Noninvasive Mechanical Ventilation in Acute Ventilatory Failure
Rationale and Current Applications

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KEYWORDS

• Noninvasive mechanical ventilation • Acute respiratory failure • Hypoxemic
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KEY POINTS

- Noninvasive ventilation (NIV) plays a pivotal role in acute ventilator failure and has been shown, in certain disease processes such as acute exacerbation of chronic obstructive pulmonary disease, to prevent and shorten the duration of invasive mechanical ventilation, reducing the risks and complications associated with it.
- The application of NIV is relatively simple and well tolerated by patients and in the right setting can change the course of their illness.
- Appropriate indications, ventilatory equipment and ventilatory setting physicians training and patients selections are essentials.
- Early diagnosis and treatment of patient ventilator-asynchrony, evaluation of airflow, pressure volume and leaks monitoring are required.
- Still new emergent ventilatory modes, indications and prevention NIV failure need more large clinical trials.

RATIONALE

Acute ventilatory failure in patients with severe hypercapnic and hypoxemic respiratory failure may require endotracheal intubation (ETI) and invasive mechanical ventilation (IMV).[1] In such patients, IMV is associated with significant morbidity and mortality.[2] The use of noninvasive ventilation (NIV) as an alternative to ETI in these circumstances reduces the incidence of serious complications and length of stay (LOS).[2,3] Over the last 15 years, NIV has become a widespread technique for ventilatory support in the intensive care unit (ICU). Currently, the main indications for treatment with NIV in the ICU include the following: acute exacerbation of chronic obstructive pulmonary disease (AECOPD), cardiogenic pulmonary edema (CPE), acute lung injury, community-acquired pneumonia, and postextubation respiratory failure as a means to avoid reintubation.[1]

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PART 1. KEY PRACTICAL ASPECTS IN ACUTE VENTILATORY FAILURE: INTERFACE, DEVICES, AND PATIENT-VENTILATOR INTERACTION

Interface

Facemasks (FM) are the gold-standard interface for NIV in acute respiratory failure (ARF). FMs are available in many different sizes and allow for ventilation through the nose and/or mouth.[4] Even though the quality, fit, and tolerability of FM have improved considerably, it is common to see nose bridge skin breakdown after a few days of use, necessitating the need for use of a different interface.[5] The experience with treatment of chronic respiratory failure or obstructive sleep apnea (OSA) provides other alternatives, such as nasal masks (NMs) and mouthpieces.[6] The use of NM for NIV in patients with ARF is limited, because these patients are usually “mouth breathers,” resulting in major air leaks through the mouth, because the peak pressures are much higher than under nasal continuous positive airway pressure (CPAP). Another therapeutic option is the helmet, where there is no direct contact with the patient’s face, and the occlusion is made at the level of neck.[7]

Patient Ventilator Asynchrony

The characteristics (ie, dead space, compliance) of devices for bilevel positive airway pressure (BIPAP) have an important influence on patient-ventilator interaction.[8] A significant asynchrony between the beginning and the end of inspiratory support and the beginning and the end of patient inspiratory effort is commonly observed during BIPAP. Wasted efforts (when a patient’s inspiratory effort was not followed by a ventilator cycle), auto-triggering (when a ventilator cycle occurs without being preceded by a patient’s inspiratory effort), and prolonged inspirations (when each insufflation lasts longer than 1.5 seconds) may be also expected during NIV.[9] The patient-ventilator asynchrony is significantly higher during helmet BIPAP than during mask BIPAP.[8,9] Among the different masks, the asynchrony is more evident with mouthpiece compared with nasal or FM interfaces.[6] With regard to helmet use, the low elasticity and high inner volume of the device create a significant overdamping of pressure assistance and a deviation of ventilator-delivered flow from the patient in order to expand the compliant helmet (in particular, the soft collar) during BIPAP ventilation.[7] These impaired patient-ventilator interactions are responsible for the reduced efficiency of helmet BIPAP in unloading the respiratory muscles in conditions where increased respiratory muscle workload is a prominent feature.[10] A positive end-expiratory pressure (PEEP) of 6 cm H_2O might be helpful in this clinical setting.[8,9] The use of higher flows and higher pressures, if tolerated by patients, may also reduce the compliance of the helmet and optimize the efficiency of helmet BIPAP.[10]

PART 2. CURRENT INDICATIONS

Acute on Chronic Hypercapnic Respiratory Failure

Hypercapnia is defined as the elevation of the arterial partial pressure of CO_2 ($Paco_2$) >45 mm Hg, often as a result of either an increase in the dead space or decrease in the alveolar ventilation.[11] Hypercapnic respiratory failure may arise as a result of many causes and can be acute or acute on chronic, for example, in AECOPD or neuromuscular disorders at a time of acute illness (fever, infection, and so forth).[12] NIV has been extensively studied in the setting of hypercapnic respiratory failure and is considered the benchmark of treatment of AECOPD. During an AECOPD, the application of IPAP has been shown to subsequently result in a decrease in $Paco_2$, increase in the partial pressure of arterial oxygen (Pao_2), increase in pH, decrease in work of breathing (WOB), increase in tidal volume, and, as a result, a decrease in respiratory rate.[13,14]

When comparing outcomes of patients treated with NIV with those who received IMV at time of admission for AECOPD, patients treated with NIV had lower inpatient mortality, shorter LOS, and reduced incidence of nosocomial pneumonia.[15] A large prospective study looking at ICU admissions with severe AECOPD found that those initially treated with NIV had a 61% lower risk of dying in the ICU, a shorter ICU stay, and a 41% lower risk of hospital mortality when compared with those who were initially treated with ETI after matching for severity of illness.[16] These benefits are likely to be at least partially attributable to the avoidance of complications associated with IMV, such as ventilator-associated pneumonia and barotrauma. On the other hand, patients who failed NIV (defined as a later need for IMV) had the highest mortality and a longer hospital stay when compared with those who initially received IMV.[16] A Simplified Acute Physiology Score (SAPS II) greater than 34 was reported to be independently associated with need for IMV,[17] and the likelihood of NIV failure increases sharply with higher SAPS II scores.[16,17]

Obesity Hypoventilation Syndrome

Obesity hypoventilation syndrome (OHS) is defined as an awake $Paco_2$ >45 mm Hg in an individual with a body mass index >30 kg/m^2 when other causes of chronic alveolar hypoventilation have been ruled out. Serum bicarbonate level (>27 mmol/L) in the