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Non-invasive positive ventilation in the treatment of sleep-related breathing disorders

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Abstract

This chapter addresses the use of long-term non-invasive positive pressure ventilation (NIPPV) (to the exclusion of continuous positive airway pressure) in the different clinical settings in which it is currently proposed: principally in diseases responsible for hypoventilation characterized by elevated $PaCO_2$. Nasal masks are predominantly used, followed by nasal pillow and facial masks. Mouthpieces are essentially indicated in case daytime ventilation is needed. Many clinicians currently prefer pressure-preset ventilator in assist mode as the first choice for the majority of the patients with the view of offering better synchronization. Nevertheless, assist-control mode with volume-preset ventilator is also efficient. The settings of the ventilator must insure adequate ventilation assessed by continuous nocturnal records of at least oxygen saturation of haemoglobin-measured by pulse oximetry. The main categories of relevant diseases include different types of neuromuscular disorders, chest-wall deformities and even lung diseases. Depending on the underlying diseases and on individual cases, two schematic situations may be individualized. Either intermittent positive pressure ventilation (IPPV) is continuously mandatory to avoid death in the case of complete or quasi-complete paralysis or is used every day for several hours, typically during sleep, producing enough improvement to allow free time during the daylight in spontaneous breathing while hypoventilation and related symptoms are improved. In case of complete or quasi-complete need of mechanical assistance, a tracheostomy may become an alternative to non-invasive access. In neuromuscular diseases, in kyphosis and in sequela of tuberculosis patients, NIPPV always significantly increases survival. Conversely, no data support a positive effect on survival in chronic obstructive pulmonary disease.

Keywords: Sleep disorders; Non-invasive positive ventilation; COPD; Neuromuscular disease; Chronic respiratory failure

1. Introduction

As early as the 1950s, limited experience with the long-term use of mechanical ventilation was acquired to replace or complement the ventilatory function after acute poliomyelitis [1]. Depending on the medical centers, the three main methods for delivering tidal volume were used: intermittent negative pressure ventilation [2–4], intermittent positive pressure ventilation (IPPV) by tracheostomy [4,5] or IPPV by mouthpiece [6,7]. These experiences have progressively encouraged a few clinicians to use therapeutic approaches such as these to chronically ventilate other types of respiratory insufficiency such as seen in Duchenne dystrophy, chest-wall deformities and even lung diseases [4,5,7–9]. Nevertheless, in the early 1980s, despite positive results, clinicians

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were reluctant to use these techniques, considering them too invasive (tracheostomy) or cumbersome or of limited efficacy to ventilate patients with impaired mechanics (negative pressure) [10]. It is now recognized, after the explosive experience of nasal continuous positive airway pressure therapy to treat obstructive apnea [11], that IPPV could also be comfortably and efficiently delivered non-invasively (NIPPV) through facial interfaces. Positive pressure is intermittently applied to the airway during inspiration at a higher value than during expiration, when pressure may remain positive or return to zero. Thus, NIPPV delivers a part or even the totality of the tidal volume. Depending on the underlying diseases, either IPPV is continuously mandatory to avoid death in the case of complete or quasi-complete paralysis or is used every day for several hours, typically during sleep, producing enough improvement to allow free time during the daylight in spontaneous breathing while hypoventilation and related symptoms are improved. This chapter will address the use of NIPPV (to the exclusion of continuous positive airway pressure (CPAP)) in the different clinical settings in which it is currently proposed: principally in diseases responsible for hypoventilation and, incidentally, in other disorders such as obstructive apnea or troubles of central drive (Cheyne–Stokes breathing, Ondine's curse). NIPPV is now the predominant technique for long-term home ventilation [12].

2. Methods of NIPPV and their uses

2.1. Interfaces

The need to select an appropriate and properly fitted interface cannot be overemphasized due to its impact on the quality of ventilation and on compliance with therapy [13–15]. The goal is a compromise between different objectives: minimized leaks, improved comfort and easy implementation. There is now a wide variety of different factory-made masks of different designs, shapes, sizes and materials. It is usually possible to find a mask that suits most individuals, which explains why the initial practice of an individually made interface is now seldom done even if that interface is probably the best [13–18]. There are four different types of factory-made interfaces: nasal mask, facial mask covering the nose and the mouth, nasal pillows or plugs and mouthpieces. Nasal masks are predominantly used, followed by nasal pillow and facial masks [13,19]. Mouthpieces are now essentially indicated in case of daytime ventilation [20,21]. This may afford an excellent and flexible adjunct to nocturnal ventilation mainly in neuromuscular patients who are unable to maintain acceptable diurnal arterial blood gases without frequent ventilatory assistance. The mouthpiece can be positioned close to the patient's mouth where it may be intermittently captured to take few assisted breaths from the ventilator and subsequently released. An advantage is that no interfaces need to be attached to the face, which befits social interactions. Thus, the patient needing assistance night and day may use a combination of interfaces.

2.2. Ventilator and mode for NIPPV

Ventilators use one of two basic methods: volume-preset and pressure-preset [13]. With volume-preset the ventilator always delivers the tidal volume which is set by the clinician, regardless of the patient's pulmonary system mechanics (compliance, resistance and active inspiration); however, leaks in the system (e.g., at the skin–mask interface, or mouth leaks when using a nasal mask) reduce the volume received by the patient. Conversely, with pressure-preset, changes in pulmonary mechanics directly influence the flow and the delivered tidal volume since the ventilator delivers the pressure which is set by the clinician. Within the limits of the flow capability and of the duration of inspiration, augmented flow is possible, which tends to compensate, although usually incompletely, leaks [22,23]. It is important to understand that NIPPV is dominated both by rapid variations of non-intentional leaks and of the geometry and the resistance of the upper airway [24]. Obviously leaks partly depend on resistance. Facing these continuous changes, the respective advantages and drawbacks of volume and pressure-preset mode, which are opposite, make a predictable effect difficult. The way to begin and end inspiration is either initiated by the ventilator or in response to a patient's effort to do so. Three ventilator modes are available: (a) when the ventilator starts and ends inspiration uniquely according to the settings prescribed by the clinician, the mode is called *control*; (b) when delivery of inspiration is initiated by either patient effort or according to programmed setting prescribed by the clinician (e.g., if the patient does not initiate a breath within a specified time interval), the mode is called *assist-control*; (c) when patient effort starts and ends inspiration the mode is called *assist* or *spontaneous.* Assist mode is only possible with pressure-preset. Most of the home ventilators function uniquely in volume or in pressure-preset, but modern ones may deliver inspiration according to the two manners [25]. Besides the classical circuitry including two valves (on the inspiratory and expiratory "limbs" of the ventilator circuit), alternatively closing and opening, bilevel positive airway pressure ventilators (BiPAP) are simpler and, therefore, lend themselves to home mechanical ventilation [26]. Inspiratory and expiratory pressure are alternatively established in a single circuit incorporating an intentional, calibrated leak located close to the patient or even on the mask. The theoretical drawback with such a circuit is the risk of variable CO_2 rebreathing. Concern about the risk of CO_2 rebreathing is not definitively