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Editorial

# Noninvasive Mechanical Ventilation. Reflections on Home Monitoring☆

## Ventilación mecánica no invasiva. Reflexiones sobre la monitorización a domicilio

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Home-based noninvasive ventilation (NIV) was initiated in the early nineties in our environment as a treatment for patients with chronic respiratory failure, secondary to restrictive ventilatory disorders or neuromuscular disease. Subsequently, NIV also proved effective in patients with obesity-related hypoventilation syndromes, and to a lesser extent in some patients with chronic obstructive pulmonary disease in stable phase. There was a simultaneous growth in interest in whether the selected parameters suited the patients' needs when using NIV in the home setting. Thus, the use of continuous overnight pulse oximetry monitoring as the gold standard for home monitoring in centers prescribing ventilation became widespread. The main issue with pulse oximetry has undoubtedly been its lack of specificity for correlation with certain patterns of patient–ventilator interaction. In other words, the effects of adverse events (desaturation) were detected, but there was a limited understanding of the underlying causes, and therefore of the potential solutions.

In order to improve the performance of pulse oximetry, a series of simplified polygraphic systems have appeared in recent years, mostly in association with the ventilator manufacturers. These systems provide a set of data on the patient's respiratory mechanics that can be downloaded from the ventilator's internal memory. The main purpose is to provide the clinician with additional information on the potential reasons for inadequate ventilation periods and the pathophysiological causes (unintentional interface leaks, uncorrected upper airway episodes, asynchrony, etc.). Over the years, almost all manufacturers of ventilation systems have developed their own download system and data display.[1] However, in our view, the performance and reliability of these devices, which are widely used today, should be analyzed in depth.

The first premise to be considered by the clinician is that a number of values provided by these software systems are not measured directly. In single-tube systems, the most widely used in home

NIV, these values are actually estimated from the internal measurements of the ventilator. In such systems, the ventilator's single tube detects all the gas provided during the different phases of the respiratory cycle, but must discriminate between the amount corresponding to the tidal volume and leaks (both intentional and unintentional). It follows that these two parameters are estimated from a series of algorithms. The first surprising aspect is that virtually no home ventilator has a system to discriminate the value of intentional leak, either by enabling a leak test (building a pressure–leakage curve, with occlusion distal to the leakage site) or by selecting the specific interface used in a ventilator-integrated menu. Obviously, the value of intentional leak is different depending on whether a full-face interface, a nasal interface or an Adams model is used. It is important to take this parameter into account in order to discriminate between intentional and unintentional leaks, and also to estimate the tidal volume.

To assess reliability in the laboratory setting, Contal et al.[2] carried out one of the first validation analyses of these estimations. The study analyzed seven ventilators in a controlled environment with specific respiratory mechanics, effort and level of continuous incremental leak. The results showed that all ventilators analyzed underestimated the tidal volume to a greater or lesser extent. Also, there was a great disparity between leakage estimations. In our view, the most important issue in this study is not the magnitude of the deviations, but the differences between devices, which are attributable more to differences in estimation algorithms than to the variability of the sensors used. Using a similar experimental model, our group showed that a possible reason for underestimation could be a lack of compensation for pressure loss in the tube.[3] Assuming that ventilators calculate leakage as a pressure function, it is understandable that estimations may vary depending on whether the pressure is measured within the ventilator itself or at the end of a 2-m long tube.

These results were obtained in experimental designs of continuous leakage. However, the actual behavior of leakage in the clinical setting should not be simplified to such an extent. A subsequent design analyzed the behavior of these parameters using a dynamic random leak model, with predominance in one or other phase of the cycle. The results of the inspiration-dominant leakage model (the most plausible from a clinical point of view) were

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diametrically opposed to those of the continuous leakage model. That is to say, tidal volume was overestimated in percentages of up to 30% of the actual volume.[4] The fact that many of these ventilators also incorporate dual control ventilation modes (pressure support with guaranteed volume) is particularly worrying, since the device makes decisions independently in these modes (increase or decrease in pressure support) based on the estimated tidal volume.

Clearly, all these issues are food for thought for manufacturers and NIV-prescribing specialists. It is little wonder, then, that the SomnoNIV expert panel grants a low level of evidence to software monitoring systems, since they are not clinically validated or based on the recommendations of scientific societies.[5] Nor does the limited clinical experience in the literature invite confidence.[6,7] Obviously, the estimation algorithms for ventilator settings are developed by manufacturers, and are the responsibility of their respective departments for research and development. However, in view of the reliability results observed by independent groups, such algorithms should be reported and homogenized. If this is not possible, the alternative should be the development of independent monitoring tools offering the parameters needed to provide the minimal required information on patient–ventilator interaction in the patient's usual environment. Such devices should be able to serve the dual function of transmitting real-time information, while storing it for later analysis. In other words, there is a requirement for independent polygraph systems, with real signal capture in the ventilator branches, that are simple enough to be used in the patient's home, similar to the monitors used in sleep disordered breathing units.

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## Conflicts of Interest

The authors declare no conflict of interest.

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