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Review Article

Non-invasive ventilation in the ED: Whom, When, How?

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ABSTRACT

As emergency physicians, we encounter patients suffering from either hypoxemic and/or hypercarbic respiratory problems on a daily basis. A stepwise approach to solving this problem seems logical from an emergency medicine perspective.

Current literature supports the notion that NIV decreases endotracheal intubation rates and, mortality in select patient populations. The key to the success of NIV is patient cooperation and support for the care givers.

In this narrative review, non-invasive ventilation (NIV) is discussed in terms of modes of delivery, interface and patient selection, as well as practical considerations.

1. Introduction

As emergency physicians, we encounter patients suffering from either hypoxemic and/or hypercarbic respiratory problems on a daily basis. A stepwise approach to solving this problem seems logical from an emergency medicine perspective. Nasal masks, non-rebreather masks with a reservoir, high flow nasal cannula (HFNC) and mechanical ventilation with either invasive or non-invasive methods are the procedures that can be performed during the ED course of a patient presenting with acute respiratory failure.

The history of the non-invasive ventilation (NIV) dates back to the 1940s. Although NIV was first used for patients with acute respiratory failure in the 1940s, it was not popular until the 1980s.[1]

Reversible disease processes, such as acute exacerbation of chronic obstructive pulmonary disease (AECOPD) or acute cardiogenic pulmonary edema (ACPE), are important for the success of NIV in an acute care setting. Current literature supports the notion that NIV decreases endotracheal intubation rates and, mortality in select patient populations. The key to the success of NIV is patient cooperation and support for the care givers.

In this narrative review, NIV is discussed in terms of modes of delivery, interface and patient selection, as well as practical considerations.

1.1. Modes

There are two types of NIV. The first mode is continuous positive airway pressure (CPAP), which applies a single pressure during inspiration and expiration (Fig. 1). During CPAP application, there are small variations in pressure during inspiration and expiration (Fig. 1). There is a pressure drop during inspiration and a rise in pressure during exhalation (Fig. 1). CPAP is most useful for those patients with hypoxemic respiratory failure (type 1). CPAP can be assumed to be analogous to positive end-expiratory pressure (PEEP) during mechanical ventilation with endotracheal intubation. BPAP is bi-level pressure applied during inspiration and expiration. Inspiratory positive airway pressure (IPAP) is the pressure support applied during inspiration, whereas expiratory positive airway pressure (EPAP) is the pressure applied during inspiration and expiration (Fig. 2). In this regard EPAP, CPAP and PEEP are analogous.

NIV reduces the work of breathing by counteracting with intrinsic PEEP, helps alveolar recruitment, decreases shunt and improves ventilation and perfusion. NIV also improves alveolar gas exchange and the removal of carbon dioxide, and decreases the oxygen consumption of the intercostal muscles. NIV increases the pressure inside the thorax. These pressure increases may impede venous return (preload) and, by lowering cardiac afterload, it acts as a left ventricular assist device. These physiological changes are the basis of NIV for the treatment of pulmonary edema, although

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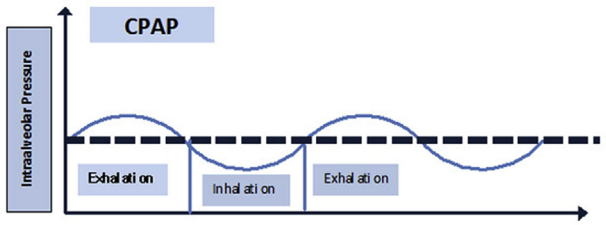

Fig. 1. CPAP: continuous positive airway pressure. A single pressure is applied during inspiration and expiration.

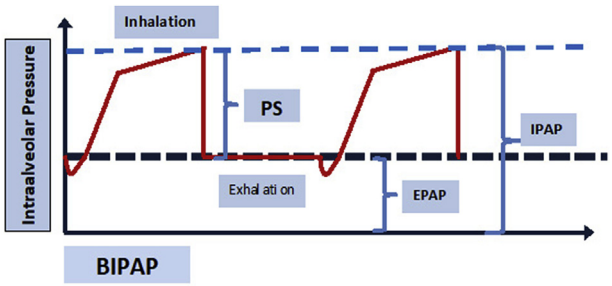

Fig. 2. BPAP IPAP: Inspiratory positive airway pressure, EPAP: Expiratory positive airway pressure, PS: Pressure Support. Here inspiration is triggered by patient effort and intra alveolar pressure increases; at the end of the inspiration a constant pressure (EPAP) is applied during expiration.

for preload-dependent patients, the increase in intrathoracic pressure may cause hypotension.

2. Patient selection

The successful application of NIV depends on the cooperation of the patient with the provider. There are some certain features that are suggestive of NIV success. The patient's diagnosis, clinical characteristics (intact dentation, lower APACHE score, good initial response to NIV), less air leaking and fewer secretions are indicators of success.[2] Strong, moderate and weak evidence for the application of NIV in certain diseases is indicated below (Table 1).

2.1. Acute exacerbation of chronic obstructive pulmonary disease

Chronic Obstructive Pulmonary Disease (COPD) is a disease characterized by expiratory airflow limitation and mucus hypersecretion. Exacerbation of COPD is known to have high mortality risk.[4] Traditional treatment of a patient with exacerbation includes oxygen, bronchodilators, systemic steroids and antibiotics. When all these measures fail, patients are intubated. However, intubation and extubation of patients with COPD carry high mortality rates. COPD exacerbation is a reversible process, so if physicians are able to buy some time for their patients, they may negate the unenviable consequences of this disease. According to a Cochrane Review published in 2004, data from good quality randomized controlled trials showed the benefit of NIV as first line intervention to be an adjunct therapy in usual medical care in all suitable patients with AECOPD.[5] When NIV plus usual medical care is compared with only usual medical care, treatment failure (RR 0.48, 95%CI:0.37–0.63), mortality (RR 0.52, 95%CI:0.35–0.76) and endotracheal intubation need (RR 0.42, 95%CI:0.33–0.53) were both less in the NIV group. The number needed to treat (NNT) for treatment failure, mortality and intubation was 5, 4 and 10 respectively.[5] NIV is the suggested ventilation in COPD patients with acute respiratory failure according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) 2017 report.[6] BPAP is the primary mode chosen. Early institution is crucial for the success of NIV. Indeed, a previous study indicated that the benefits of NIV were not seen after institution of usual treatment failure.[7]

In a recent Cochrane review, NIV was assessed for the management of hypercarbic respiratory failure due to exacerbation of COPD. The use of NIV decreased the risk of mortality (risk ratio (RR) 0.54, 95% confidence interval (CI) 0.38 to 0.76), and decreased the need for endotracheal intubation (RR 0.36, 95% CI 0.28 to 0.46).[8]

2.2. Acute cardiogenic pulmonary edema

ACPE is a leading cause of acute respiratory failure and it is an important medical issue with an increased in-hospital mortality rate.[4]

Increased end-diastolic pressure in the left ventricle decreases the preload in the left atrium and, according to communicating vessel law, increased pressure in the left atrium increases the pressure in the pulmonary vessel. Edema in the interstitial area and fluid in the alveoli disrupt gas exchange, and additionally cause a collapse in the alveoli and pathologic shunt formation, altogether causing hypoxemic respiratory failure.

The fundamental aim of the treatment of patients with ACPE is decreasing right ventricular preload and left ventricular afterload. The mainstay of treatment is oxygen, nitrates and diuretics. Here, the application of NIV not only decreases preload by increasing intrathoracic pressure, but acts also as a left ventricular assist device, thus decreasing afterload.

NIV is strongly suggested in the literature. In a Cochrane review, the addition of NIV to standard treatment was shown to be effective and safe intervention for patients with ACPE.[9] NNT values for in-hospital mortality and endotracheal intubation with CPAP were 9 and 8 patients respectively.[4] In a previous study, BPAP use was

Table 1
Types of evidences in certain diseases.

Type of Evidence	Disease	Source
Strong	AECOPD ACPE Immunocompromised patients Facilitation of weaning in COPD patients	Multiple randomized, controlled trials and meta-analyses
Intermediate	Preoxygenation in hypoxemic respiratory failure Postextubation respiratory failure	Single controlled trial and cohort series or multiple randomized studies with conflicting findings
Weak	ALI/ARDS Neuromuscular disease Pneumonia Status asthmaticus	Cohort studies, anecdotal reports and case series

AECOPD: Acute exacerbation of chronic obstructive pulmonary disease, ACPE: Acute cardiogenic pulmonary edema, COPD: Chronic obstructive pulmonary disease, ALI: Acute lung injury, ARDS: Acute respiratory distress syndrome.[2,3]

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