CHEST

Initiation of Noninvasive Ventilation for Sleep Related Hypoventilation Disorders

Advanced Modes and Devices

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Although noninvasive ventilation (NIV) has been used since the 1950s in the polio epidemic, the development of modern bilevel positive airway pressure (BPAP) devices did not become a reality until the 1990s. Over the past 25 years, BPAP technology options have increased exponentially. The number of patients receiving this treatment both in the acute setting and at home is growing steadily. However, a knowledge gap exists in the way the settings on these devices are adjusted to achieve synchrony and match the patient's unique physiology of respiratory failure. This issue is further complicated by differences in pressure and flow dynamic settings among different types of NIV devices available for inpatient and home care.

CHEST 2018; 153(1):251-265

KEY WORDS: alveolar hypoventilation; cycle sensitivity; inspiratory time; noninvasive ventilation; trigger sensitivity

Prevalent alveolar and sleep related hypoventilation disorders include patients with COPD presenting with acute-on-chronic hypercapnic respiratory failure, overlap syndrome (COPD plus OSA), obesity hypoventilation syndrome (OHS), and progressive restrictive pulmonary disorders, such as thoracic cage abnormalities and neuromuscular disease (NMD). Careful selection of NIV mode and settings should be based on the patient's distinctive needs and level of acute illness. This review focuses on providing a practical approach to NIV in prevalent stable sleep-related alveolar hypoventilation syndromes, both in non-ICU hospital settings and at home, with emphasis on customizing NIV settings to the patient's unique physiology of respiratory failure.

Noninvasive ventilation (NIV) is used widely in hospitalized patients with COPD presenting with acute-on-chronic hypercapnic respiratory failure,[1,2] overlap

ABBREVIATIONS: ABG = arterial blood gas; ALS = amyotrophic lateral sclerosis; AVAPS = average volume-assured pressure support; AVAPS-AE = average volume-assured pressure support with auto-expiratory positive airway pressure; BPAP = bilevel positive airway pressure; CMS = Centers for Medicare & Medicaid Services; EPAP = expiratory positive airway pressure; FOT = forced oscillation technique; iPAP = inspiratory positive airway pressure; iPEEP = inspiratory positive end-expiratory pressure; iVAPS = intelligent volume -assured pressure support; NIV = noninvasive ventilation; NMD = neuromuscular disease; OHS = obesity hypoventilation syndrome; PAP = positive airway pressure; PC = pressure assist control mode; PS = pressure support; PSG = polysomnography; RR = respiration rate; S = spontaneous; ST = spontaneous timed; $TcCO_2$ = transcutaneous CO_2; Ti = inspiratory time; Ti max = maximal inspiratory time; Ti min = minimal inspiratory time; Va = alveolar ventilation; VAPS = volume-assured pressure support; V_T = tidal volume; V_{Te} = expiratory tidal volume

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DOI: http://dx.doi.org/10.1016/j.chest.2017.06.036

syndrome (COPD plus OSA)[3], and OHS, the latter being defined as obesity (BMI > 30 kg/m^2) and daytime hypercapnia ($Paco_2$ > 45 mm Hg), when other causes of chronic alveolar hypoventilation have been ruled out.[4-6] It is also frequently used in other causes of hypoventilation syndrome related to opioid and sedative use, as well as progressive restrictive pulmonary disorders such as thoracic cage abnormalities and NMD.[7-9]

A thorough understanding of NIV modes and settings is crucial to guarantee an uneventful transition from hospital to home for patients with chronic respiratory disease, but a knowledge gap exists about advanced NIV modes.[10] Although most pulmonary and critical care practitioners are comfortable with the use of inspiratory positive airway pressure (IPAP) and expiratory positive airway pressure (EPAP), other setting options are misunderstood and frequently ignored. Settings such as trigger and cycle sensitivity, rise time, and inspiratory time (Ti) are poorly understood and are usually left in the factory's default mode. The purpose of this review is to provide a practical approach to NIV in prevalent stable sleep-related alveolar hypoventilation syndromes, both in the non-ICU hospital setting and at home, with emphasis on customizing NIV settings to the patient's unique physiology of respiratory failure.

Bilevel Positive Airway Pressure Devices: What Is in the Box?

Hardware

In minimally monitored hospital areas and at home, the most common NIV devices being used are bilevel positive airway pressure (BPAP) devices exclusively designed to interact with a mask. They are basically composed of a blower (or turbine), a respiratory circuit (generally a single limb), heated humidity, and a mask. Based on flow and pressure sensors located in the device, a microprocessor-based controller is constantly adjusting the turbine speed (dynamic blower) to reach a preset device output (positive pressure).[11] The mask, which contains an obligatory leak to minimize CO_2 rebreathing, is the point of interface between the device (mechanical pump) and the patient (respiratory pump) (Fig 1A).[12] In highly monitored areas of the hospital (predominantly the ICU), other ventilator options (and circuits) are available for NIV, such as mechanical ventilators (MVs) with a capability to deliver NIV and hybrid mechanical ventilators (Table 1).

Software

1) Modes in BPAP—fixed vs self-adjusting (targeted) pressure: By definition, NIV encompasses BPAP devices that are capable of separately adjusting IPAP and EPAP.

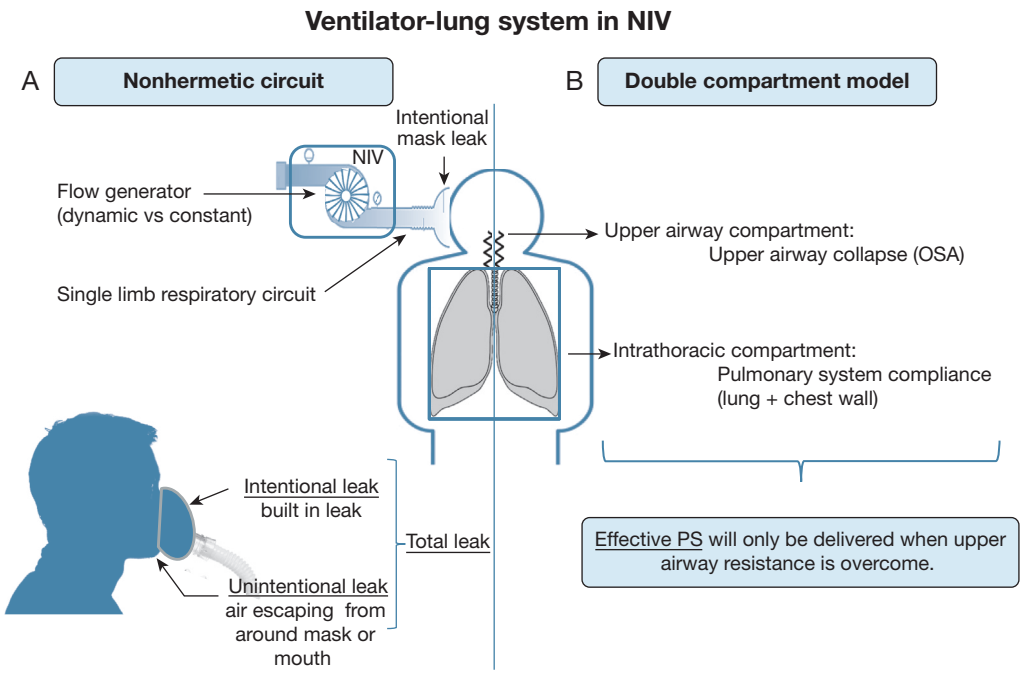

Figure 1 – *Ventilator-lung system in NIV. NIV = noninvasive ventilation; PS = pressure support.*