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Non-invasive ventilation in acute exacerbation of chronic obstructive pulmonary disease: pressure support versus volume assured pressure support

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Abstract
Chronic obstructive pulmonary disease is a prevalent and debilitating respiratory condition with an important mortality, being ranked as the 4th leading cause of death worldwide. Exacerbations are acute events that appear in the natural history of the disease, contributing to its high mortality and morbidity. With each exacerbation, the patient loses pulmonary function resulting in disease progression and reduced exercise ability. Muscular mass loss is common in these patients and has many causes: lack of exercise due to exertional dyspnea, corticosteroid use and systemic inflammation (more important during exacerbations). The purpose of this review is to analyze the use of conventional pressure control ventilation bilevel positive airway pressure in spontaneous/timed mode versus average volume-assured pressure support ventilation (average volume-assured pressure support and intelligent volume-assured pressure support) in acute hypercapnic respiratory failure due to chronic obstructive pulmonary disease exacerbation in the light of current research. Although intelligent or hybrid modes do not seem to be superior to pressure control non-invasive ventilation in exacerbation, there are however some groups (chronic obstructive pulmonary disease - obstructive sleep apnea overlap syndrome, patients with chronic obstructive pulmonary disease and morbid obesity) that could benefit. As most data are on chronic respiratory failure, more clinical trials are required in this direction.

Keywords: acute exacerbation of chronic obstructive pulmonary disease, pressure assured control modes, average volume-assured pressure support, intelligent volume-assured pressure support.

Introduction

Chronic obstructive pulmonary disease (COPD) is a prevalent and debilitating respiratory condition with an important mortality, being ranked as the 4th leading cause of death worldwide (***, 2010; Lozano et al., 2012; Laribi et al., 2017). Acute exacerbations of chronic obstructive disease (AECOPD) are acute events that appear in the natural history of COPD, contributing to its high mortality (***, 2010).

Data show that 2.5% up to 24.5% of AECOPD patients die during hospitalization and up to 8% in the following month after discharge (Papi et al., 2017; Lencu et al., 2016). Each exacerbation results in deterioration of lung function, which leads to reduced exercise capacity and muscle hypotrophy. Muscle loss is common in COPD patients, and has several reasons (Alexescu et al., 2019; Albu et al., 2011). The first is reduced activity due to development of dyspnea. The patient will reduce effort intensity to improve dyspnea. The second reason is corticosteroid treatment. Systemic corticosteroids are part of COPD exacerbation; the more frequent the exacerbations, the higher the probability of corticosteroid myopathies. And the last reason is systemic inflammation that characterizes COPD, which is more important during exacerbation. Each one of these factors leads to muscle mass loss and impaired exercise activity. Therefore, one of the main purposes of treatment is to prevent exacerbation.

In patients with severe exacerbation, with hypercapnic respiratory failure and respiratory acidosis (ph: 7.25 - 7.35), non-invasive ventilation (NIV) is a well established therapy, alongside optimal medical and oxygen therapy. NIV refers to the provision of respiratory support through

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patient's upper airway using a mask or similar device. It has been shown to reduce the intubation rate, length of hospital stay and hospital mortality (Kramer et al., 1995; Baudouin et al., 2002; Elliot et al., 2018; Davidson et al., 2016). Current evidence supports the use of pressure control or pressure support modes in acute respiratory failure due to COPD exacerbation (Simmonds & Roussos, 1998; Lightowler et al., 2003; Elliot et al., 2018; Davidson et al., 2016; Hussein, 2016). As 20% of patients are intubated, requiring invasive mechanical ventilation with the associated risks, other modes have been evaluated in order to prevent treatment escalation (Murphy et al., 2012; Hussein, 2016).

Objectives

The aim of this review is to analyze the use of pressure control ventilation versus hybrid/intelligent ventilation modes [*average volume-assured pressure support (AVAPS) and intelligent volume-assured pressure support (iVAPS)*] in acute hypercapnic respiratory failure due to COPD exacerbation, in the light of current research.

Bilevel positive airway pressure spontaneous/timed mode (BiPAP S/T) is a pressure control ventilation mode where the ventilator applies a fixed level of pressure (within a range of minimum and maximum of IPAP settings) and has a back-up rate and a fixed inspiratory time (Papi et al., 2017). Once breath has been initiated, pressure rises depending on the settings to a pressure plateau, where it is held for the duration of inspiration. When inspiratory flow falls below a certain level, usually 25% of peak inspiratory flow, this marks the end of inspiration. Therefore it is the patient who determines respiratory frequency and timing of each breath. If the patient fails to make the required respiratory efforts, the ventilator sets in and completes the respiratory rate. Tidal volume is variable from breath to breath (Papi et al., 2017; Briones et al., 2013). Volume assured pressure support modes (iVAPS and AVAPS) are new spontaneous dual modes using the closed loop technique to obtain targeted tidal volume or alveolar ventilation by adjusting pressure support from one respiratory cycle to another (Briones et al., 2013).

Average volume-assured pressure support (AVAPS) maintains a tidal volume equal to or higher than the targeted tidal volume by changing pressure support with every breath between the minimum and maximum IPAP settings. As it averages tidal volume over several minutes, it can adjust the pressure support depending on the patient's efforts. If patient's effort decreases, AVAPS will increase, increasing tidal volume; if patient's effort increases, AVAPS will decrease (Davidson et al., 2016; Briones et al., 2013).

Intelligent volume-assured pressure support (iVAPS) targets alveolar ventilation by estimating the dead space using patient's height (Davidson et al., 2016). By targeting alveolar ventilation, iVAPS maintains ventilation according to the patient's metabolic needs, decreasing the risk of inefficient ventilation with changing respiratory rate (Elliot et al., 2018). iVAPS seems to be more physiological and adapted to the mechanism of acute respiratory failure in COPD (alveolar hypoventilation). This leads to impaired removal of carbon dioxide and consequently, hypercapnia. Hypercapnia decreases the ratio between bicarbonate ions (HCO3-) and arterial carbon dioxide (PaCO2), leading to acidemia. There is however a limitation of these modes. In patients with lung disease in general and COPD in particular, the dead space is increased and is larger than that estimated by height. Furthermore, if patient's tidal volume is higher than the targeted one, the support is reduced (Davidson et al., 2016).

Intelligent ventilation modes have been used for some years in chronic conditions, and in certain subgroups (restrictive disorders) they have been proved to be superior to conventional pressure-support NIV (Simonds & Hare, 2013; Nilius et al., 2017). In stable COPD, existing data are inconsistent. While there are some studies that found no relevant improvements in prognosis, others reported small improvements in prognosis together with improved quality of life (Briones et al., 2013).

In acute COPD exacerbation, hybrid modes seem to have some benefits compared with conventional non-invasive ventilation, but more data are required. In 2013, Briones et al., comparing the benefits of using NIV with AVAPS versus conventional NIV in acute hypercapnic respiratory failure, found a statistically significant difference in patients from the VAPS group in terms of consciousness, PaCO2 levels and peak inspiratory positive airway pressure. Nevertheless, there were no significant differences in terms of length of hospital stay or NIV duration between the 2 groups. Hussien, in a prospective randomized controlled trial, revealed that the intelligent ventilation mode (iVAPS) was not inferior to standard PS ventilation when considering the improvement of respiratory rate, pH, hypercapnia, and oxygenation (Hussein, 2016). However, it should be considered that in the first study, patients had hypercapnic encephalopathy, therefore higher paCO2 values, which could explain the significant difference in the analyzed parameter. In Hussien's study, patients had lower paCO2 values, therefore lower severity. Shaaban et al. concluded in their research presented in the ERS Congress (Shaaban et al., 2017) that patients ventilated with AVAPS showed a more rapid and steady improvement of clinical parameters and a shorter duration on NIV. All studies had small numbers of patients.

In our experience, NIV-pressure controlled - BIPAP ST is the first choice in acute hypercapnic respiratory failure with respiratory acidosis secondary to COPD exacerbation. We switch to hybrid modes (AVAPS) if the patient does not tolerate the ventilator or if there is no clinical improvement. NIV with AVAPS is the first choice in AECOPD in patients with either sleep apnea or morbid obesity, where in our opinion is superior to conventional non-invasive ventilation. In the end, our feeling is that the best ventilation mode, considering the international recommendations, is the one that you are familiar with, as experience is a key factor in NIV success. We use iVAPS, with good results in stable restrictive patients (neuromuscular or thoracic cage deformation), not in acute exacerbation.

Conclusions

1. Although intelligent modes have not been demonstrated to be superior to classic NIV COPD exacerbation, they are worth a trial in certain situations, as this could provide a better adaptation to the patient's own ventilatory pattern and needs, which vary.

2. Patients with COPD-OSA overlap syndrome and obesity hypoventilation syndrome seem to benefit the most from these intelligent modes in acute settings.

3. A rapid resolution of exacerbation reduces the risk of its complications: intubation and mechanical ventilation, prolonged corticosteroid aggravation of COPD myopathy, and deterioration of exercise capacity.

Conflicts of interest

Nothing to declare.

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