

Scientific letter

Sham CPAP as a Practical Preevaluation Technique for Home Mechanical Ventilation



CPAP subterapéutica como técnica práctica de preevaluación en ventilación mecánica domiciliaria

Dear Editor,

Home mechanical ventilation (HMV) is the standard treatment in selected patients with chronic ventilatory failure.^{1–3} At present, the patient's response to HMV is determined by evaluating data from the ventilator's built-in software and by analyzing the individual–ventilator interaction.^{4,5}

During the night of adaptation to HMV, subtherapeutic ventilator settings (i.e., low pressure) are used to improve initial treatment adherence.⁶ During this acclimatization process, the ventilator software allows us to detect obstructive events (apnoea-hypopnea index; AHI) and to determine the patient's spontaneous nocturnal ventilatory pattern (NVP). Both the AHI and NVP can be highly useful in selecting the most appropriate ventilatory parameters.

The present cohort study involved patients with chronic hypoventilation with an indication for HMV treated at a tertiary university hospital between the years 2017 and 2021. The study was approved by the hospital ethics committee (Hospital de la Santa Creu i Sant Pau, Barcelona, Spain; IIBSP-VMD-2019).

Participant data were prospectively included in a database used for equipment-related purposes. Clinical data and outcomes for all patients who completed the treatment protocol were retrospectively reviewed.

Nighttime Sham CPAP (4 cm H₂O) recording was performed with a facemask and Stellar™ 150 ventilator (ResMed, Bella Vista, NSW, Australia) with its built-in ResScan™ data program. The built-in software (ResScan) provides the following NVP data: tidal volume (Vt); minute ventilation (VM); respiratory rate (rr); inspiratory time [Ti]; Ti/Total cycle time ratio (Ti/Ttot); unintentional leak (median and p95); and obstructive events (AHI).

The variables were compared using ANOVA or Kruskal–Wallis test. Correlations between continuous variables were performed using the Spearman test. Statistical analyses were performed with the IBM-SPSS Statistics, v. 22 (IBM Corp., Armonk, NY, USA).

Initially, 32 patients were included in the study. However, three were excluded due to technical issues (inability to download the data from the software program). Consequently, a total of 29 patients were included in the final analysis. The procedure was well-tolerated by all patients.

The mean ($\pm$ SD) patient age was 67 ± 12 years. Most patients (72%) were women. The most common diagnosis was obstructive disease, present in 14 patients (49%), followed by restrictive disease in 7 (24%), slow-onset neuromuscular disease in 5 (17%), and

fast-onset neuromuscular disease in 3 (10%). Respiratory function data for all patients are shown in Table 1.

The mean rate of obstructive events was 12 events/h, with no differences between the different diagnostic groups (shown in Table 2). No significant between-group differences in the NVP were observed, except for a higher Vt and MV in obstructive patients compared to restrictive patients (shown in Table 2). Globally, no variable related to the ventilatory pattern (rr, Ti, Ti/Tot) was correlated with the effective MV of the patient.

Surprisingly, in this cohort of patients with an indication for HMV, we did not observe any significant differences in spontaneous NVP values between the diagnostic groups. Also, globally, the NVP was not related to the patient's VM. The AHI, with a mean of 12 events/h, was high in all treatment groups, but without significant differences between the groups.

Many expert groups recommend implementing a progressive approach to HMV adaptation in order to improve tolerance.^{7–9} However, previous studies have not evaluated the role of the ventilatory pattern and/or the presence of previous obstructive events in patients on HMV. In fact, to our knowledge, this is the first study to assess and compare NVP in patients with different respiratory conditions and also to evaluate the prevalence of obstructive events prior to the start of HMV.

The AHI estimation method using the respiratory software has been previously validated.¹⁰ Paradoxically, the obese patients (rib cage disease) included in this study did not present higher AHI values than the non-obese patients. Patients with neuromuscular disease have a higher AHI level, possibly, due to instability of the upper airway and this is important to recognize so as not to later attribute it to a ventilation effect. It is important to assess the AHI because this information can help determine – especially in patients with a high AHI – whether future obstructive events are related (or not) to the mask or ventilator settings. In patients with a high AHI, it seems reasonable to select a higher PEEP.

An advantage of determining the spontaneous respiratory rate at night is to help select the most appropriate safety frequency in each ventilation mode.¹¹ Similarly, the spontaneous Ti value is important to set certain sub-parameters, such as the minimum Ti. In our study, the spontaneous Ti did not differ between diagnostic groups. Thus, the underlying disease should not condition the ventilatory sub-parameters related to the ventilatory pattern (Ti; Ti min). In any case, the type of patient's ventilatory pattern does not correlate with the effective MV itself. In other words, there does not seem to be one ventilatory pattern more effective than another. Finally, the spontaneous VM, ineffective for the patient, allows us to determine the minimum VM needed for treatment; this is especially important when using intelligent ventilation modes (assured volume mode).¹²

The acclimatization process, together with determination of the respiratory data described above, can be especially useful in

Table 1
Respiratory function data.

Variable ^a	Total (n = 29)	Obstructive (n = 14)	Restrictive (n = 7)	Neuromuscular (n = 8)	p-Value
FVC, %	57 ± 20	59 ± 17	66 ± 24	39 ± 11	0.035 ^b
FEV1, %	44 ± 25	31 ± 17	70 ± 29	45 ± 12	0.006 ^c
FEV1/FVC, %	59 ± 26	39 ± 16	73 ± 12	90 ± 9	0.000 ^d
PaO ₂ , mmHg	69 ± 20	66 ± 19	69 ± 25	74 ± 22	0.607
PaCO ₂ , mmHg	57 ± 8	59 ± 6	60 ± 4	52 ± 12	0.106
pH	7.39 ± 0.3	7.38 ± 0.3	7.39 ± 0.2	7.40 ± 0.03	0.580
Excess bases (meq/L)	7 ± 4	8 ± 3	9 ± 5	5 ± 5	0.235

Abbreviations: FVC, forced vital capacity; FEV1, forced expiratory flow in 1 second.

^a Median and standard deviation.

^b Restrictive vs neuromuscular patients.

^c Restrictive vs obstructive patients.

^d Neuromuscular and restrictive vs obstructive patients.

Table 2
Data provided by the built-in software.

Variables ^a	Total (n = 29)	Obstructive (n = 14)	Restrictive (n = 7)	Neuromuscular (n = 8)	p-Value
AHI (event/h)	12 ± 15	11 ± 12	8 ± 7	15 ± 23	0.917
rr (rpm)	23 ± 6	22 ± 8	22 ± 3	26 ± 6	0.281
Leak (mean L/min)	4 ± 6	5 ± 7	2 ± 3	5 ± 6	0.448
Leak (p95, L/min)	32 ± 41	27 ± 41	33 ± 41	43 ± 47	0.344
Ti (s)	0.90 ± 0.24	0.99 ± 0.25	0.87 ± 0.15	0.78 ± 0.23	0.118
Ti/Tot	0.32 ± 0.05	0.32 ± 0.05	0.32 ± 0.04	0.33 ± 0.06	0.938
VM (L/min)	5.77 ± 1.56	6.34 ± 1.51	4.64 ± 0.87	5.75 ± 1.72	0.034 ^b
Vt (L)	0.27 ± 0.10	0.31 ± 0.11	0.21 ± 0.04	0.23 ± 0.08	0.047 ^b
rr/Vt (rpm/L)	106 ± 65	89 ± 74	108 ± 29	135 ± 68	0.060

Abbreviations: AHI, apnoea-hypopnea index; Ti, inspiratory time; rr, respiratory rate; Vt, tidal volume; VM, minute ventilation.

^a Median and standard deviation.

^b Obstructive vs restrictive patients.

the process of outpatient adaptation, telemonitoring, and remote treatment.^{8,13}

The main limitation of this study is the retrospective data analysis. However, patient recruitment was done prospectively. Another limitation is the sample size, which may explain, at least partially, the lack of differences. However, no clear trends were observed either.

The findings of this study show that patients with an indication for HMV may present a high rate of obstructive events. Interestingly, we observed no differences in the ventilatory patterns in this patient cohort, regardless of the specific underlying pathology. Also, the ventilatory pattern did not correlate with the effective MV. Overall, our findings suggest that determination of the NVP and AHI during the night of acclimatization to HMV is highly beneficial, as it can facilitate selection of the optimal ventilatory parameters, especially during the process of outpatient adaptation and remote monitoring.

Funding

The study does not have external funding.

Authors' contributions

JD: study design, requests, data management, and manuscript review.

MG: study design, data management, and manuscript review.

AA: study design, data management, and manuscript editor.

Conflicts of interest

The authors declare that they have no conflicts of interest.

References

1. Randerath W, Verbraecken J, Andreas S, Arzt M, Bloch KE, Brack T, et al. Definition, discrimination, diagnosis and treatment of central breathing disturbances during sleep. *Eur Respir J*. 2017;49. <http://dx.doi.org/10.1183/13993003.00959-2016>.
2. Mokhlesi B, Masa JF, Afshar M, Balachandran JS, Brozek JL, Dweik RA, et al. Evaluation and management of obesity hypoventilation syndrome. An official American Thoracic Society clinical practice guideline. *Am J Respir Crit Care Med*. 2019;200:E6–24.
3. Ergon B, Oczkowski S, Rochwerf B, Carlucci A, Chatwin M, Clini E, et al. European Respiratory Society guidelines on long-term home non-invasive ventilation for management of COPD. *Eur Respir J*. 2019;54:1901003. <http://dx.doi.org/10.1183/13993003.01003-2019>.
4. Gonzalez-Bermejo J, Janssens JP, Rabec C, Perrin C, Lofaso F, Langevin B, et al. Framework for patient-ventilator asynchrony during long-term non-invasive ventilation. *Thorax*. 2019;74:715–7.
5. Janssens JP, Borel JC, Pépin JL. Nocturnal monitoring of home non-invasive ventilation: the contribution of simple tools such as pulse oximetry, capnography, built-in ventilator software and autonomic markers of sleep fragmentation. *Thorax*. 2011;66:438–45.
6. Hannan LM, Rautela L, Berlowitz DJ, Mc Donald CF, Cori JM, Sheers N, et al. Randomised controlled trial of polysomnographic titration of noninvasive ventilation. *Eur Respir J*. 2019;53:1802118. <http://dx.doi.org/10.1183/13993003.02118-2018>.
7. Pallero M, Puy C, Güell R, Pontes C, Marti S, Torres F, et al. Ambulatory adaptation to noninvasive ventilation in restrictive pulmonary disease: a randomized trial with cost assessment. *Respir Med*. 2014;108:1014–22. <http://dx.doi.org/10.1016/j.rmed.2014.04.016>.
8. Duiverman ML, Vonk JM, Bladder G, Van Melle JP, Nieuwenhuis J, Hazenberg A, et al. Home initiation of chronic non-invasive ventilation in COPD patients with chronic hypercapnic respiratory failure: a randomised controlled trial. *Thorax*. 2020;75:244–52.
9. Murphy PB, Patout M, Arbane G, Mandal S, Katsakas G, Polkey MI, et al. Cost-effectiveness of outpatient versus inpatient noninvasive ventilation setup in obesity hypoventilation syndrome: the OPIP trial. *Thorax*. 2023;78:24–31.
10. Georges M, Adler D, Contal O, Espia F, Perrig S, Pepin JL, et al. Reliability of apnea-hypopnea index measured by a home bi-level pressure support ventilator versus a polysomnographic assessment. *Respir Care*. 2015;60:1051–6.
11. Macias A, Alvarez JM, Perez N, Puy C, Peñacoba P, Segura M, et al. Controlled cycles in spontaneous-timed noninvasive ventilation:

- incidence and associated factors. *Respir Med.* 2022;204:107005, <http://dx.doi.org/10.1016/j.rmed.2022.107005>.
12. Selim BJ, Wolfe L, Coleman JM, Dewan NA. Initiation of noninvasive ventilation for sleep related hypoventilation disorders: advanced modes and devices. *Chest.* 2018;153:251–65.
 13. Montserrat JM, Suárez-Girón M, Egea C, Embid C, Matute-Villacis M, Martínez LM, et al. Spanish Society of Pulmonology and Thoracic Surgery positioning on the use of telemedicine in sleep-disordered breathing and mechanical ventilation. *Arch Bronconeumol.* 2021;57:281–90.

Jose M^a Díaz^a, Maria del Mar García^b, Macarena Segura^c,
Antonio Antón^{c,*}

^a Respiratory Department, Hospital Universitario de Getafe (HUG), Madrid, Spain

^b Respiratory Department, Hospital Universitario Torrecárdenas, Almería, Spain

^c Respiratory Department, Hospital de la Santa Creu i Sant Pau, Barcelona, Spain

* Corresponding author.

E-mail address: panton@santpau.cat (A. Antón).