Scoring Abnormal Respiratory Events on Polysomnography During Noninvasive Ventilation

Jean-Louis Pepin, MD, PhD[a,*], Jean-Christian Borel, PhD[b], Olivier Contal, PhD[c], Jésus Gonzalez-Bermejo, MD, PhD[d], Claudio Rabec, MD[e], Renaud Tamisier, MD, PhD[a], Dan Adler, MD[f], Jean-Paul Janssens, MD[f]

KEYWORDS

• Noninvasive ventilation • Settings • Polysomnography • Titration

KEY POINTS

- Monitoring of nocturnal NIV is required to determine if NIV is correctly adapted to detect residual or de novo respiratory events and patient-ventilator asynchrony.
- Understanding and classifying the mechanisms involved in respiratory events under NIV is crucial for adapting appropriate NIV settings or interfaces.
- Periodic polysomnography is recommended by experts in the follow-up of home-ventilated patients.
- Future studies are needed to establish whether recognition and correction of these abnormalities during sleep positively impact long-term efficacy of NIV, compliance, or quality of life.

INTRODUCTION

Noninvasive ventilation (NIV) is widely accepted as a long-term treatment of chronic hypercapnic respiratory failure. NIV is predominantly applied at night, when profound changes in ventilatory patterns, respiratory drive, and respiratory and upper airway muscle recruitment occur. These physiologic conditions promote sleep hypoventilation and upper airway obstruction particularly in patients with chronic respiratory failure. NIV per se may also induce de novo undesirable respiratory events.[1,2] Positive pressure ventilation–induced hyperventilation has been shown to promote active periodic breathing and glottic closures. NIV is also inevitably associated with unintentional leaks, which have been shown to alter not only efficacy of ventilation, but also quality of sleep.

There are simple tools, such as oximetry, transcutaneous P_{CO_2}, and device software, available to assess NIV efficacy during sleep.[2] However, increasing awareness of nocturnal respiratory events occurring under NIV has led to a wider use of respiratory polygraphy and polysomnography (PSG) to improve adjustment of long-term

Conflict of Interest Statement: None of the authors has a conflict of interest regarding this article.
[a] INSERM U 1042, Sleep Laboratory, Grenoble University Hospital, CHU de Grenoble, Grenoble 38043, France; [b] Research and Development Department, AGIR à dom, Meylan 38240, France; [c] Department of Physiotherapy, HESAV School of Health Sciences, University of Applied Sciences Western Switzerland, Lausanne 1011, Switzerland; [d] Service de Pneumologie et Réanimation Respiratoire, Hôpital de la Pitié-Salpêtrière, Assistance Publique-Hôpitaux de Paris, Paris 75013, France; [e] Service de Pneumologie et Réanimation Respiratoire, Centre Hospitalier et Universitaire de Dijon, Dijon 21033, France; [f] Division of Pulmonary Diseases, Geneva University Hospitals, Geneva 1211, Switzerland
* Corresponding author. Laboratoire EFCR, CHU de Grenoble, CS 10 217, 38043 Grenoble Cedex 9, France.
E-mail address: JPepin@chu-grenoble.fr

Sleep Med Clin 9 (2014) 327–339
http://dx.doi.org/10.1016/j.jsmc.2014.05.002
1556-407X/14/$ – see front matter

NIV settings.[3] Whether systematic PSG is necessary for titrating NIV, as suggested by the American Academy of Sleep Medicine,[3] remains a subject of debate, but the first step is to improve knowledge about a correct classification of abnormal respiratory events under NIV. Appropriate analysis of polygraphic or polysomnographic recordings must take into account the type of ventilator used (volume- or pressure-cycled), ventilator settings (ventilatory mode, triggers), and type of interface (nasal or full face mask).

During NIV, there is a continuous interaction between the ventilator, generating an intermittent positive pressure, and the patient's neural respiratory drive. Therefore, events can result from the patient, the ventilator, or poor patient-ventilator coordination. This article summarizes how to score abnormal respiratory events on PSG during NIV. The most frequent problems detected are unintentional leaks (ie, not related to exhalation valve of interface), central or obstructive events (either residual or induced by NIV), persistent rapid eye movement (REM) hypoventilation, and patient-ventilator asynchrony. In this article we limit our description to pressure support ventilators with intentional leaks, which are by far the most widely used in chronic respiratory failure.

POLYSOMNOGRAPHIC FEATURES OF ABNORMAL RESPIRATORY EVENTS UNDER NIV

Unintentional Leaks

Detrimental effects of unintentional leaks

Leaks are by far the most common event occurring during NIV.[4] It has been demonstrated that major leaks cause microarousals and disrupt patients' sleep and conversely, that correction of mouth leaks is associated with improved sleep structure.[5] Leaks increase the probability of poor or nondetection of inspiratory efforts and may lead to unrewarded inspiratory efforts, or to other forms of patient-ventilator asynchrony with or without prolonged episodes of desaturation and hypoventilation.[1] Although home bilevel positive airway pressure (PAP) ventilators have a high capacity of leak compensation, increased flow related to leak compensation can also be a source of discomfort. In presence of leaks, we recently demonstrated that a higher percentage of cycles triggered by the ventilator occur and that there is a marked increase in respiratory effort proportional to the amount of the leaks.[6]

Recent ventilators designed for home care have built-in software that provides potentially useful information for the clinician in terms of monitoring NIV. Clinicians need to know if values of tidal volume (V_T), leaks, or apnea-hypopnea index recorded by built-in software are reliable and can be used. There is large variability in the reliability of the results particularly for V_T and this is specially the case with major leaks.[7] This means that V_T can be overestimated when associated with important leaks and this can lead clinicians to improperly adjust the ventilator settings.

Polysomnographic features of unintentional leaks occurring under NIV

The importance of the leak and the ability of the ventilator to compensate for leaks determines whether the pressure signal amplitude remains stable or decreases. A fall in positive pressure (inspiratory and expiratory) indicates major unintentional leaks (**Fig. 1**). With pressure-controlled ventilators, an increase in ventilator flow signal during insufflation with a simultaneous decrease in thoracic and abdominal belt signal amplitude is suggestive of unintentional leaks (see **Fig. 1**). Ventilator flow increases to compensate for drop in pressure, but leaks result in decreased effective V_T delivered to the patient. If present on baseline tracing (pneumotachograph between mask and expiratory valve), an amputation of the expiratory part of the flow curve indicates the loss of expiratory flow in the circuit and thus leaks (see **Fig. 1**).

Additionally, leaks may promote the nondetection of the patient's inspiratory efforts by the ventilator. This may result in patient-ventilator asynchrony with a switch to back-up respiratory frequency in assist-controlled mode or to autotriggering of the ventilator (**Fig. 2**).

Central Events Under NIV: Partial or Total Upper Airway Obstruction with Reduction of Ventilatory Drive

Physiologic and mechanistic background

Ventilatory control is physiologically altered during sleep, with a decreased responsiveness to chemical, mechanical, and cortical inputs.[1] The Pa_{CO_2} apneic threshold is unmasked, at 1.5 to 5.8 mm Hg below eupneic Pa_{CO_2}.[8] If NIV settings lead to hyperventilation, bursts of central apnea or hypopnea can occur, particularly during transitions between sleep onset and wakefulness. Furthermore, NIV has the potential to induce periodic breathing during sleep (**Fig. 3**).[9] In a PSG study, 40% of obese patients using NIV showed a high index of periodic breathing, mostly occurring in light stages of sleep and associated with severe nocturnal hypoxemia.[10] The susceptibility to induction of periodic breathing varies considerably among subjects; its occurrence under NIV is thus difficult to predict and needs to be specifically monitored. It is possible that not only hyperventilation, but