

Biphasic cuirass ventilation in the escalation of non-invasive ventilation in COVID-19: case report and review

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Abstract

Ventilatory alternatives to prolong noninvasive ventilation in COVID-19 patients are attractive and poorly understood. New

devices to deliver negative noninvasive ventilation as biphasic cuirass ventilation (BCV) have been introduced. BCV device assist in spontaneous breathing and support ventilation. We describe a case of the combination of BCV with high-flow nasal oxygenation (HFNO) in the treatment of a COVID-19 pneumonia patient that required prolonged NIV leading to face mask intolerance, ventilator dependency secondary to residual lung fibrosis and respiratory muscular weakness. BCV provides an efficient non-invasive approach in de-escalation of therapy and weaning of prolonged NIV.

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Introduction

The COVID-19 pandemic brought to light a large number of patients who received noninvasive ventilation (NIV) approaches and high-flow nasal oxygenation (HFNO) in an effort to avoid endotracheal intubation. It's well known that prolonged mechanical ventilation and NIV failure could be catastrophic in this patient population. From the pathophysiology point of view, late NIV-failure is complex, and may include muscular weakness, psychologic and mask interface intolerance. Strategies and ventilatory alternatives to prolong NIV in these patients and maintain gas exchange and muscular weakness are attractive and are poorly understood. Recently, new devices to deliver negative noninvasive ventilation have been introduced. The technology biphasic cuirass ventilation (BCV) that has been developed applies equal pressure throughout the thorax, which then allows for even expansion of the lungs and uniform ventilation in an effort to treat various forms of acute and chronic respiratory failure [1].

BCV device assist in spontaneous breathing and support ventilation by enabling negative pressure in the inspiratory phase to actively move the diaphragm downward and positive pressure in the expiratory phase to push air back out of the lungs. This latter function is more effective at clearing carbon dioxide, weaning patients dependent on mechanical ventilation, increasing cardiac output, and achieving alveolar recruitment. It could also be used to help decrease the complications of invasive mechanical ventilation (ventilator-associated pneumonia, laryngeal injury and respiratory muscle atrophy) and improve the quality of life [2,3]. Its application in patients who are already receiving NIV reduces the requirements for pressure support and inspired oxygen and increases tidal volumes with enhanced CO₂ removal [4].

In this case, we describe the combination of this methodology (BCV) with HFNO in the treatment of a COVID-19 pneumonia patient admitted to the intensive care unit (ICU). This patient that endured prolonged NIV consequently presented with face mask discomfort and intolerance, ventilator dependency secondary to residual lung fibrosis and respiratory muscular weakness.

Case Report

A 58-year-old woman, without major medical history and who was active and independent, presented to the Emergency Department with bilateral alveolar infiltrates on chest X-ray and was positive for COVID-19. She had tachypnea (35 rpm), tachycardia (120 bpm), arterial blood pressure of 120/80 mmHg, fever of 38°C; and leukocytosis. She was admitted to the ICU and NIV was started with BIPAP mode (Philips Respironics V60) and full-face mask: IPAP 18 cmH₂O; EPAP 8 cmH₂O; FiO₂ 0,8; ramp: 0.05 sec. During the first week of the ICU stay, the patient presented a slow improvement of bilateral pulmonary infiltrates that permitted the de-escalation of pressure values and inspiratory fraction of oxygen, finally allowing de-escalation to HFNO. However, in the second week the patient began to develop a progressive picture of hypercapnia and sustained tachypnea, which prevented the de-escalation to HFNO and required prolonged NIV for 30 days. During this time, residual lung fibrosis was noted. She also developed a urinary tract infection due to *Escherichia coli*, that also contributed to prolonging her length of the ICU stay.

Due to the patient developing a late intolerance to adaptation with facial interface and the persistence of muscle weakness, treat-



Figure 1. Patient under combination of high-flow nasal oxygenation and biphase cuirass ventilation.

ment with BCV (Hayeck device) was introduced. This technology was applied as complementary therapy during periods of disconnection from NIV and this combination therapy lasted for a 30-day period. It was applied following this protocol: disconnection of the NIV for periods of 30 min with the addition of HFNO (Figure 1) in the initial stages to maintain a target saturation of oxygen <92%. Use of NIV through a nasal interface during the night period. During NIV de-escalation periods, treatment with pulmonary rehabilitation were applied by bedside staff.

Discussion

There is controversy about the prolonged use of NIV in critically ventilator dependent patients because it has been associated with a significant risk of NIV failure. These patients end up developing mask intolerance and an increase in mortality. However, prolonged endotracheal intubation in COVID-19 patients has been shown to have worst outcome.

In daily ICU practice, this represents a complex and unresolved problem that require the development of alternatives to NIV and prevent the use of de-escalation protocols that resort to NIV, thus freeing the patient from NIV with a conventional mask. HFNO is a useful alternative tool in the de-escalation phase in patients with low or middle muscular weakness, who are not hypercapnic and have not developed the physiology effects of respiratory muscular weakness and other ventilatory effects of prolonged NIV.

In this sense, there is no previous report in COVID-19 patients admitted to the ICU of the combination use of HFNO and BCV and we believe that this combination represents a new non-invasive ventilatory strategy which allows de-escalation and avoid endotracheal intubation in ventilation depend on COVID-19 patients.

Conclusions

Biphase cuirass ventilation provides an efficient method of non-invasive alternative approach in de-escalation of therapy and weaning of prolonged noninvasive ventilation therapy. Further large clinical trials are needed to confirm this observation.

References

1. Bauer AR. Mechanical respirator for newborn infants and other patients: preliminary report. *JAMA* 1956;161:723-5.
2. Linton DM. Cuirass ventilation: a review and update. *Crit Care Resusc* 2005;7:22-8.
3. Onweni C, Rashid S, Goswami R, et al. Cuirass ventilation: An alternative home-based modality for chronic respiratory failure. *Home Health Care Manag Pract* 2020;32:40-4.
4. Takeda S, Nakanishi K, Takano T, et al. The combination of external high-frequency oscillation and pressure support ventilation in acute respiratory failure. *Acta Anaesthesiol Scand* 1997;41:670-4.