Study of the value of percutaneous nocturnal oximetry in the monitoring of obese hypoventilation syndrome patients under non invasive home ventilation

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Background Nocturnal noninvasive ventilation (NIV) is often a treatment option for obesity hypoventilation syndrome (OHS). Monitoring this treatment is important to verify its efficacy.

Aim The aim of the present study was to assess the role of overnight pulse oximetry in the monitoring of OHS patients under NIV.

Patients and methods Twenty patients with OHS using nocturnal bilevel positive airway pressure therapy without supplemental oxygen were included in the present study. Overnight pulse oximetry study was performed, and according to the results, the patients were divided into two groups: group I (normal study) and group II [abnormal study showing nocturnal percutaneous oxygen saturation (SpO_2) $<$90% in $\geq$10% of the total recorded time]. Group II patients were subjected to respiratory polygraphy for more detailed assessment, and then, appropriate therapeutic modifications were done, after which a second overnight pulse oximetry study was performed to verify the efficacy of ventilation after these modifications.

Results Twenty OHS patients using nocturnal NIV were included in the present study. There were eight (40%) male patients and 12 (60%) female patients, with a mean age of 58.7±7.39 years. The mean BMI was 45.86±3.71 kg/m^2. Group I consisted of 11 (55%) patients and group II had nine (45%) patients. Respiratory polygraphy performed to group II detected airway obstruction in two patients, insufficient ventilation in five patients and significant nonintentional leaks in two patients. Therapeutic modifications were done, and then a second overnight pulse oximetry performed showing normal results in seven patients, whereas two patients showed lesser desaturations but results were still abnormal.

Conclusion Overnight pulse oximetry is a very useful tool in assessment of NIV efficacy in OHS patients, it is portable, simple, and it can detect oxygen desaturations that direct to perform further tests to apply appropriate therapeutic modifications to optimize NIV.

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Introduction

Obesity became a global phenomenon affecting, adults, children, and adolescents, and its prevalence is increasing worldwide [1]. Obesity hypoventilation syndrome (OHS) refers to a combination of obesity (i.e. BMI$\geq$30 kg/m^2) and awake chronic hypercapnia (i.e. $PaCO_2\geq$45 mmHg) accompanied by sleep-disordered breathing. It is important to recognize that OHS is a diagnosis of exclusion and should be distinguished from other conditions that are commonly associated with hypercapnia [2]. In general, patients with OHS are middle-aged with a 2 : 1 male-to-female ratio. These patients tend to be extremely obese and experience significant sleep-disordered breathing. The incidence of obese hypoventilation is steadily increasing because of the global epidemic of obesity. On presentation, the patients usually report the classic symptoms of obstructive sleep apnea (OSA) such as fatigue, hypersomnolence, loud habitual snoring, nocturnal choking episodes, and morning headaches. In contrast to patients with simple OSA, dyspnea, lower extremity edema, and low oxygen saturation measured by pulse oximetry during wakefulness are common. A restrictive defect seen on pulmonary function tests is common and is due to obesity [3].

The optimal management of patients with OHS remains uncertain. Several studies have reported improvement in chronic daytime hypercapnia and hypoxia with positive airway pressure (PAP) therapy [continuous PAP or bilevel positive airway pressure (BiPAP)]. It is not uncommon that patients with OHS require oxygen therapy in addition to PAP therapy upon initiation of treatment. Although PAP is the mainstay of therapy in both OSA and OHS patients, there is no standard protocol for its titration [4]. The improvement in hypercapnia and hypoxia is directly related to the daily dose of PAP therapy, and maximum improvement in blood gas levels is achieved as early as 1 month after the start of therapy [5]. Several

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comorbidities have been reported to be associated with OHS, the most frequently seen are arterial hypertension, heart failure, pulmonary hypertension, type II diabetes mellitus, and erythrocytosis [6–8].

Accordingly, identifying patients with OHS in a timely manner is important and treatment should be initiated without delay to avoid adverse outcomes such as repeated hospital admissions, acute on top of chronic respiratory failure requiring intensive care monitoring, or death. More importantly, adherence with therapy, especially PAP therapy, should be emphasized and monitored objectively [7].

Aim

The aim of the present study was to assess the role of overnight pulse oximetry in the monitoring of OHS patients under noninvasive ventilation (NIV).

Patients and methods

Twenty patients with OHS were included in this prospective study; the patients were recruited from private clinics during the year 2016 and the tests were performed at the patient's home.

Inclusion criteria

Patients with already diagnosed OHS (BMI$\geq$30 kg/m^2, $PaCO_2 \geq 45$ mmHg), and using nocturnal NIV in the form of BiPAP, without supplemental oxygen.

Exclusion criteria

Patients with OHS using supplemental oxygen with BiPAP, or who have associated significant respiratory disorder (interstitial pulmonary diseases, neuro-muscular disorders), or patients who refuse to participate in the study or refuse to sign the informed consent were excluded.

The approval of the ethical committee was obtained to perform the study, and all the patients signed a written informed consent.

The included patients were subjected to the following:

Overnight pulse oximetry was performed while the patients using BiPAP. The device used to perform this test was Nonin 3150 (Nonin Medical Inc., Plymouth, Minnesota, USA). The device is portable, can be attached around the wrist with a small sensor arising from it, and clipped onto the skin of the index or any other finger. The most important parameters recorded by this device include oxygen desaturation index, minimum and maximum oxygen saturation, cumulative time spent below a specified saturation, average and lowest pulse rate. The data analysis was computerized with automatic scoring, and data processing is done using powerful statistical and mathematical methods.

According to the results, the patients were divided into two groups: group I: normal study showing nocturnal SpO_2 more than 90% for more than 90% of the recorded time; and group II: abnormal study showing nocturnal SpO_2 less than 90% in 10% or more of the total recorded time [9].

No further investigations was performed to group I, whereas patients in group II were subjected to respiratory polygraphy done at home under NIV using the polygraph (Embletta PDS; ResMed, Abingdon, UK) for further assessment of the cause of desaturations. The following signals were detected:

(1) Flow/pressure.
(2) Chest wall movement (by thoracic belt).
(3) Abdominal movement (by abdominal belt).
(4) Oximeter (monitoring the average and beat to beat saturation, pulse rate, and pulse waveform).

The software Somnologica for Embletta provides a computer-based analysis that allows automatic or manual scoring of predefined breathing events or oxygen desaturation.

According to the results of respiratory polygraphy under NIV, the most probable detected cause of ineffective ventilation was managed. Application of appropriate therapeutic intervention in the form of modifications in the ventilator settings or adjustment of the interface.

A second overnight pulse oximetry study was performed to patients in group II to detect any further periods of desaturation after the therapeutic modifications had been applied to assess the impact of these modifications.

Statistical analysis

Data were tabled and statistically analyzed using SPSS version 15 (SPSS Inc., Chicago, Illinois, USA). Parametric data were expressed as minimum, maximum, mean±SD. Comparisons of parametric data between two groups were done using the unpaired *t*-test. Comparison between predata and postdata among the same group was carried out using the paired *t*-test. Nonparametric data were

expressed as number and percentage. Comparison between two groups as regards nonparametric data was done using Fisher's exact test. Two-tailed *P*-value greater than 0.05 was considered insignificant and less than or equal to 0.05 was considered statistically significant.

Results

Twenty patients with OHS and using nocturnal BiPAP were included in the present study. There were eight (40%) male patients and 12 (60%) female patients. The mean age of the studied patients was 58.7±7.39 years, and the mean BMI was 45.86±3.71 kg/m^2. All the patients were using BiPAP in spontaneous time mode, and the duration of BiPAP treatment ranged from 3 to 36 months, with a mean duration of 11.4±8.35 months. Table 1 demonstrates sociodemographic and duration of NIV in the studied patients.

Overnight pulse oximetry was performed to all patients, and according to the results, the patients were divided into two groups. Group I consisted of 11 (55%) patients: normal results (nocturnal SpO_2>90% for >90% of the recorded time). Group II (nine patients): abnormal results (nocturnal SpO_2<90% for more ≥10% of the recorded time). Table 2 shows overnight pulse oximetry results.

Table 3 shows a comparison between both groups as regards sociodemographic data, ventilation parameters, and overnight pulse oximetry results. The mean BMI was 44.36±3.11 kg/m^2 in group I versus 47.68±3.72 kg/m^2 in group II, showing a statistically significant difference. The duration of NIV was longer in group I, with 14.81±9.67 versus 7.22±3.59 months in group II, with a statistically significant difference. The percentage of time spent with of SpO_2 less than 90% was significantly different between the two groups: group I showed a mean percentage of time less than 90% of 4.27±1.84, whereas in group II, it was 23±6.26 with much more oxygen desaturations.

Respiratory polygraphy results in group II showed that the most probable cause of oxygen desaturation was airway obstruction in two (22.2%) patients, insufficient ventilation in five (55.5%) patients, and significant nonintentional leaks in two (22.2%) patients.

Therapeutic modifications were applied as following:

(1) In cases of airway obstruction, expiratory PAP was increased from 5 to 7 mmHg in one patient and from 6 to 8 mmHg in the other patient.
(2) In cases of significant leaks, interface adjustment was done to one patient, and the interface was changed for the other patient (nasal mask replaced by an oronasal).
(3) In cases of insufficient ventilation, inspiratory PAP was increased by 2–4 mmHg.

Following the application of these modifications, a second overnight oximetry was performed to group II, patients were showing a mean percentage of time with

Table 1 Sociodemographic and duration of noninvasive ventilation in the studied patients

	Minimum–maximum (mean±SD)
Age (years)	46–69 (58.7±7.39)
Sex (male/female) [*n* (%)]	8 (40)/12 (60)
BMI (kg/m^2)	40.1–53.1 (45.86±3.71)
Duration of NIV (months)	3–36 (11.4±8.35)

NIV, noninvasive ventilation.

Table 2 Overnight pulse oximetry results

Overnight oximetry results	*N* (%)
Normal (group I)	11 (55)
Abnormal (group II)	9 (45)

Normal study: nocturnal SpO_2>90% for >90% of the recorded time. Abnormal study: nocturnal SpO_2<90% in ≥10% of the total recorded time.

Table 3 Comparison between both groups as regards sociodemographic data, ventilation parameters, and overnight pulse oximetry results

	Group I (*n*=11) [minimum–maximum (mean±SD)]	Group II (*n*=9) [minimum–maximum (mean±SD)]	*P*
Age (years)	46–69 (57.27±8.95)	53–67 (60.44±4.85)	0.3
Sex (male) [*N* (%)]	4 (36.36)	4 (44.44)	1
BMI (kg/m$^{2)}$	40.1–49.5 (44.36±3.11)	42–53.1 (47.68±3.72)	0.04*
Duration of NIV (months)	3–36 (14.81±9.67)	3–12 (7.22±3.59)	0.03*
IPAP (mmHg)	14–18 (16.63±1.68)	14–18 (16.11±1.61)	0.4
EPAP (mmHg)	4–8 (5.9±1.37)	5–8 (5.77±0.97)	0.8
RR (breaths/min)	10–14 (12.36±1.2)	10–14 (12.22±1.56)	0.8
Duration of oxygen desaturation (% of recorded time)	2–8 (4.27±1.84)	16–35 (23±6.26)	0.0001*

EPAP, expiratory positive airway pressure; IPAP, inspiratory positive airway pressure; NIV, noninvasive ventilation; RR, respiratory rate. *P*>0.05, insignificant. *P*≤0.05, significant. *Significant.

SpO_2 less than 90% of 8.66±3.74 with a significant difference when compared with the results before modifications. Table 4 and Fig. 1 show duration of oxygen desaturation before and after therapeutic intervention.

Out of the nine patients in group II, seven patients normalized their results after the therapeutic modifications, and two patients were showing lesser duration of desaturations, but their results were still abnormal: one patient showed SpO_2 less than 90% in 13% of recorded time in second overnight pulse oximetry versus 16% in first test; the second patient showed only 15% of recorded time less than 90% in second test versus 35% in the first test.

Discussion

The prevalence of obesity is increasing worldwide, and OHS is now frequently seen in clinical practice. The treatment of this syndrome is often delayed despite the associated morbidity and mortality [1]. PAP therapy is a well-established treatment for OHS, and the adherence to this treatment should be well encouraged to prevent serious complications. Continuous PAP proved to be effective in some stable patients with OHS, but NIV using BiPAP is the preferred mode of therapy [7].

The occurrence of different complex respiratory events in patients under NIV may have a negative impact on sleep quality and nocturnal hypoventilation. These events include airway obstruction, asynchronism between the patient and the ventilator, and significant leaks. It is therefore important to verify the efficacy of NIV after its initiation [10].

As oxygen desaturations represent a major determinant of adverse cardiovascular and neurocognitive consequences, it is very important to ensure that oxygen saturation is adequate. Overnight pulse oximetry is a simple tool that can be used to detect oxygen desaturations and monitor NIV efficacy [11].

In sleep medicine, pulse oximetry is an essential noninvasive tool for tracking the rapid fluctuations in arterial oxygen saturation that are characteristic for the unstable ventilation in patients with sleep apnea. It is increasingly being used for initial screening as it relatively inexpensive and can be performed at home, and hence enabling the patient to have a typical night sleep [12,13].

Recently, there is a progress in pulse oximetry in three aspects: first, the size and weight of the hardware are significantly reduced, most devices are portable consisting of a convenient patient interface that is clipped onto the skin; second, paper chart recordings replaced by digital signal acquisition; third, new powerful mathematical and statistical techniques are being applied to computerized analysis of the recordings [11].

In the present study, we investigated the role of overnight pulse oximetry as a monitoring tool to assess the efficacy of NIV (BiPAP) in patients with OHS.

The current study results demonstrated that nine (45%) of the studied obese hypoventilation patients were having significant oxygen desaturations on BiPAP, with more than 10% of the recorded time spent with SpO_2 less than 90%. Further analysis showed that the most probable cause of oxygen desaturation was airway obstruction in two patients, insufficient ventilation in five patients, and major nonintentional leaks in two patients.

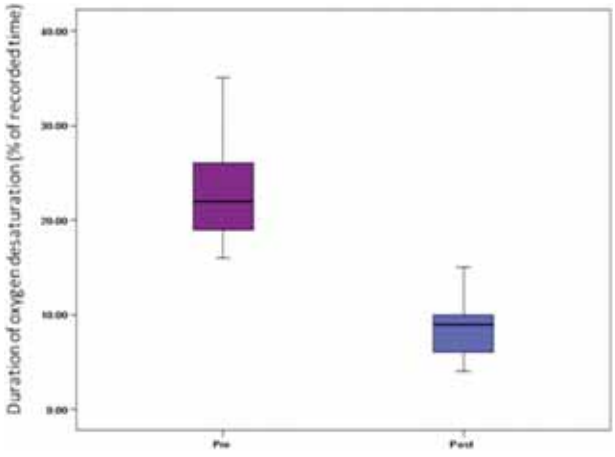
Modifications in the ventilator settings and interface adjustments were useful to normalize the nocturnal

Table 4 Duration of oxygen desaturation before and after therapeutic intervention in group II

Duration of oxygen desaturation in overnight pulse oximetry	Percentage of recorded time [minimum–maximum (mean±SD)]	*P* value
First overnight pulse oximetry (pretherapeutic modifications)	16–35 (23±6.26)	0.0001*
Second overnight pulse oximetry (post-therapeutic modifications)	4–15 (8.66±3.74)	

*Significant.

Figure 1



Comparison between duration of oxygen desaturation (percentage of recorded time) before and after therapeutic intervention in group II patients.

oxygen saturation in seven (77.7%) patients, whereas two (22.3%) patients were showing better but still abnormal results after the therapeutic modifications, and thus those patients will require full polysomnography for further more detailed assessment.

Different monitoring devices to assess the efficacy of NIV have been studied by Rabec *et al.* [14]; they were evaluating NIV using a monitoring system coupled to the ventilator to assess the ventilatory quality. They included patients with different pathologies, and they detected abnormalities in 66% of the performed monitoring. In the present study, abnormalities were found in 45% of the recordings, and all the patients had the same pathology (OHS). Even though the monitoring procedure used in the study of Rabec *et al.* [14] was more sophisticated than overnight pulse oximetry, but it relied essentially on the results of nocturnal oxygen saturation as a basic part of the monitoring. They found that abnormal leaks was the commonest abnormality (34.2%) and chin strap was the proposed solution, the second-most common problem detected was desaturation dips (23.8%) denoting airway obstruction and necessitated increase in expiratory PAPA. The commonest abnormality found in the present study was insufficient ventilation (55.5%), whereas each of airway obstruction and significant leaks were found in 22.2% of the cases. Rabec *et al.* [14] stated that persistence of abnormalities occurred in 15.7% of cases for whom a polygraphy was performed for better assessment.

This study totally agree with other authors who previously mentioned that overnight pulse oximetry may not be sufficient to assess the efficacy of NIV and that it only reflects ineffective ventilation without determining the underlying cause [11]. In fact, it was suggested to perform more specific monitoring like polysomnography to monitor NIV [15–17], but this is not practical due to both technical and economic aspects. It is only indicated in complicated cases in which it is difficult to optimize the NIV [18], and even in these cases, it is nearly impossible to reperform polysomnography after every modification applied to the ventilator settings.

There are some technical limitations because pulse oximetry relies on pulsatile blood flow for its measurements and is vulnerable to the effects of poor peripheral arterial blood flow. Therefore, body movements, vasoconstriction, and hypotension can cause artifacts through an interruption of the pulse signal.

It can be concluded from the results of current study that overnight pulse oximetry is a very important, portable, and simple tool that can be useful as a first step in the assessment of NIV efficacy in OHS patients; it can detect oxygen desaturations under NIV, and further analysis should be done to diagnose the specific cause of desaturation, and therefore therapeutic modifications can be provided to optimize NIV.

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Conflicts of interest
There are no conflicts of interest.

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