Influence of age on adherence to auto-CPAP: experience from a sleep center in Portugal

Abstract

Introduction: Obstructive sleep apnea (OSA) is a disorder characterized by obstructive apneas, hypopneas, and/or arousals related to respiratory effort caused by repetitive collapse of the upper airway during sleep. Left untreated, or with poor adherence to treatment, is likely to lead to negative outcomes, especially cardiac or cerebrovascular diseases. Our objective was to investigate age as a potential factor that may interfere with adherence to treatment with automatic positive airway pressure (APAP).

Materials and methods: This is a cross-sectional study on 1151 patients with OSA and we analyzed the adherence data of all patients who had been on APAP for at least six months during the period from July 1, 2019 to December 31, 2020 at Centro de Medicina do Sono. Spearman correlation was used in the bivariate analysis and to determine the factors associated with APAP adherence, a logistic regression was performed.

Results: Of 1151 patients included, 780 patients were men (67.1%) and the majority was under 65 years (59.4%). APAP adherence was higher in older age groups (p < 0.001) and in patients with a higher AHI (p < 0.001), no differences were observed with regards to gender. In the multivariable regression analysis, the main factors associated with adherence were age group over 65 years (OR = 2.435; 95% CI = 1.862-3.185), AHI 15–30/h (OR = 1.733; 95% CI = 1.242–2.416), and AHI > 30/h (OR = 3.406; 95% CI = 2.426–4.782).

Conclusions: Patients older than 65 years have better adherence to APAP than younger ones and with moderate but especially severe AHI have better adherence than those with the milder form of the disease.

Key words: obstructive sleep apnea, APAP adherence, older patients, cross-sectional study, predict-model

Introduction

Obstructive sleep apnea (OSA) is a disorder characterized by obstructive apneas, hypopneas, and/or arousals related to respiratory effort caused by repetitive collapse of the upper airway during sleep. It is a common disorder that adversely impacts sleep quality, daytime alertness and promotes cognitive deterioration, metabolic dysfunction, and a greatly increased risk of cardiovascular disease such as acute myocardial infarction and hemorrhagic stroke [1–3]. It is proven that untreated OSA leads to significant morbidity and mortality.

Positive airway pressure therapy, a first-line medical treatment in adults with moderate to severe OSA, reduces the apnea hypopnea index (AHI), normalizes oxyhemoglobin saturation, and reduces cortical arousals associated with apneic/hypopneic events. However, its effectiveness in improving health outcomes is limited by adherence [4, 5].

The OAS may begin at any age and when diagnosed it should be effectively treated with positive airway pressure (PAP). A recent study [6] suggested that adherence to positive airway pressure tends to decrease with age, reaching a peak of “poor adherence” around the age of 75. On the
other hand, another large study\textsuperscript{1} showed that the group with the lowest compliance was young women (18–30 years). The cause of this heterogeneity is unclear and evidence is conflicting regarding whether demographic factors such as age influence adherence \textsuperscript{7}.

Globally, the annual growth of the elderly population is approximately 3%; this number is expected to increase to 2.1 billion by 2050 \textsuperscript{8}. In Europe, more than one fifth (20.6 \%\textsuperscript{9}) of the population was aged 65 and over in 2020. In Portugal, 22.3\% of the population is over 65 years of age, in 2020 \textsuperscript{10}. Due to the high rate of population aging we should be focus on health outcomes in this population to avoid serious health problems in the future.

Our objective was to investigate the effect of age as a potential factor that may influence with adherence to treatment with APAP.

**Materials and methods**

This cross-sectional study took place at Centro Medicina do Sono (Centro Hospitalar Universitário de Coimbra, Portugal). Adherence data for all patients who had been on automatic positive airway pressure (APAP) therapy for at least six months during the period July 1, 2019 to December 31, 2020 were analyzed sequentially.

We included patients of both genders, over 18 years of age, with a diagnosis of OSA confirmed by polysomnography (AHI > 5 respiratory events per hour of sleep). Cases of central apnea and subjects previously treated with continuous positive airway pressure (CPAP) or bi-level positive airway pressure were excluded, as well as those who, at the time of the study, had not yet completed six months of therapy.

We stratified the patients into two groups: under 65 and over 65 years of age. The other variables accounted for were disease severity (measured by the AHI), defined as mild (AHI 5–15), moderate (AHI 15–30) and severe (AHI > 30), and percentage of APAP use.

The validation of therapeutic adherence was performed by analyzing the data stored in the internal memory of each device, made available in a report format corresponding to six months of use.

Adherence standards were defined according to established in the literature and defined by the National Health Service (NHS), namely regarding the number of hours used and the total percentage of days of use. Adherence to treatment is defined if these two criteria are met (> 4h/night and on more than 70\% of the days).

The need for written informed consent from all participants was waived because this was a retrospective study with anonymized patient data.

**Statistical analysis**

The characteristics of the study population were described using the mean and standard deviation (for continuous variables) and proportions (for categorical variables). The Kolmogorov-Smirnov test was performed to test the normality of the distributions. In the absence of normality, non-parametric tests were performed. Spearman correlation was used in the bivariate analysis. In the multivariate analysis, to determine the factors associated with APAP adherence, a logistic regression was performed where the variable APAP adherence (dichotomous) was considered the dependent variable (0) no adherence and (1) adherence. The forward conditional method was used for the stepwise selection of variables. The Hosmer and Lemeshow test was used to adjust the model with the independent variables. The validation of the model, its discriminatory ability, sensitivity, and specificity were analyzed using the area under the receiver operating characteristic curve (AUROC). The independent variables considered were gender, age (in age groups), AHI, and days of 4/h use (in scale). The choice of the reference group for categorical variables (dichotomous or not) was based on the highest absolute frequency of the category, as is the case of gender, or on the first category of the variable under study for the remaining variables. The established significance level was 0.05 and the confidence intervals were 95\%. All statistical treatment was performed with the statistical program IBM SPSS Statistics for Windows, Version 23.0.

**Results**

**Study population**

Of the 1151 patients admitted, 780 patients were men (67.1\%) and 371 were women (31.9\%). Most patients were under 65 years (59.4\%), but patients over 65 years had the highest adherence with 76.4\% (76.4\% versus 56.5\%). Patient characteristics are shown in Table 1.

The distribution of patients by OSA severity focuses on AHI > 30/hr with a total of 493 patients (42.4\%) and AHI 15–30/hr with 433 patients (37.3\%), and 75.5\% of patients with AHI > 30/hr adhered to APAP treatment.
Table 1. Demographic characteristics

<table>
<thead>
<tr>
<th>Population</th>
<th>Episodes (%)</th>
<th></th>
<th>APAP (n, %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>780 (67.1)</td>
<td>272 (34.9)</td>
<td>508 (65.1)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>371 (31.9)</td>
<td>137 (36.9)</td>
<td>234 (63.1)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>under 65</td>
<td>690 (59.4)</td>
<td>300 (43.5)</td>
<td>390 (56.5)</td>
</tr>
<tr>
<td></td>
<td>over 65</td>
<td>461 (39.7)</td>
<td>109 (23.6)</td>
<td>352 (76.4)</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td></td>
<td>65.01 ± 13.42</td>
<td></td>
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</tr>
</tbody>
</table>

APAP — automatic positive airway pressure; SD — standard deviation

Table 2. Categorization of patients according to the severity of OSA with and without adherence

<table>
<thead>
<tr>
<th>AHI</th>
<th>Episodes (%)</th>
<th></th>
<th>APAP (n, %)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15</td>
<td>225 (19.4)</td>
<td>120 (53.3)</td>
<td>105 (46.7)</td>
<td></td>
</tr>
<tr>
<td>15-30</td>
<td>433 (37.3)</td>
<td>168 (38.8)</td>
<td>265 (61.2)</td>
<td></td>
</tr>
<tr>
<td>&gt; 30</td>
<td>493 (42.4)</td>
<td>121 (24.5)</td>
<td>372 (75.5)</td>
<td></td>
</tr>
</tbody>
</table>

APAP — automatic positive airway pressure; AHI — apnea/hypopnea index

Table 3. Bivariable analysis of APAP adherence according to gender, age group and AHI

<table>
<thead>
<tr>
<th>Variables</th>
<th>APAP Adherence</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R</td>
<td>P value</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>-0.02</td>
<td>P = 0.496</td>
<td></td>
</tr>
<tr>
<td>Age group (years)</td>
<td>0.203</td>
<td>P &lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>AHI</td>
<td>0.225</td>
<td>P &lt; 0.001</td>
<td></td>
</tr>
</tbody>
</table>

APAP — automatic positive airway pressure; AHI — apnea/hypopnea index; R — Spearman’s rho

Table 2 shows the categorization of patients according to the severity of OSA with and without adherence to APAP.

APAP adherence

APAP adherence was higher in older age groups ($r = 0.203$, $p < 0.001$) and in patients with a higher AHI ($r = 0.225$, $p < 0.001$). No differences were observed with regards to gender.

Table 3 shows the correlation values of APAP adherence according to gender, age group and AHI.

Factors Associated with APAP Adherence

In the multivariable regression analysis with APAP adherence as the dependent variable we observed that the main factors associated with adherence were age group over 65 years (OR = 2.435; 95% CI = 1.862–3.185), AHI 15–30/h (OR = 1.733; 95% CI = 1.242–2.416) and AHI > 30/h (OR = 3.406; 95% CI = 2.426–4.782).

Table 4 presents the results of the multivariable logistic regression analysis fitted to the independent variables with adherence as the dependent variable, and the model was statistically significant ($p < 0.001$), with the Hosmer-Lemeshow test ($p > 0.988$) and the area under the receiver operating characteristic curve was 0.863.

Conclusions

In this study we identified patients diagnosed with OSA and their adherence to APAP. Our findings suggest that patients older than 65 years have better adherence to APAP than younger ones.

Several epidemiological studies [11, 12] have shown that an elderly patient could present a series of characteristics that have been associated with poorer compliance: living alone, fewer symptoms (particularly sleepiness), less dexterity, alterations in cognitive capacities, comorbidities, and neurological deficiencies. However, this assumption did not hold true in our study. Adherence to APAP was better in the elderly patients compared to the under-65 age group (OR = 2.435). Several studies have been conducted in this regard, suggesting APAP treatment may lead to adaptive changes in the neurocognitive architecture that underlies reduced sleepiness, and improve verbal episodic memory in OSA.
patients [13–17]. We speculated that our results might be due to improve cognitive deficits in this population.

Our study found no differences between male and female patients regarding adherence to APAP, contradicting previous studies [1, 18]. Patel et al. [1] and Lin et al. [18] have reported that females show overall less adherence to APAP when compared to males, especially when considering younger women. The reasons for this gender difference are not completely known, however social expectations related to female appearance and concerns about changing one’s image when using CPAP have been identified as a barrier to adherence to CPAP, as this may be seen as un-attractive. We speculate that our results may be related to the severity of the disease.

AHI is closely related to disease severity. According to our data the higher the AHI, the better the adherence [AHI > 30/h (OR = 3.406)]. These results are in agreement with previous studies [19] that have been evaluating this association between disease severity and treatment adherence. A comparative study [20] showed that 73% of participants with sleep apnea had depression, with worsening symptoms in those with more severe OSA. Therefore, it is expected that in the more severe cases of the disease, better adherence will be achieved. One possible explanation for this is the patient characteristics, social and psychological factors, as well as the improvements in quality-of-life.

On the other hand, Sweetman et al. [21, 22] showed that most patients with OSA have clinically significant symptoms of insomnia, and these patients show lower adherence use of CPAP therapy compared to patients with OSA alone [22, 23]. Several researchers [24, 25] suggest that patients’ insomnia should be treated before starting PAP, and if the insomnia was a precursor to OSA or if conditioned insomnia developed from the initial OSA. Other study [26] showed that APAP treatment can improve insomnia symptoms in 80% of patients with insomnia and OAS. In our study the presence of insomnia was not assessed, but in future work it should be considered due to its clinical implications on APAP adherence.

There are some limitations to this study. First, it is a single-center study, retrospective design, non-random sample choice, absence of possible confounding variables (e.g., insomnia). Second, we do not know which different models of APAP were adapted as well as different interfaces. Most patients had both nasal and facial masks. And third, as we only looked at adherence to treatment at 6 months, we cannot extrapolate these results in the long term.

Advantageously, this study has the advantage of being easily reproducible in other OSA diagnostic centers and thus compare results with other centers.

Additionally, this study reinforces the idea that the older age group adheres more to APAP, without

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**Table 4. Multivariable logistic regression analysis of APAP adherence**

<table>
<thead>
<tr>
<th>Factors Associated</th>
<th>APAP Adherence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OR</strong></td>
<td><strong>CI 95%</strong></td>
</tr>
<tr>
<td>Age group (years)</td>
<td></td>
</tr>
<tr>
<td>Under 65 (Ref.)</td>
<td>1</td>
</tr>
<tr>
<td>Over 65</td>
<td>2.435</td>
</tr>
<tr>
<td><strong>AHI</strong></td>
<td></td>
</tr>
<tr>
<td>&lt; 15/h (Ref.)</td>
<td>1</td>
</tr>
<tr>
<td>15–30/h</td>
<td>1.733</td>
</tr>
<tr>
<td>&gt; 30/h</td>
<td>3.406</td>
</tr>
<tr>
<td>Constant</td>
<td>0.649</td>
</tr>
<tr>
<td>Model P value</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hosmer-Lemeshow test</td>
<td>0.988</td>
</tr>
<tr>
<td>AUROC</td>
<td>0.863</td>
</tr>
</tbody>
</table>

APAP — automatic positive airway pressure; AHI — apnea/hypopnea index; OR — odds ratio; CI — confidence interval; ref. — reference category; AUROC — area under the curve of the receiver operating characteristic curve

**Figure 1.** Receiver operating characteristics curve for automatic positive airway pressure adherence
gender differences, proving the importance of investing in the elderly population, because we know that aging is increasing in developed countries and the treatment of the disease has a direct impact on the reduction of comorbidities that this population is naturally more susceptible to.

**Clinical implications and future directions**

This study reinforces the idea that the older age group adheres more to APAP without gender differences, proving the importance of investing in the elderly population, because we know that aging is increasing in developed countries and the treatment of the disease has a direct impact on the reduction of comorbidities that this population is naturally more susceptible to. In the future it would be interesting to do a prospective study to evaluate the long-term adherence of the same cohort and to assess the causes of non-adherence (e.g., insomnia), so that we can improve adherence in the younger age groups.

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**Conflict of interest**

None declared.

**References**