Effectiveness of nocturnal oximetry in predicting obstructive sleep apnea hypopnea syndrome: value of nocturnal oximetry in prediction of obstructive sleep apnea hypopnea syndrome

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Background Polysomnography (PSG) is the gold standard for diagnosing obstructive sleep apnea (OSA). However, it is time-consuming, expensive and requires technical expertise. Thus, a number of alternatives to PSG have been proposed. The present study was conducted to analyse the sensitivity, specificity and accuracy of night oximetry as a diagnostic tool in patients suspected to have sleep apnea hypopnea syndrome (SAHS), and to reduce the number of saved PSGs.

Patients and methods In total, 40 middle-aged patients clinically suspected to have Obstructive Sleep Apnea Hypopnea Syndrome (OSAHS) were included in the study. They were classified into two groups: group I (the SAHS group), comprising 33 patients with apnea hypopnea index greater than or equal to 5; and group II (the non-SAHS group), comprising seven patients with apnea hypopnea index l than 5. All patients were subjected to the following: (a) OSA screening questionnaire; (b) BMI in kg/m^2, neck circumference in cm, and cardiac, chest and ENT examinations; (c) investigation in the form of arterial blood gases, chest radiograph, ECG and spirometry; and (d) full PSG and overnight oximetry, which were carried out simultaneously.

Results The baseline values of O_2 saturation derived from PSG and oximetry were 93.33±2.32 and 91.50±2.79, respectively. The overnight oxygen desaturation index of oximetry was significantly lower in the SAHS group. Minimal SpO_2 of PSG was significantly lower in the SAHS group. The best predicted cutoff value of overnight pulse oximetry using oxygen desaturation index for mild to moderate OSA patient diagnosis was 14.78, with 87.88% sensitivity and 88.71% specificity. However, the optimal cutoff value for severe OSA diagnosis was 52.55, with 86.67% sensitivity and 96% specificity.

Conclusion Overnight pulse oximetry may be considered a diagnostic tool in patients suspected to have SAHS, with excellent diagnostic sensitivity, specificity and accuracy, which increased with severity.

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Keywords: apnea hypopnea index, night oximetry, obstructive sleep apnea, polysomnography, sleep apnea hypopnea syndrome

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Introduction

The obstructive sleep apnea (OSA) syndrome is a common sleep-related breathing disorder with prevalence ranging from 5 to 15% among the general population [1]. Polysomnography (PSG) is considered the gold standard for its diagnosis; it is time-consuming, expensive and needs technical expertise [2]. The waiting time to diagnose patients suspected to have OSA is long even in the developed countries; for example, it ranges from 0 to 48 months in the UK, a few weeks to more than a year in the USA and 8 to 30 months in Canada [3]. The waiting time ranges from 2 to 3 months in our sleep disordered breathing unit.

As a result, primary care providers may be reluctant to order PSG, and, also, patients often are unwilling to attend it; therefore, a number of alternatives to PSG have been proposed [4].

Oximetry has widespread availability but the results from previous studies have varied in sensitivities, ranging from 40 to 100% [5–9]. The diagnostic performance of an automated analysis algorithm based on falls and recovery of digitally recorded oxygen saturation was compared with PSG [10].

Automated analysis night oximetry has been evaluated in patients with sleep apnea hypopnea syndrome (SAHS) because it analyses arterial oxygen desaturation, one of the sequelae of SAHS [11].

Most countries with universal health coverage have a large number of patients who need sleep disorders clinics to be diagnosed and managed with limited resources [12].

The aim of this study was to analyse the sensitivity, specificity and accuracy of night oximetry as a diagnostic tool in patients suspected to have SAHS, and to reduce the number of PSGs that could have been

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saved if the diagnosis of SAHS had been established by using this method.

Patient and methods

This case study was carried out in the Sleep Disorders Breathing Unit, Chest Department of the Mansoura University Hospital, Egypt. All participants were enrolled from October 2013 to January 2014. Local ethical approval had been obtained from Mansoura University.

The study comprised 40 middle-aged patients clinically suspected to have OSAHS. They were recruited from the sleep outpatient clinic. They were classified according to apnea hypopnea index (AHI) into two groups:

Group I (the SAHS group), which comprised 33 patients with AHI greater than 5.

Group II (the non-SAHS group), which comprised seven patients with AHI less than 5.

Exclusion criteria

The exclusion criteria included age less than 18 years, patients with BMI greater than 40 kg/m^2, history of neuromuscular disease or stroke, pulmonary or cardiac diseases associated with ventilatory or diffusion defect daytime hypoxaemia or hypercapnia or central sleep apnea.

All patients were subjected to the following:

(1) Full history taking with special stress on age, sex, occupation and symptoms suggestive of OSAHS (excessive daytime sleepiness, nocturnal choking, snoring and witnessed apnea); and OSA screening questionnaire such as the Stopbang, Berlin questionnaire and the Epworth Sleepiness Scale (ESS).
(2) General examination with stress on BMI in kg/m^2, neck circumference (NC) in cm and cardiac, chest and ENT examinations.
(3) Routine investigations in the form of complete blood count, liver and kidney functions, arterial blood gases, chest radiograph, ECG and spirometry.
(4) All patients were admitted to the sleep laboratory and underwent full PSG and overnight oximetry, which were performed simultaneously.

Polysomnography

PSG data were recorded by a computerized PSG system (somno screen plus; SomnoMedics, GmbH, Randersacker, Germany). This included a standardized montage: two-channel electroencephalograms (C4/A1, C3/A2), bilateral electro-oculograms, submental electromyogram, bilateral leg electromyograms and ECG. Airflow was measured using a thermistor (Healthdyne Technologies, SomnoMedics, GmbH, Randersacker, Germany), respiratory effort was assessed by inductance plethysmography, and oxygen saturation was recorded using a finger probe. The oxygen saturation signal was digitally sampled at 1 Hz and stored both on the PSG record and in a separate monitor for offline analysis.

Pulse oximetry

The Nonin Wrist pulse oximetry 3100 (Nonin, Plymouth, Minnesota, USA) was used to compare its diagnostic accuracy with full-night PSG. Wrist oximetry was attached to the participant's finger using a flexible probe. The instrument detects 20 data points per minute, each point representing the lowest saturation in a 3-s interval. A desaturation event was considered when the haemoglobin saturation level (SaO_2) fell below 3% from baseline saturation. Baseline saturation was considered as the mean saturation in the previous minute. Oximetry values were periodically checked using arterial blood gas samples. The signals were digitalized and recorded using software, and were manually reviewed by two observers blinded to the polysomnographic data. The total number of desaturations was divided by the hours in bed, and an oxygen desaturation index (ODI) per hour was obtained for each patient to achieve the best cutoff point with high sensitivity and specificity.

Statistical analysis

Data were analyzed using SPSS (Statistical Package for Social Sciences; IBM Corporation Inc, USA) version 15. Qualitative data were presented as number and percentage. Comparison between groups was carried out by using the χ^2-test. Quantitative data were tested for normality by using the Kolmogorov–Smirnov test. Normally distributed data were presented as mean±SD. Student's *t*-test was used to compare between the two groups. Pearson's correlation coefficient was used to test correlation between variables. The receiver operating characteristic curve analysis was also used as it has the ability to discriminate diseased cases from normal cases. A P value of less than 0.05 was considered to be statistically significant.

Results

The study was conducted on 40 patients with possible OSA; 55% of them were males. The mean age was 45.55±10.37 years, BMI mean 40.21±8.91 kg/m^2 and

mean of NC was 32.5±8.4 cm. The mean FEV_1/FVC ratio was 83.62±8.15. The baseline O_2 saturation derived from PSG and oximetry were 93.33±2.32 and 91.50±2.79, respectively (Table 1).

The BMI and NC were significantly increased in the SAHS group than in the non-SAHS group. Moreover, both ESS and Stopbang were significantly higher in the SAHS group compared with the non-SAHS group (Table 2).

The overnight ODI of oximetry was significantly higher in the SAHS group. Both basal SpO_2 of oximetry and of PSG were significantly lower in the SAHS group compared with the non-SAHS group. Minimal SpO_2 of PSG was significantly lower in the SAHS group. The SpO_2 time less than 90% was significantly higher in the SAHS group. On the other hand, arousal index was significantly higher in the SAHS group compared with the non-SAHS group (Table 3).

The best predicted cutoff values of overnight pulse oximetry using ODI for mild to moderate OSA patient diagnosis was 14.78, with 87.88% sensitivity, 88.71%

Table 1 Demographic data and patient characteristics

Patient characteristics	*n*=40
Sex [*n* (%)]	
Male	22 (55)
Female	18 (45)
	Mean±SD
Age (years)	45.55±10.37
BMI (kg/m^2)	40.21±8.91
NC (cm)	32.5±8.4
FEV_1/FVC (% of predicted)	83.62±8.15
ESS	11.22±6.71
Stopbang	5.47±1.23
Baseline O_2sat. derived from PSG	93.33±2.32
Baseline O_2sat. derived from oximetry	91.50±2

ESS, Epworth Sleepiness Scale; FEV_1, forced expiratory volume; FVC, forced vital capacity; NC, neck circumference; PSG, polysomnography.

Table 2 Anthropometric parameters and OSA screening questionnaires in the SAHS group versus the non-SAHS group

	Group I (SAHS) (*n*=33)	Group II (non-SAHS) (*n*=7)	*P* value
Age (years)	47.70±9.53	35.43±8.36	0.003*
BMI (kg/m^2)	41.61±8.92	33.57±5.85	0.029*
NC (cm)	36.22±4.89	30.21±2.33	0.03*
ESS	12.09±6.82	7.14±3.02	0.007*
Stopbang	5.67±1.19	4.57±1.40	0.038*

ESS, Epworth Sleepiness Scale; NC, neck circumference; OSA, obstructive sleep apnea; SAHS, sleep apnea hypopnea syndrome. *P<0.05, significant.

Table 3 PSG and overnight pulse oximetry variables in the SAHS group versus the non-SAHS group

	Group I (SAHS) (*n*=33)	Group II (non-SAHS) (*n*=7)	*P* value
ODI of oximetry	48.52±29.23	9.43±8.54	0.001*
Basal SpO_2 of oximetry	91.10±2.83	93.41±1.61	0.045
Baseline SpO_2 of PSG	93.09±2.47	94.43±0.98	0.017
Minimal SpO_2 of PSG	77.88±11.19	87.14±2.54	0.001*
SpO_2 time<90%	28.08±29.53	0.67±0.67	0.001*
Arousal index/h	15.67±13.80	4.82±3.20	0.001*

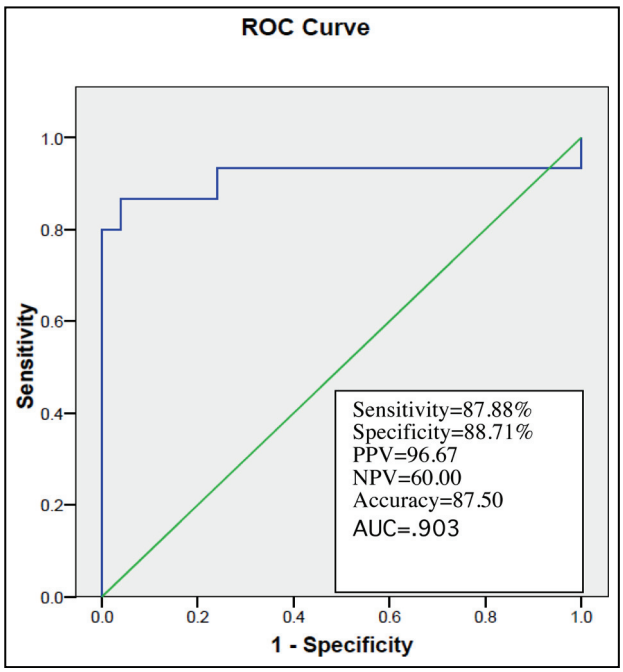
ODI, oxygen desaturation index; PSG, polysomnography; SAHS, sleep apnea hypopnea syndrome. *P<0.05, significant.

Table 4 Validity of predicted cutoff values for diagnosis of OSA depending on ODI of overnight pulse oximetry

	Mild–moderate OSA (AHI=5–30)	Sever OSA (AHI? 30)
Sensitivity	87.88%	86.67%
Specificity	88.71%	96%
Accuracy	87.50%	92.50%
PPV	96.67%	92.86%
NPV	60.00%	92.31%
Cutoff value	14.78	52.55

AHI, apnea hypopnea index; NPV, negative predictive value; ODI, oxygen desaturation index; OSA, obstructive sleep apnea; PPV, positive predictive value.

Figure 1



Receiver operating characteristic (ROC) curves of oxygen desaturation index (ODI) parameters for the diagnosis of mild and moderate obstructive sleep apnea (OSA) patients with thresholds apnea hypopnea index (AHI)=5–30.

specificity, 87.50% accuracy and an area under the curve of 0.903 (Table 4 and Fig. 1). However, the optimal cutoff value for severe OSA diagnosis was 52.55, with 86.67% sensitivity, 96% specificity, 92.50 accuracy and an area under the curve of 0.915 (Table 4 and Fig. 2).

There was a strong positive correlation between AHI and ODI of overnight pulse oximetry (r=0.819 and P=0.000) (Fig. 3).

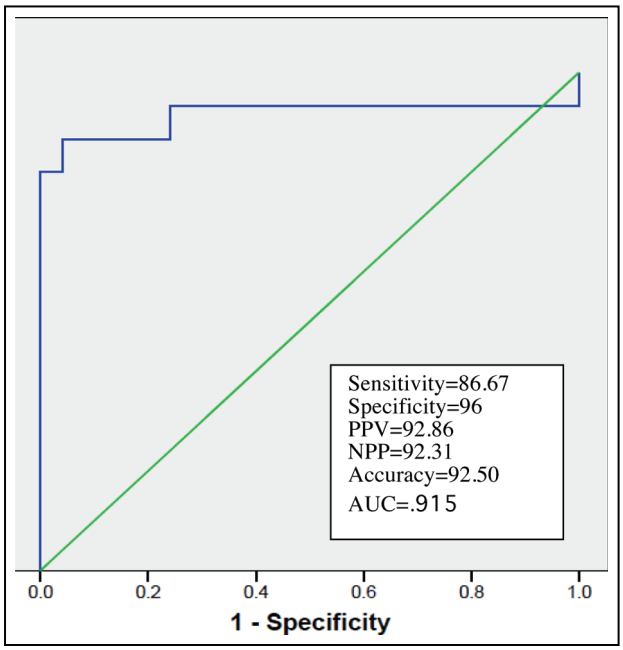
Discussion

PSG is considered the gold standard for diagnosing OSA. However, it is time-consuming, technically difficult and expensive. Prediction of OSA using questionnaires, clinical features and physiological examination has been previously studied as a predictive method for diagnosing patients with OSA [13]. In addition, nocturnal pulse oximetry has been used as a diagnostic approach for OSA syndrome in the last decade [14].

Pulse oximetry has been considered as a valuable screening tool, although its effectiveness in screening patients with OSA has been debated for several years [15]. A number of studies have assessed its usefulness [16].

This study was carried out on 40 patients suspected to have OSA and no other concomitant heart or lung diseases or neurological diseases that may affect pulmonary haemodynamics.

Figure 2



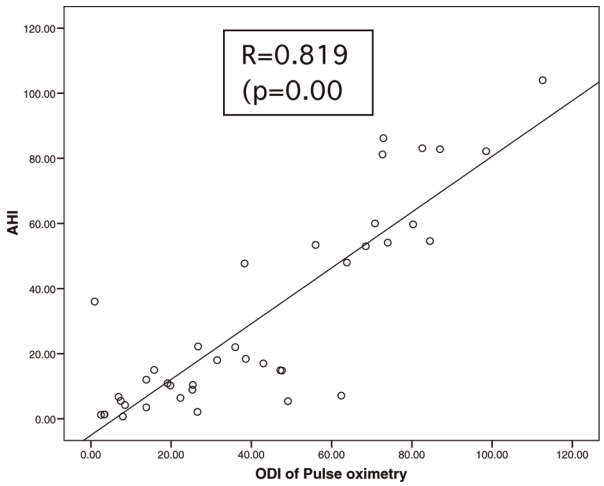
Receiver operating characteristic (ROC) curves of oxygen desaturation index (ODI) parameters for the diagnosis of severe obstructive sleep apnea (OSA) patients with thresholds apnea hypopnea index (AHI) > 30.

Our study revealed that patients with SAHS were older (P<0.003) and had more BMI (P<0.029). This indicates that obesity is one of the important risk factors for OSA. This was reported by Simpson *et al.* (2010) [17], who demonstrated that the effect of obesity in OSA may be due to mechanical mass and biochemical mediators. Furthermore, other risk factors like male sex, older age, family history, and smoking, central obesity and larger NC were found to significantly increase the risk for OSA [18,19].

The ESS score and that of Stopbang questionnaire were significantly higher in the SAHS group compared with the non-SAHS group (P<0.007 and 0.038, respectively), which signify that both questionnaires may be predictors of OSA. Chung *et al.* [20] reported that when the Stopbang score was greater than or equal to 3 (any three positive items), the sensitivity and specificity for identifying moderate–severe OSA was 87 and 31%, respectively. In addition, Stevens [21] found significant positive correlation between ESS and AHI, and concluded that if ESS was more than 10, sleep-related breathing disorders should be suspected.

Our study revealed significant lower basal SpO_2 and minimum SpO_2 in SAHS patients compared with non-SAHS patients, and there were significant higher SpO_2 less than 90% in SAHS patients compared with non-SAHS patients (P<0.017 and P<0.000). This was in agreement with the findings of a study by Fanfulla *et al.* (2008) [22], who reported significant lower basal SpO_2 (92±1.6 vs. 95±1.7) (P=0.005) in SAHS patients in comparison with non-SAHS patients, and also minimum SpO_2 was significantly lower in SAHS patients than in non-SAHS patients (72±13 vs. 85±4, P<0.001).

Figure 3



Correlation between apnea hypopnea index (AHI) and oxygen desaturation index (ODI) of overnight pulse oximetry.

This study evaluated the diagnostic performance of pulse oximetry by detecting cutoff values for the diagnosis of OSA in different stages using the receiver operating characteristic curve. The optimal cutoff values of ODI of overnight pulse oximetry for mild to moderate OSA patient diagnosis was 14.78, with 87.88% sensitivity, 88.71% specificity and 87.50% accuracy. These results were in agreement with those of Huang *et al.* (2015) [3] who reported that ODI parameters provided by overnight oximetry measurements may become good predictors in the diagnosis of moderate OSA with the optimal cutoff values of overnight pulse oximetry of 21.2 with 88.53% sensitivity, 85.34% specificity and 87.77% accuracy [3].

However, the optimal cutoff value of overnight pulse oximetry for severe OSA diagnosis was 52.55 with 86.67% sensitivity, 96% specificity and 92.50% accuracy. This was also demonstrated by Huang *et al.* (2015) [3] who noticed increased sensitivity, specificity and accuracy of overnight pulse oximetry in diagnosing severe OSA than in mild to moderate OSA.

There was a strong positive correlation between AHI and ODI of overnight pulse oximetry (P=0.000), which indicates validity of overnight pulse oximetry. This is in agreement with the findings of a study by Dumitrache-Rujinski *et al.* [14] who demonstrated a significant positive correlation between ODI of night oximetry and AHI (P<0.001). Moreover, they concluded that the assessment of the desaturation index by nocturnal pulse oximetry maintains its utility as a screening method for OSAS.

Orr *et al.* (1994) [23] studied the validity of overnight pulse oximetry as a diagnostic tool for OSA, and reported sensitivity of 100% and a specificity of 93% for diagnosing OSA (AHI>15/h). On the other hand, Chiner *et al.* (1999) [11] reported sensitivity of overnight pulse oximetry at different cutoff points ranging between 82% (ODI-5) and 62% (ODI-15), whereas specificity varied between 76% (ODI-5) and 93% (ODI-15). The accuracy for each ODI was 0.81, 0.75 and 0.69, respectively.

Vazquez *et al.* (2000) [10] using an automated analysis oximetry data and a desaturation event definition (4% lower than baseline) reported a very high sensitivity of 98% and specificity of 88%; however, this study used a definition of hypopnea without arousal, which differs from the criteria proposed by the Atlas Task Force [24]. As a result, their definition of hypopnea differs from ours. These investigators found that the addition of arousal-based scoring criteria (using their definition of arousal) for hypopnea causes only small changes in the AHI [25]. However, a large study found that incorporating arousals on the basis of the Atlas Task Force criteria on the hypopnea definition does impact on the value of the AHI [26].

Recently it was demonstrated that overnight oximetry recording appears to be a very sensitive and specific screening method for diagnosing OSAHS [27]. Pulse oximetry is accepted as the sole diagnostic evaluation criterion in the USA, Australia and Sweden [28]. On the other hand, the Apnea Task Group of the German Society for Sleep Research and Sleep Medicine stated that pulse oximetry can be employed to attain a tentative diagnosis that requires further evaluation at a sleep laboratory.

The sensitivity and specificity of pulse oximetry ranged from 31 to 98% and from 41 to 100%, respectively, according to Hornero *et al.* (2007) [29], Raymond *et al.* (2003) [30] and Vazquez *et al.* (2000) [10].

Epstein and Dorlac (1998) [31] concluded that the use of overnight pulse oximetry as a diagnostic tool was limited because of the high false positive results.

This study could overcome these by adjusting the settings of the oximeter at 3 s. In addition, using overnight pulse oximetry simultaneously with PSG in the same environment leads to the elimination of night to night variability of the AHI. On the other hand, the population studied by Epstein and Dorlac (1998) [31] had a low prevalence of SAHS. Moreover, our unit had a specific profile in respiratory sleep disorders and 70% of the patients were referred by pulmonary physicians depending on high clinical suspicion. Thus, this high prevalence may be respectable.

Limitation of the study

One of important limitation in oximetry as diagnostic tool in OSA in this study was the lack of data about sleep stage of studied patients; in addition, there was no differentiation between central and OSA. The artefacts that can result from movements or haemoglobin percent may affect signal quality.

Conclusion

Overnight pulse oximetry maybe considered a diagnostic tool in patients suspected to have SAHS, with excellent diagnostic sensitivity, specificity and accuracy, which increased with severity.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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