Association between Sleep Load Pressure Values with Sleep Apnea Diagnosis

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Abstract

Background: Sleep apnea is a risk factor for many cardiovascular conditions, therefore, its diagnosis is essential.
Objective: To check in patients with systemic arterial hypertension and sleep apnea whether there is an association between these diagnoses.
Methods: Retrospective study with adult patients of both sexes from the database of Clínica Paulista de Doenças Cardiovasculares diagnosed with systemic arterial hypertension and sleep apnea from January 2011 to January 2015. Data from ambulatory blood pressure monitoring (ABPM) and polysomnography associated for the presence of increased pressure load and no pressure decrease during sleep and the presence of obstructive episodes that diagnosed sleep apnea. Patients were also evaluated for cardiovascular risk factors: physical inactivity, obesity, smoking, glucose level and lipid profile.
Results: Altogether, 59 patients have been evaluated, 32 of which (54.2%) presented, during ABPM, stable or increased pressure load with no decline during sleep compared to wakefulness. Of these patients, 31 (96.9%) had sleep apnea in polysomnography, showing an association of 97.0%.
Conclusion: In this study, we observed a strong association between systemic arterial hypertension and sleep apnea.

Keywords: Sleep apnea syndromes; Masked hypertension; Blood pressure monitoring, ambulatory; Polysomnography

Introduction

Sleep apnea (SA) is a disorder characterized by the collapse and obstruction of the upper airway during sleep, leading to respiratory pauses of 10 or more seconds¹. It may be accompanied by oxygen desaturation, hypercapnia and maintenance of respiratory effort¹,². Clinical suspicion is determined by the presence of snoring and daytime sleepiness, and the gold standard for diagnosis is polysomnography which has sensitivity and specificity of 95%³. The apnea syndrome is confirmed when the number of obstructive events per hour of sleep is equal to or greater than five events per hour of sleep¹.

SA affects one in every four men and one in every ten women, brings repercussions to the quality of life of patients due to excessive daytime sleepiness, poor performance in daily activities, irritability and mood lability, and it is strongly related to cardiovascular diseases. The main cardiovascular consequences are abnormalities in the autonomic nervous system, systemic arterial hypertension (SAH), cardiac arrhythmias, coronary artery disease, stroke, and heart failure (HF)³–⁵.

SAH is the most common consequence of SA and it is estimated that 40.0% of SAH patients have associated
undiagnosed and untreated SA. Of patients with SA, 60.0% have SAH. Evidence points SA as an important cause of secondary hypertension and as a contributing factor to uncontrolled blood pressure and target-organ injury. There is great variability in blood pressure at night, which may not present the nighttime decrease observed in normal individuals, while maintaining high average nighttime value even in situations where normal blood pressure levels are observed during the day. Recurrent awakenings resulting from episodes of apnea cause repeated outbreaks of catecholamine release and sharp increase in the sympathetic tone. The increase in sympathetic vascular nerve activity and circulating catecholamines subsequently lead to increased peripheral vascular resistance, episodic increases in nocturnal blood pressure and propagation of atherosclerosis. SAH is secondary to persistently high sympathetic state. The management of SA may lead to decreased blood pressure.

Ambulatory blood pressure monitoring (ABPM) is a method that allows indirect and intermittent recording of blood pressure for 24 hours or more, while the patients perform their usual activities during periods of wakefulness and sleep. One of its biggest advantages is the ability to identify changes in blood pressure according to the circadian cycle, especially the abnormalities during sleep, which have considerable prognostic implications.

Systolic or diastolic pressure loads (PL) above 50% during periods of sleep and wakefulness are considered abnormal. Physiologically speaking, decrease in blood pressure during sleep is expected, but some factors such as, for example, quality of sleep, may be responsible for poor reproducibility of this data. Physiologic decrease in blood pressure during sleep is considered to be a reduction of at least 10% of the systolic blood pressure (SBP) and diastolic blood pressure (DBP) and/or systolic decrease, diastolic decrease, systolic and diastolic decrease observed between wakefulness and sleep.

This study aims to determine whether patients with increased pressure load during sleep have SA, even if there are no sleep disorder complaints, which would allow, in theory, early diagnosis and taking preventive measures with regard to injury of target organs due to SAH.

Methods

Retrospective study of patients under cardiac monitoring for SAH and SA registered in the database of FGM-Clínica Paulista de Doenças Cardiovasculares from January 2010 to February 2015.

This study has been approved by the Research Ethics Committee of Universidade Anhembi Morumbi under no. 689226. Because it is a retrospective study, Informed Consent Form was not required.

One hundred patients were diagnosed with SAH and SA. Among them, 59 were selected, 29 (49.2%) of which were men and 30 (50.88%) were women with a mean age of 61.4±11.0 years according to the following inclusion criteria: SAH before SA; ABPM before polysomnography performed to diagnose SA; laboratory controls for cardiovascular risk factors such as lipid profile and fasting glucose; being under drug treatment for SAH and blood pressure under control.

Forty-one patients were excluded because of the absence of polysomnography tests and ABPM, since the diagnosis occurred prior to the start of follow-up in the study clinic; because they failed to perform laboratory tests or showed poor adherence to the drug treatment prescribed by the attending physician.

Of the 59 individuals selected, 6 underwent polysomnography only and 53 met the medical request to undergo ABPM and polysomnography. Although the tests are not complete, the data were used to calculate adherence to tests and knowledge of potential limitations in the diagnosis of SA.

The result of ABPM pressure load (nighttime PL and decrease) was associated with the data of obstructive episodes found in polysomnography in the first diagnosis of SA.
Positive association between SAH and SA was considered when there was increased pressure load or absence of nighttime decrease on ABPM followed by the presence of obstructive episodes in polysomnography (diagnosis of SA). The association was negative when there was nighttime pressure load change and no decrease on ABPM and polysomnography without obstructive episodes (negative for SA).

All patients were assessed for cardiovascular risk by anthropometric measures, by factors reported in the clinical history such as physical inactivity, smoking and eating habits, and laboratory control tests with information on lipid profile and glycemic control.

The results were compared between the groups with and without sleep apnea through ANOVA and chi-square tests. Post hoc Bonferroni test was applied when necessary. A p value ≤0.05 was considered significant.

**Results**

Fifty-nine patients were studied: 29 (49.2%) males and 30 (50.88) females with mean age of 61.4±11.0 years (15-85 years). The characteristics of the population studied are found in Table 1. The most prevalent factors were obesity, SAH, physical inactivity and dyslipidemia.

The patients’ ABPM was analyzed for pressure load during wakefulness (PLW) and during sleep (PLS), SBP and DBP. Sleep values higher than wakefulness values were questioned for the presence of SA (Table 2). Six patients who failed to bring ABPM were excluded.

To observe the association between SAH diagnosed in ABPM and SA diagnosed in polysomnography, the study included data from 32 patients presenting, in ABPM, stable or increased PL during sleep compared to wakefulness and those who underwent polysomnography. The presence of SA was found in 31 patients (Table 3). The study excluded 2 patients who did not undergo polysomnography for personal reasons (they reported fear).

It was observed that 97.0% of the patients presented nighttime apnea with an average number of events per night of sleep of 78.1.

**ABPM and polysomnography association**

Based on the data collected, it was found that the association between stable/increased PL during sleep compared to wakefulness with the outcome of SA in the polysomnography was a constant, therefore not applicable to the p value.

There was a difference in the behavior SPL and DPL during wakefulness and sleep with lower value during

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**Table 1**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>n (%)</th>
</tr>
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<tbody>
<tr>
<td>SAH</td>
<td>48 (81.4)</td>
</tr>
<tr>
<td>Obesity</td>
<td>49 (83.0)</td>
</tr>
<tr>
<td>Type 2 diabetes mellitus</td>
<td>14 (23.7)</td>
</tr>
<tr>
<td>Dyslipidemia</td>
<td>36 (61.0)</td>
</tr>
<tr>
<td>HF</td>
<td>6 (10.2)</td>
</tr>
<tr>
<td>Previous cardiovascular diseases</td>
<td>4 (6.8)</td>
</tr>
<tr>
<td>Smoking</td>
<td>11 (18.6)</td>
</tr>
<tr>
<td>Physical inactivity</td>
<td>47 (79.7)</td>
</tr>
</tbody>
</table>

SAH – systemic arterial hypertension; HF – heart failure
Table 3
Patients with suspected sleep apnea in ABPM and diagnosis of sleep apnea in polysomnography

<table>
<thead>
<tr>
<th>Diagnosis of apnea in polysomnography</th>
<th>Yes n (%)</th>
<th>No n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected apnea in ABPM (n=32)</td>
<td>31 (97.0%)</td>
<td>1 (3.0%)</td>
</tr>
</tbody>
</table>

ABPM – ambulatory blood pressure monitoring

Figure 1
Behavior of systolic pressure load during periods of wakefulness (1) and sleep (2)
PLW – pressure load during wakefulness; PLS – pressure load during sleep

Figure 2
Behavior of diastolic pressure load during periods of wakefulness (1) and sleep (2)
PLW – pressure load during wakefulness; PLS – pressure load during sleep
wakefulness and increased sleep (Figures 1 and 2). There was also a similar variation in DPL, with lower value in wakefulness compared to the values found in sleep (Figure 2).

Associations have been determined between anthropometric measurements and the presence of SA diagnosed in polysomnography in order to identify factors that could indicate the presence of the disease (Table 4).

It was observed that patients with SA were older than 60 and overweight.

The mean values of PLS and PLW were compared with the severity of apnea observed in polysomnography (Table 5) through the apnea indexes (SAI) established by consensus of SA: mild apnea - between 5 and 15; moderate apnea - between 15.1 and 30; severe apnea - higher than 30.1.

It was found that most participants had SAI>30, indicating severe apnea. No significant difference was found between pressure loads and SAI.

<table>
<thead>
<tr>
<th>Table 4</th>
<th>Anthropometric variables and diagnosis of sleep apnea in the population studied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnea confirmed by polysomnography</td>
<td></td>
</tr>
<tr>
<td>Age (in years)</td>
<td>62.6±11.0</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>82.2±18.0</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>99.6±16.0</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.66±0.09</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>29.9±4.4</td>
</tr>
<tr>
<td>Values expressed as mean±standard deviation</td>
<td></td>
</tr>
<tr>
<td>BMI – body mass index</td>
<td></td>
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</tbody>
</table>

The association between the pressure load in ABPM and dyslipidemia (DLP) (Table 6) was also analyzed.

An association between increased PL and the presence of DLP was found.

This study randomly selected patients with routine follow-up in an outpatient cardiology clinic. The most relevant risk factors were: SAH, obesity, DLP and

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Correlation between mean values of pressure load and severity of sleep apnea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apnea degrees</td>
<td>PLW (SBP)</td>
</tr>
<tr>
<td>Mild</td>
<td>n</td>
</tr>
<tr>
<td></td>
<td>mean±SD</td>
</tr>
<tr>
<td>Moderate</td>
<td>n</td>
</tr>
<tr>
<td></td>
<td>mean±SD</td>
</tr>
<tr>
<td>Severe</td>
<td>n</td>
</tr>
<tr>
<td></td>
<td>mean±SD</td>
</tr>
<tr>
<td>Total</td>
<td>n</td>
</tr>
<tr>
<td></td>
<td>mean±SD</td>
</tr>
<tr>
<td>p</td>
<td></td>
</tr>
</tbody>
</table>

PLW – pressure load during wakefulness; PLS – pressure load during sleep; PL – pressure load; SBP – systolic blood pressure; DBP – diastolic blood pressure; SD – standard deviation
physical inactivity. Ambulatory control patients showed complete non-adherence to treatment, since 6 (10.1%) patients failed to undergo ABPM, a test requested to identify SAH and the possibility of SA; and 21 (37.5%) failed to complete polysomnography after ABPM. Among patients who completed ABPM and polysomnography, 31 (97.0%) had SA.

**Discussion**

Cardiovascular disease is considered the one with the highest mortality rate of all others, including external causes, worldwide, reaching the remarkable rate of 30.0%\(^{11,12}\). However big are the efforts undertaken, overall mortality continues to rise because the positive results of a country are often less efficient in absolute numbers than the growing outbreak that the disease has in other countries that do not have quality programs to address this issue.

It is known that SAH is most prevalent risk factor among all risk factors in terms of mortality, accounting for 7.6 million deaths worldwide\(^{13}\). This study aimed to analyze ABPM, in particular the difference of sleep PL, which, from a physiologic point of view, should be smaller than PL during wakefulness. Once the patients were selected, it was decided to study them through polysomnography, which revealed a nearly total association between the presence of PL during sleep higher than during wakefulness and the presence of SA. Therefore, we can consider that hypertension during sleep is a very important factor in this association or the presence of apnea can transform a restful sleep into an extremely tense period for the body.

It is important to remember that the presence of SA implies oxygen desaturation, consequent agitation during sleep, stimulus to the production of red blood cells, increasing blood viscosity, platelet aggregation, probable increased renin-angiotensin-aldosterone system stimulation and consequently a vicious cycle that will certainly increase the likelihood of cardiovascular outcomes.

This study found, as the predominant cardiovascular profile, obese, physically inactive and dyslipidemic patients with significant association between dyslipidemia (DLP) and SA, as those patients with dyslipidemia presented higher PL during sleep. Cintra et al.\(^4\), in a randomized trial, also found the same cardiovascular profile in Brazilian patients with SA, a fact that confirms the potential association between DLP and SA.

Acute consequences of apnea, including hypoxemia, hypercapnia, repeated awakening and increased negativity of intrathoracic pressure may affect the regulation of blood pressure by neural and humoral mechanisms. It is a fact that people with SA have increased sympathetic activity, decreased baroreceptor sensitivity, vascular hyperresponsiveness and altered metabolism of salt and water, which may contribute to increased blood pressure. During periods of apnea, hypoxemia and acidosis stimulate the carotid chemoreceptors, causing vasoconstriction and consequent increase in peripheral vascular resistance\(^{14,15}\). These mechanisms explain why patients with SAH controlled with medication and diet have increased PL in ABPM when associated with SA, a fact found to be a constant

### Table 6
Correlation between dyslipidemia and pressure load on ABPM

<table>
<thead>
<tr>
<th>Abnormal nighttime pressure</th>
<th>Dyslipidemia</th>
<th>Total</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent n (%)</td>
<td>6 (75.0)</td>
<td>2 (25.0)</td>
<td>8 (100.0)</td>
</tr>
<tr>
<td>Present n (%)</td>
<td>4 (25.0)</td>
<td>12 (75.0)</td>
<td>16 (100.0)</td>
</tr>
<tr>
<td>Total n (%)</td>
<td>10 (41.7)</td>
<td>14 (58.3)</td>
<td>24 (100.0)</td>
</tr>
</tbody>
</table>

ABPM – ambulatory blood pressure monitoring
Andrchuk and Ceolim found, in a cross-sectional study, that hypertensive patients hospitalized for acute myocardial infarction have a high prevalence of SA, undergo clinical deterioration due to SA and deserve special attention in the postoperative period. Such prevalence was also observed by Floras in a review on the subject. SA also increased the risk of events related to SAH, such as stroke, heart failure and premature death. Arboix believes that SA is a new risk factor for ischemic stroke. Thus, it is concluded that SAH associated with SA is an important factor of increased cardiovascular risk and it is critical to provide early diagnosis, justifying the investigation of SA by polysomnography in patients with SAH with abnormality found in ABPM despite medications.

ABPM, therefore, unequivocally contributed to confirm SA when it reported the abnormal PL during sleep/wakefulness. All patients diagnosed were suggested to make lifestyle changes, increase physical activity, lose weight where applicable and, together with the pulmonology group, were instructed to use CPAP. These patients continue to be followed in the clinic and their future condition will certainly be the subject of future work.

As limitations, the reduced sample has limited the analysis of correlation between SAH and SA. Another point to be highlighted was the resistance of patients to undergo polysomnography because of the low adherence was detrimental to the correlation.

It is suggested to carry out prospective multicenter studies to address people of different social classes and more accurately identify whether presence of abnormal PL on ABPM can be considered a predictor of SA and cardiovascular risk.

**Conclusion**

In this study, a strong association between systemic arterial hypertension and sleep apnea was found.

**Potential Conflicts of Interest**

This study has no relevant conflicts of interest.

**Sources of Funding**

This study had no external funding sources.

**Academic Association**

This study is not associated with any graduate programs.

**References**