Nocturnal oximetry for the diagnosis of the sleep apnoea hypopnoea syndrome: a method to reduce the number of polysomnographies?

Eusebi Chiner, Jaime Signes-Costa, Juan Manuel Arriero, Juan Marco, Isabel Fuentes, Antonia Sergado

Abstract

Background—Polysomnography (PSG) is currently the “gold standard” for the diagnosis of the sleep apnoea hypopnoea syndrome (SAHS). Nocturnal oximetry (NO) has been used with contradictory results. A prospective study was performed to determine the accuracy of NO as a diagnostic tool and to evaluate the reduction in the number of PSGs if the diagnosis of SAHS had been established by this method.

Methods—Two hundred and seventy five patients with a clinical suspicion of SAHS were admitted to undergo, in the same night, full PSG and NO. Desaturation was defined as a fall in the haemoglobin saturation level (SaO₂) to lower than 4% from the baseline level and an oxygen desaturation index per hour (ODI) was obtained in each patient with three cut off points: ≥5 (ODI-5), ≥10 (ODI-10), and ≥15 (ODI-15).

Results—SAHS was diagnosed in 216 patients (194 men). After withdrawing patients with abnormal lung function (forced expiratory volume in one second (FEV₁) lower than 80% predicted), sensitivity (SE), specificity (SP), positive and negative predictive values (PPV and NPV) of NO were: ODI-5 (80%, 89%, 97%, 48%); ODI-10 (71%, 93%, 97%, 42%); ODI-15 (63%, 96%, 99%, 38%). The accuracy for each ODI was 0.81, 0.75, and 0.70, respectively. If NO had been considered as a diagnostic tool and PSG had been performed only in patients with a negative NO (false negative and true negative) and those with a positive NO and abnormal pulmonary function tests, 135/275 (ODI-5), 156/275 (ODI-10), and 170/275 (ODI-15) PSGs would have been performed, a reduction of 140, 119, and 105, respectively.

Conclusion—Nocturnal oximetry in patients with suspected SAHS and normal spirometric values permits the institution of therapeutic measures in most patients.

Keywords: sleep apnoea hypopnoea syndrome; sleep apnoea syndrome; nocturnal oximetry; diagnosis
Nocturnal oximetry for the diagnosis of the sleep apnoea hypopnoea syndrome

Nocturnal oximetry for the diagnosis of the sleep apnoea hypopnoea syndrome considered to analyse the nocturnal oximetry

Table 1 Mean (SD) demographic data and comparisons between groups

<table>
<thead>
<tr>
<th></th>
<th>Non-SAHS</th>
<th>SAHS</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>52</td>
<td>194</td>
<td>NS</td>
</tr>
<tr>
<td>Women (n)</td>
<td>7</td>
<td>22</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>48 (14)</td>
<td>53 (10)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>30 (5)</td>
<td>32 (5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Epworth sleepiness scale</td>
<td>10 (5)</td>
<td>14 (5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Neck circumference (cm)</td>
<td>43 (4)</td>
<td>43 (4)</td>
<td>NS</td>
</tr>
</tbody>
</table>

referred for more detailed examination. Patients were then admitted to our unit to undergo a nocturnal full PSG and oximetry.

OXYMETER

A pulse oximeter (N-200; Nellcor Inc, Hayward, California, USA) was attached to the subject’s finger using a flexible probe. The instrument detects 10 data points per minute, each point representing the lowest saturation in a six second interval. A desaturation event was considered when the haemoglobin saturation level (SaO₂) fell below 4% from baseline saturation. Baseline saturation was considered as the mean saturation in the previous minute. Falls in oxygen saturation to >4% in the interval 90–100% of saturation were also considered as desaturations. Oximetry values were periodically checked using arterial blood gas samples. The signals were digitalised and recorded using the packaging 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 per hour (ODI) was obtained for each patient with three cut off points: >5 (ODI-5), >10 (ODI-10), and >15 (ODI-15).

POLYSOMNOGRAPHY

Patients underwent standard overnight polysomnography (Somnostar a 4100; Sensor Medics, California, USA) which included continuous recordings of electroencephalography (EEG), electro-oculography (EOG), and chin electromyography (EMG) for sleep staging according to the criteria of Rechtshaffen and Kales. Nasal and oral thermistors were used to measure airflow and uncalibrated induttance plethysmography was used to measure rib cage and abdominal motion. The electrocardiogram (ECG) and SaO₂ were also continuously monitored. Apnoea was defined as a cessation of flow of more than 10 seconds duration. Hypopnoea was defined as a 50% reduction in the flow signal or thoracoabdominal movement compared with the baseline value of immediately preceding breaths lasting more than 10 seconds accompanied by a fall of >4% in saturation or a microarousal. A desaturation was therefore not a requisite criterion if a microarousal was present with reduction in airflow. SAHS was defined as an apnoea plus hypopnoea index (AHI) of 15 or more. All signals were computer analysed with manual editing.

DATA ANALYSIS

Data from NO and PSG were stored in a database for statistical analysis (Rsigma, Horus, Madrid, Spain) and were independently analysed using NO as the test and PSG as the gold standard for the correct classification of SAHS patients. The number of true positive (TP), false positive (FP), false negative (FN), and true negative (TN) oximetric results were then determined. Sensitivity (TP/TP+FN), specificity (TN/TN+FP), positive predictive values (TP/TP+FP), and negative predictive values (TN/TN+FN) and confidence intervals (CI) were calculated for each ODI. The accuracy of (TP+TN+FP+FN+TN+TP) of NO was also obtained for each cut off point and then recalculated for each ODI after the withdrawal of patients with abnormal pulmonary function (FEV₁ lower than 80% predicted). Numerical data were expressed as mean values and standard deviation (SD). Numerical variables between groups were compared using the Student’s t test for unpaired data and the Mann-Whitney test for variables not normally distributed. Qualitative data were compared using the χ² and Fisher exact tests. A p value of <0.05 was considered significant.

Table 2 Sensitivity (SE), specificity (SP), positive predictive value (PPV) and negative predictive value (NPV) and 95% confidence interval (CI) of nocturnal oximetry for each cut off point in 216 patients with SAHS (194 men, 22 women)

<table>
<thead>
<tr>
<th>ODI</th>
<th>SE % (CI)</th>
<th>SP % (CI)</th>
<th>PPV % (CI)</th>
<th>NPV % (CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>82 (77 to 87)</td>
<td>76 (63 to 86)</td>
<td>93 (88 to 96)</td>
<td>54 (43 to 65)</td>
<td>NS</td>
</tr>
<tr>
<td>10</td>
<td>71 (65 to 77)</td>
<td>90 (79 to 96)</td>
<td>96 (92 to 99)</td>
<td>46 (37 to 56)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>15</td>
<td>62 (56 to 69)</td>
<td>93 (83 to 98)</td>
<td>97 (92 to 99)</td>
<td>40 (32 to 49)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Table 3 Comparison between false negative (FN) and true positive (TP) patients when cut off points in the oxygen desaturation index (ODI) of >5, >10, and >15 were considered to analyse the nocturnal oximetry

<table>
<thead>
<tr>
<th>ODI</th>
<th>Age (years)</th>
<th>Duration of symptoms (months)</th>
<th>BMI (kg/m²)</th>
<th>Epworth sleepiness scale</th>
<th>Neck circumference (cm)</th>
<th>Cephalometric abnormalities</th>
<th>AHI (n)</th>
<th>Baseline SaO₂ (kPa)</th>
<th>Minimal SaO₂ (kPa)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>51 (10)</td>
<td>52 (52)</td>
<td>12 (4)</td>
<td>11.6 (0.7)</td>
<td>22 (7)</td>
<td>12.5 (0.3)</td>
<td>11.0 (0.7)</td>
<td>6.37</td>
<td>6.37</td>
<td>NS</td>
</tr>
<tr>
<td>10</td>
<td>53 (10)</td>
<td>52 (52)</td>
<td>12 (5)</td>
<td>12.5 (0.3)</td>
<td>22 (7)</td>
<td>12.5 (0.3)</td>
<td>11.0 (0.7)</td>
<td>6.37</td>
<td>6.37</td>
<td>NS</td>
</tr>
<tr>
<td>15</td>
<td>53 (10)</td>
<td>52 (52)</td>
<td>12 (5)</td>
<td>12.5 (0.3)</td>
<td>22 (7)</td>
<td>12.5 (0.3)</td>
<td>11.0 (0.7)</td>
<td>6.37</td>
<td>6.37</td>
<td>NS</td>
</tr>
</tbody>
</table>

BMI = body mass index; AHI = apnoea hypopnoea index; SaO₂ = oxygen saturation.
Table 4: Sensitivity (SE), specificity (SP), positive predictive value (PPV) and negative predictive value (NPV) and 95% confidence interval (CI) of nocturnal oximetry for each cut off point in 216 patients with SAHS after the withdrawal of patients with abnormal spirometric values.

<table>
<thead>
<tr>
<th>ODI</th>
<th>SE % (CI)</th>
<th>SP % (CI)</th>
<th>PPV % (CI)</th>
<th>NPV % (CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥5</td>
<td>80 (71 to 86)</td>
<td>89 (69 to 97)</td>
<td>97 (91 to 99)</td>
<td>48 (34 to 63)</td>
</tr>
<tr>
<td>≥10</td>
<td>71 (62 to 79)</td>
<td>93 (74 to 99)</td>
<td>97 (91 to 99)</td>
<td>42 (20 to 65)</td>
</tr>
<tr>
<td>≥15</td>
<td>63 (54 to 72)</td>
<td>96 (78 to 100)</td>
<td>99 (92 to 100)</td>
<td>38 (27 to 51)</td>
</tr>
</tbody>
</table>

(p<0.01), and had more daytime sleepiness (p<0.001) (table 1).

When a diagnosis of SAHS was established by PSG the results of NO at the different cut off points were analysed. With ODI-5 192 patients had positive oximetry results (178 TP and 14 FP), with ODI-10 there were 160 patients with a positive oximetry test (154 TP and six FP), and with ODI-15 139 patients had positive oximetry results (135 TP and four FP). The accuracy for each ODI was 0.81, 0.75, and 0.69, respectively. The sensitivity (SE), specificity (SP), positive predictive values (PPV), and negative predictive values (NPV) are shown for each cut off point in table 2.

When the FN patients in each ODI group were analysed they were found to have a lower AHI, higher baseline and minimal saturation, a shorter time with symptoms, less daytime sleepiness, lower body mass index, and fewer craniofacial abnormalities than TP patients, but no differences were found in age or pulmonary function tests between these two groups of patients (table 3).

Patients with abnormal oximetry (ODI-5) and AHI of <15 (FP) had the following diagnoses: chronic obstructive pulmonary disease (COPD) in eight, obesity hypoventilation in three, ischaemic heart disease in two, and one with myotonic dystrophy. These patients had poorer lung function than TP patients (forced vital capacity (FVC) 74 (18)% vs 87 (17)%), p<0.01; FEV1/FVC 78 (23)% vs 91 (17)%), p<0.01. The SE, SP, PPV and NPV of NO after withdrawal of patients with abnormal spirometric values are shown for each cut off point in table 4. The accuracy for each ODI was 0.81, 0.75, and 0.70, respectively.

If we had considered NO as a diagnostic tool in the patients with SAHS included in our study and had performed PSG only in those with a negative NO (FN and TN) or those with a positive NO and abnormal pulmonary function tests, we would have performed 135/275 PSGs for a cut off point of ODI-5, 156/275 for ODI-10, and 170/275 for ODI-15, reducing the number of PSGs by 140, 119, and 105, respectively.

Discussion

This study shows that a quantitative analysis of pulse oximetry can help in the diagnosis of SAHS and this approach can reduce the number of PSGs in countries with limited resources. The sensitivity of NO at different cut off points ranged between 82% (ODI-5) and 62% (ODI-15), whilst specificity varied between 76% (ODI-5) and 93% (ODI-15). The accuracy for each ODI was 0.81, 0.75, and 0.69, respectively, which did not change (0.81, 0.75, and 0.70) after withdrawal of patients with abnormal spirometric values.

These results differ from those of other studies. Several possible reasons can be put forward to explain these discrepancies. When the population studied has a high prevalence of SAHS the sensitivity and specificity of NO may improve because the accuracy of NO lies in the detection of apnoeas while hypopnoeas are underdiagnosed. In this study 216 of 275 patients had a diagnosis of SAHS by PSG, a prevalence of 78% which is higher than that in any of the previous studies. Sleep units in countries with universal health coverage have a bias towards studying patients who are more likely to have positive tests (patients with a high clinical suspicion of SAHS). Moreover, because our unit has a specific profile in respiratory sleep disorders and 60% of referrals were made by pulmonary physicians, this high prevalence may be justified.

Another explanation for the disparity of the results is the method of quantifying nocturnal desaturation. Oximeters have different time responses and, depending on the settings, they can underestimate the number of desaturations. Modifying the average time of the pulse oximeter would account for up to 60% of underestimated desaturations.

Pépin et al used a mathematical index to detect changes in SaO2, associated with sleep apnoeas with a sensitivity of 75% and a specificity of 86%. In spite of a small number of patients with different disorders (SAHS, COPD, and restrictive lung disease), their results do not differ significantly from ours when using a point intermediate between ODI-5 and ODI-10.

Williams et al used a visual analysis of oximeter tracings without taking into account desaturations of ≥4% when they occurred at levels of saturation above 90%. They obtained a sensitivity of 75% and a specificity of 100% in a small number of patients.

Sériès et al used oximetry as a diagnostic tool but the high numbers of false positives negated its use as a case selection tool for detecting SAHS in suspected patients. They did not define desaturations with a fixed numerical criterion, counting as abnormal patients who had more than 10 transient desaturations per hour followed by a rapid return to the baseline level. Moreover, they did not show pulmonary function data in patients with normal polysonomography and more than 10 desaturations per hour.

Gyulay et al identified patients with SAHS using clinical assessment and home oximetry. More than 15 desaturations/hour of ≥4% gave a sensitivity of 40% and a specificity of 98%. They concluded that patients with positive oximetry should start on treatment with continuous positive airway pressure (CPAP). These results with ODI-15 could be improved if the settings of the oximeter had been put at six seconds as in our study. On the other hand, the population they studied had a low prevalence of SAHS.

Epstein et al compared the cost of nocturnal oximetry as a case selection tool with the...
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