies improved respiration as well as better gas exchange [1]. At the haemodynamic level, applying CPAP results in decreased pre-load and post-load (by reducing venous return and left ventricular wall systolic pressure), with slightly decreased systolic blood pressure and cardiac output in patients with normal heart function. In patients with heart failure who have increased pulmonary capillary pressure and hypervolemia, the cardiac output may increase [2]. A comparison of CPAP with traditional

oxygenation systems shows a significantly reduced need for intubation (50-60%) as well as lower in-hospital mortality (40-47%), and it is considered the oxygen therapy system of choice for many pathologies [3]. Recently, a study [4] suggested the use of a device for continuous positive airway pressure (CPAP) and Positive End-Expiratory Pressure (PEEP) to limit the spread of viruses into ambient air. It has also been described as a means of avoiding or delaying admission to the ICU [5] and several publications have reported the usefulness of CPAP in acute lung oedema [6-8] as well as its application in the emergency department [9].

The European Society for Intensive Care Medicine has recommended the use of PEEP in patients with acute respiratory failure as a result of COVID-19 [10]. However, there are not

enough conventional CPAP systems available on the market to treat these patients. To be able to provide ventilatory support to patients with acute respiratory failure secondary to COVID-19, a number of alternative systems have been developed capable of producing CPAP and, secondarily, PEEP. For the diagnosis of respiratory failure, we used the SAFi [11] indicator (oxygen saturation / unreacted oxygen fraction) less than 100.

We present three cases of patients with severe respiratory failure secondary to COVID-19 pneumonia admitted to IFEMA Field Hospital who were treated with these alternative CPAP systems.

#### Case 1

A 47-year-old male diagnosed with COVID-19 pneumonia who required alternative CPAP due to presenting tachypnea of 30 bpm at 98% saturation with VMask at 15 litres per minute (lpm) with FiO<sub>2</sub>0.5 (SAFI 99). His medical history included high blood pressure, diabetes mellitus, dyslipemia and asthma. He received azithromycin, ritonavir/lopinavir, hydroxychloroquine and tocilizumab. He was on day 20 of the illness. No hemodynamic changes were observed. 24 hours after the start of the alternative CPAP, his respiratory rate improved to 15 Breaths Per Minute (bpm), with saturation levels remaining at around 99%. At 48 hours and 72 hours, his situation was similar and his respiratory status had not deteriorated. The CPAP was stopped at 24 hours of use.

#### Case 2

A 65-year-old man with a medical history of high blood pressure and dyslipemia who presented ventilatory deterioration with a saturation of 90% and a respiratory rate of 20 with a reservoir mask (SAFI 99), for which reason it was decided to use alternative CPAP to improve the initial situation. The patient had been treated with chloroquine, ritonavir/lopinavir, dexamethasone, tocilizumab and azithromycin. No hemodynamic changes were observed. However, after 24 hours his ventilatory condition worsened and he required bolus of dexamethasone. 72 hours after the start of the alternative CPAP, the patient was stable with 99% saturation and a respiratory rate of 18 bpm; the alternative CPAP was maintained. The patient uses the CPAP 3 days.

#### Case 3

A 31-year-old woman with no relevant medical history who

began to suffer ventilatory deterioration dropping to 89% saturation with a VMask at 15 lpm with a FiO<sub>2</sub> of 0.5 (SAFI 89). She was on day 10 of the illness and had been treated with azithromycin, hydroxychloroquine, ritonavir/lopinavir, azithromycin and ceftriaxone. No hemodynamic changes were observed. After 24 hours of CPAP, the patient was transferred to the ICU for monitoring, but maintained 99% saturation with a respiratory rate of 18 bpm. At 72 hours, she was stable from a ventilatory perspective and the CPAP was retired.

In patients with acute respiratory distress syndrome, heterogeneity in the filling of the lung parenchyma results in the appearance of both distended and collapsed areas. Protective low-volume ventilation strategies have demonstrated increased survival in this context. In addition to PEEP, recruitment manoeuvres, which are still under discussion, were used to distend the lung [12]. To implement PEEP, the best option is the use of non-invasive mechanical ventilation [9], but the high number of patients with severe respiratory failure and the scarcity of non-invasive ventilation devices has forced us to use CPAP alternatives that are capable of producing PEEP.

The indication for initiating the use of alternative CPAP was, in our case, a decrease in O<sub>2</sub> saturation to below 94%, despite oxygen being supplied through a Vmask at 15 lpm or a reservoir-type mask. We think that these devices should be used earlier to achieve the expected effect. Patients in whom there is a relationship between O<sub>2</sub> saturation and an inspired fraction of O<sub>2</sub> below 100 or 200 should be eligible for this type of therapy. Sat/FiO<sub>2</sub> correlates to PaO<sub>2</sub>/FiO<sub>2</sub> for diagnosing respiratory distress [13].

The devices used have been modified during this first campaign against the disease. The most widely used alternative devices have been developed by the staff of the intensive care units in Príncipe de Asturias University Hospital and Henares University Hospital and are assembled using similar elements:

- PEEP valve
- Antibacterial and antiviral filter
- Mapleson C Bagging system
- Conventional oxygen intake
- Mask (Venturi mask with plugged seals, conventional CPAP interface or Decathlon<sup>®</sup> diving mask)



**Figure 1**



**Figure 2**

**Figures 1 and 2:** Show the arrangement of the elements.

In the first device, the T-piece for assembling the various elements was manufactured with a 3D printer specifically for this device. It was made by Hewlett Packard®.

The use of these devices has helped in ventilating several patients by improving their oxygenation parameters and, in some cases, eliminating the need to admit them to the ICU. To better observe the evolution of patients undergoing this therapy and compare them with patients on other types of ventilator support, more studies needed. A comparative study of these two types of oxygenation therapy is currently in progress.

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