



Original Article

Insomnia symptoms and CPAP compliance in OSAS patients: A descriptive study using Data Mining methods

Xuân-Lan Nguyễn^{a,*}, Joël Chaskalovic^{b,c}, Dominique Rakotonanahary^a, Bernard Fleury^a

^a Unité de Sommeil, Service de Pneumologie, Hôpital Saint-Antoine, Paris, France

^b Department of Mathematics, University Center of Samaria, Ariel, Israel

^c Institut Jean le Rond D'Alembert, Université Pierre et Marie Curie, Paris VI, France

ARTICLE INFO

Article history:

Received 7 September 2009

Received in revised form 29 March 2010

Accepted 9 April 2010

Available online 6 July 2010

Keywords:

Insomnia complaint

Obstructive sleep apnea

Continuous positive airway pressure

CPAP compliance

Insomnia Severity Index

Data Mining analysis

ABSTRACT

Background: Obstructive Sleep Apnoea Syndrome (OSAS) and insomnia are common pathologies sharing a high comorbidity. CPAP is a cumbersome treatment. Yet, CPAP compliance must remain optimal in order to reverse excessive daytime sleepiness and prevent the cardiovascular consequences of OSAS. But chronic insomnia could negatively affect CPAP compliance.

Objective: To assess the consequences of insomnia symptoms on long-term CPAP use.

Methods: A prospective study was conducted on 148 OSAS patients (RDI = 39.0 ± 21.3 /h, age = 54.8 ± 11.8 years, BMI = 29.1 ± 6.3 kg/m², Epworth Score = 12.2 ± 5.4 , on CPAP. Using the Insomnia Severity Index (ISI) as an indicator of insomnia (ISI ≥ 14 = moderate to severe insomnia) and baseline data (anthropometric data, sleeping medication intakes, CPAP compliance, Epworth, Pittsburgh Sleep Quality and ISI scores, polygraphic recording data), Data Mining analysis identified the major rules explaining the features “High” or “Low ISI” and “High” or “Low Use” in the groups defined, according to the median values of the ISI and the 6th month-compliance, respectively.

Results: Median ISI was 15 and median 6th month-compliance was 4.38 h/night. Moderate to severe insomnia complaint was found in 50% of patients. In the “High” and “Low ISI,” the 6th month-compliance was not significantly different (3.7 ± 2.3 vs 4.2 ± 2.3 h/night). In the classification models of compliance, the ISI was not a predictor of CPAP rejection or of long-term use, the predictor for explaining CPAP abandonment being the RDI, and the predictor of the 6th month-compliance being the one month-compliance.

Conclusion: Insomnia symptoms were highly prevalent in OSAS patients, but had no impact on CPAP rejection or on long-term compliance.

© 2010 Elsevier B.V. All rights reserved.

1. Introduction

Obstructive Sleep Apnoea Syndrome (OSAS) and insomnia are two prevalent and public health pathologies sharing a high comorbidity [1–5]. The activation of the wakefulness drive involved in the physiopathology of insomnia [6,7] could become reinforced by repeated micro-arousals, the consequences of intermittent pharyngeal occlusions in the OSAS patient; this phenomenon could lead to a complaint of sleep maintenance insomnia or early morning awakenings and exacerbate a pre-existing insomnia complaint.

Continuous positive airway pressure ventilation (CPAP) [8], the first-line therapy for OSAS, is able not only to reduce daytime sleepiness and improve daily functioning [9], but also to improve cardiovascular outcomes [10,11]. Continued adherent use of CPAP must be optimal in order to maintain treatment effects [12]. But,

despite technological progress, nasal CPAP remains a cumbersome treatment that some patients reject from the start (the primary acceptance rate is typically only 85–90%) or decide to give up after some use (the withdrawal rate varies between 15% and 35%) [13–15].

Pre-existing insomnia could explain part of the early abandonment of nasal CPAP and poor compliance due to the sleep difficulties induced by the mechanical constraints of nasal CPAP. The challenge facing clinicians consists of increasing acceptance and adherence to CPAP; thus every effort should be made in order to maintain or facilitate compliance. In this context, screening for insomnia symptoms in patients recommended for CPAP therapy and starting systematic cognitive behavioural therapy in case of associated insomnia has been deservedly proposed [16]. However, to our knowledge, there are no data in the literature that establish the adverse impact of insomnia symptoms on CPAP compliance. If, in fact, comorbid insomnia does not affect CPAP compliance, screening for and treatment of the insomnia would unnecessarily delay OSAS treatment and lead to increasing public health costs.

* Corresponding author. Address: Hôpital Saint-Antoine, 184, rue du Faubourg Saint-Antoine 75012, Paris. Tel.: +33 1 49283160; fax: +33 1 49282331.

E-mail address: xuan-lan.nguyen@sat.aphp.fr (X.-L. Nguyễn).

The objective of this study was to determine the potential influence of insomnia symptoms on CPAP compliance in a sample of patients whose severity of the sleep apnea syndrome indicated the need for treatment.

2. Methods

2.1. Patients

Subjects in this study were 166 consecutive OSAS patients fitted with the device for continuous positive airway pressure (CPAP) between November 2005 and March 2007.

The study was approved by the Institutional Review Board of the Société de Pneumologie de Langue Française.

2.2. Procedures

2.2.1. Diagnostic procedure

Sleep-disordered breathing was diagnosed in 166 consecutive patients with an apnea–hypopnea index ≥ 10 /h on the basis of ambulatory cardiorespiratory monitoring according to the recommendations of the ATS/ACCP/AASM Taskforce Steering Committee [17,18]. The portable monitor (CID 102, CIDELEC, Gemmes sur Loire, France) analyzes snoring, oxyhaemoglobin saturation, nasal airflow by a nasal cannula and monitors respiratory effort with thoracic and abdominal strain gauges and a substernal pressure captor [19].

Abnormal breathing events and the time spent in a SaO₂ less than 90% were quantified per hour of monitoring time, as a Respiratory Disturbance Index (RDI) and “SaO₂ < 90%.”

2.2.2. Assessing baseline sleep quality

The insomnia complaint was assessed by the score on the Insomnia Severity Index (ISI) questionnaire, containing seven items, scored from 0 to 4, respectively:

1. Difficulty falling asleep.
2. Difficulty staying asleep.
3. Problem waking up too early.
4. Dissatisfaction with the current sleep pattern.
5. Interference with daily functioning.
6. Importance of the sleeping problem according to others.
7. Distress about the sleep problem.

The maximum ISI score is 28, 8 being the threshold for subclinical insomnia and 14 the threshold for a moderate to severe insomnia complaint [20].

2.2.2.1. Definition of ISI_{1,2,3}. We defined ISI_{1,2,3} as the index made of the sum of the first 3 items of the ISI, more specific for insomnia symptoms.

- The subjective quality of sleep was assessed by the Pittsburgh questionnaire (PSQI) [21], for which the maximum score is 21, and a value of ≥ 5 indicates poor sleep quality. The components of the PSQI score are Subjective Sleep Quality, Sleep Latency, Sleep Duration, Habitual Sleep Efficiency, Sleep Disturbances, Use of Sleep Medications, and Daytime Dysfunction. Each of these components is scored 0–3 (0 designating the absence of difficulty and 3 severe difficulties).
- Somnolence was assessed by the Epworth Sleepiness Scale [22], for which a value above 11 is an indicator of an excessive daytime somnolence [23].

2.2.3. Installing the CPAP device

Patients were fitted with the CPAP masks on the day after the announcement of the positive diagnosis of sleep apnea, on a scheduled visit at the hospital; the procedure was identical for all patients. During this visit, the patient could benefit from a training session explaining the pathology and treatment. A nasal mask was applied, unless the patient could confirm he was not able to breathe nasally; in this case a full-face mask was chosen. Finally the patient was given a 30 min-practice session with the CPAP before starting home treatment with the best-fitting equipment.

The positive airway pressure device was an auto-adjusting positive airway pressure (APAP) device initially with minimum and maximum pressures empirically set at 6 and 12 cm H₂O, respectively.

Home treatment was carried out by a technician specialized in home-care medical appliances contracted from the service-provider. Following a routine procedure, patients were systematically visited by a technician on days 8, 15 and at the end of the first month. On each visit, CPAP memory recordings (compliance, leaks) were collected. The mask was changed in cases of leakage or discomfort, and a heated humidifier was provided in cases of nasobuccal dryness. A full-face mask was proposed in case of persisting symptoms of oronasal dryness despite the use of a humidifier.

Overnight oximetry recording (PalmSAT® 2500, NONIN Medical, Inc., Plymouth, Minnesota, USA) was performed on two consecutive nights after verifying that the patient was sufficiently comfortable. Mechanical efficacy was defined by an ODI < 10/h; in case of an ODI ≥ 10 /h, the range of positive pressures was modified and additional visits were made in order to control treatment efficacy [24,25].

Epworth Sleepiness scores were systematically collected during the scheduled visits on the 1st and on the 6th month.

2.2.4. CPAP compliance

CPAP use M1 (month 1) and M6 (month 6) extracted from the CPAP device memory recordings, represented the mean efficient use, measured in hours, at 1 month and 6 months.

3. Statistical analyses and modeling on the study sample

The design of the study was prospective.

We chose to apply Data Mining (DM) methods (Clementine Software, SPSS Inc., USA) on our data. Since the study's objective was to assess the influence of the insomnia complaint on long-term CPAP compliance, we conducted the analysis, using successively the ISI and the 6th month CPAP use as the target variables.

Data Mining [26,27] involves information extraction, the goal of which is to discover hidden or a priori unknown facts contained in databases. Using a combination of machine learning, statistical analysis, modelling techniques and database technology, Data Mining automates the process of finding patterns and subtle relationships in data and infers rules for predicting trends and behaviours.

The first step in the DM process was to arbitrarily define “High ISI” subjects (whose ISI was \geq median ISI in the study sample) and “Low ISI” subjects (whose ISI was < median ISI), “High use” subjects (whose CPAP use was \geq median CPAP use M6) and “Low use” subjects (whose CPAP use was < median CPAP use M6). The following step was to identify from the database, the major rules explaining the feature “High” or “Low ISI” and “High” or “Low Use.” The database contained each of the following variables: age, sex, BMI, baseline RDI, percentage of time spent at SaO₂ < 90%, baseline Epworth Score, ISI and PSQI scores, as well as the details of their different components, consumption of psychotropic, hypnotic, anxiolytic

and anti-depressant drugs, compliance at one month and compliance as a proportion of sleep time (compliance/sleep time) at one month, the Epworth Score at one month, and finally compliance and compliance/sleep time at six months. In the present context, the most appropriate DM method was decision tree segmentation. This technique allowed the building of classification models using the most discriminating factors among all the variables, called predictors, leading lastly to the identification of the most homogenous subgroups regarding the target variables, i.e., the ISI status and the 6th month-compliance. Starting from the “root” of the tree, each new division brings an enhancement in the degree of homogeneity, this latter being defined by the “improvement” of the ratio $(p_n - p_{n-1})/p_n$, where n is the latest division, and p is the probability of rightly affecting a given subject to the appropriate category. The so-called “improvement” reflects the importance of the contribution of the predictor for explaining the target variable. Each of these classification models has a corresponding reliability level, which represents the probability of assigning a patient in the database to the appropriate ISI category or compliance at six months category.

Overweighting technique was used in DM to rebalance samples of different sizes for accurate analysis; this process only applies to the classification model of CPAP continuation/discontinuation (Fig. 3) in the section “Analysis of the 6th month CPAP compliance.”

As descriptive statistics we used the Z test to compare means calculated for the two groups of patients, the Student test to test the significance of the difference of the means for a given variable in two subgroups of subjects with regard to the total sample, and the Pearson χ^2 to compare the qualitative variables [26]. Linear multivariate analysis using the Pearson correlation test (under IBM-SPSS software) was conducted to explore correlations between the ISI and the other explanatory variables. Statistical significance was set at 0.01.

4. Results

Study flowchart (Fig. 1).

4.1. Patients

4.1.1. Total sample ($n = 166$)

The total sample consisted of 166 patients, 138 men and 28 women; the average age was 54.4 ± 11.4 years, BMI = 29.2 ± 6.3 kg/m²; RDI = 41.7 ± 22.2 events per hour, % SaO₂ < 90% = 14.4 ± 24.5 . Baseline Epworth Score was 12.5 ± 5.6 , ISI score 13.8 ± 5.5 , PSQI score 8.0 ± 3.4 . Data on 18 patients whose questionnaires were incomplete were excluded.

4.1.2. Study sample ($n = 148$)

For the 121 men and 27 women, mean age (54.8 ± 11.8 years), BMI (29.1 ± 6.3 kg/m²), RDI (39.0 ± 21.3 /h), % SaO₂ < 90% = 13.5 ± 20.3 , baseline Epworth (12.2 ± 5.4), ISI (13.9 ± 5.2) and PSQI (8.0 ± 3.3) scores were not statistically different from the data collected for the total sample.

Forty-six patients (31%) were taking psychotropic drugs, 17 (11%) of whom were under hypnotics, 25 (17%) under anti-depressants and 28 (19%) receiving anxiolytic treatment.

4.1.3. The mechanical effectiveness of the treatment

This was confirmed by the mean oxyhaemoglobin desaturation index (ODI) under CPAP of less than 5/h (3.6 ± 2.3) in the 148 patients. The continuous positive pressures applied through the masks were for the P95 (i.e., the 95th percentile of the positive airway pressure values during the night) and the P50 (i.e., the 50th percentile of the positive airway pressure values during the night) equal to 10.5 ± 2.4 hPa and 8.2 ± 2.3 hPa, respectively.

Among our 148 participants, 118 utilized CPAP by a nasal mask and 30 utilized a full-face mask. CPAP compliance was the same between groups averaging 4.1 ± 2.4 h/night and 3.5 ± 2.8 h/night, respectively, at one month (NS; mean \pm SD) and 3.9 ± 2.4 h/night and 3.8 ± 2.4 h/night, respectively, at six months (NS).

4.1.4. Analysis of the insomnia complaint

4.1.4.1. Description of the high ISI ($n = 73$) and low ISI ($n = 75$) groups (see Table 1). The median value of the ISI score was 15 in the study sample.

According to the PSQI data, sleep latency was significantly longer, while total sleep time was shorter for *High ISI*. As compared to the *Low ISI*, the Epworth Score, the Pittsburgh index and all seven items of the PSQI score were significantly higher in the *High ISI*.

There were no significant differences in age, BMI, RDI, in SaO₂ < 90%, nor in one-month CPAP use durations between *High* and *Low ISI*.

The use of sleep medications, either psychotropics in general or, specifically, hypnotics, anti-depressants or anxiolytics, was relatively high in both groups, but significantly higher in *High ISI*. Twenty-eight (38%) of *High ISI* were taking psychotropics compared to 15 (20%) of *Low ISI* ($p < 0.01$). Twelve (16%) *High ISI* were consuming hypnotics compared to 4 (5%) of *Low ISI* ($p < 0.01$). Taking anxiolytics and anti-depressants was also more frequent for *High* than *Low ISI* (24 (33%) versus 13 (17%), $p < 0.01$).

4.1.5. Classification model of the ISI status (see Fig. 2)

The decision tree obtained on the target variable ISI with the two modalities “*Low ISI*” and “*High ISI*” led to identifying two homogeneous subgroups of patients. The only predictor retained by the decision tree algorithm to define the “*High ISI*” was the Pittsburgh Index (mean value 12 ± 2.3 in the “*High ISI*”) responsible for a major 20% improvement in the probability of appropriately classifying subjects. The most significant predictors defining the “*Low ISI*” were successively the Pittsburgh Index (mean value 6.3 ± 2 in the corresponding subgroup) and the Subjective Sleep Quality, as a component of the PSQI index (mean value 1.5 ± 0.5 in the corresponding subgroup) responsible for a 4% improvement in the probability of appropriately classifying subjects.

The reliability of this segmentation model was 82%, meaning that patients were assigned to their category of high or low ISI with

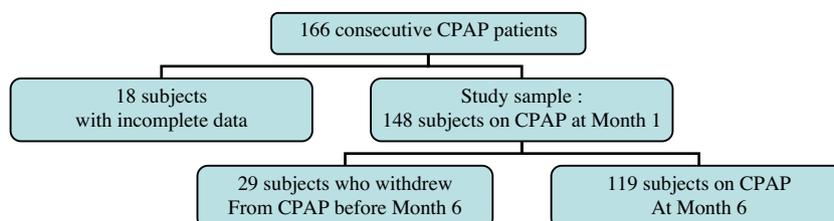


Fig. 1. Study flowchart.

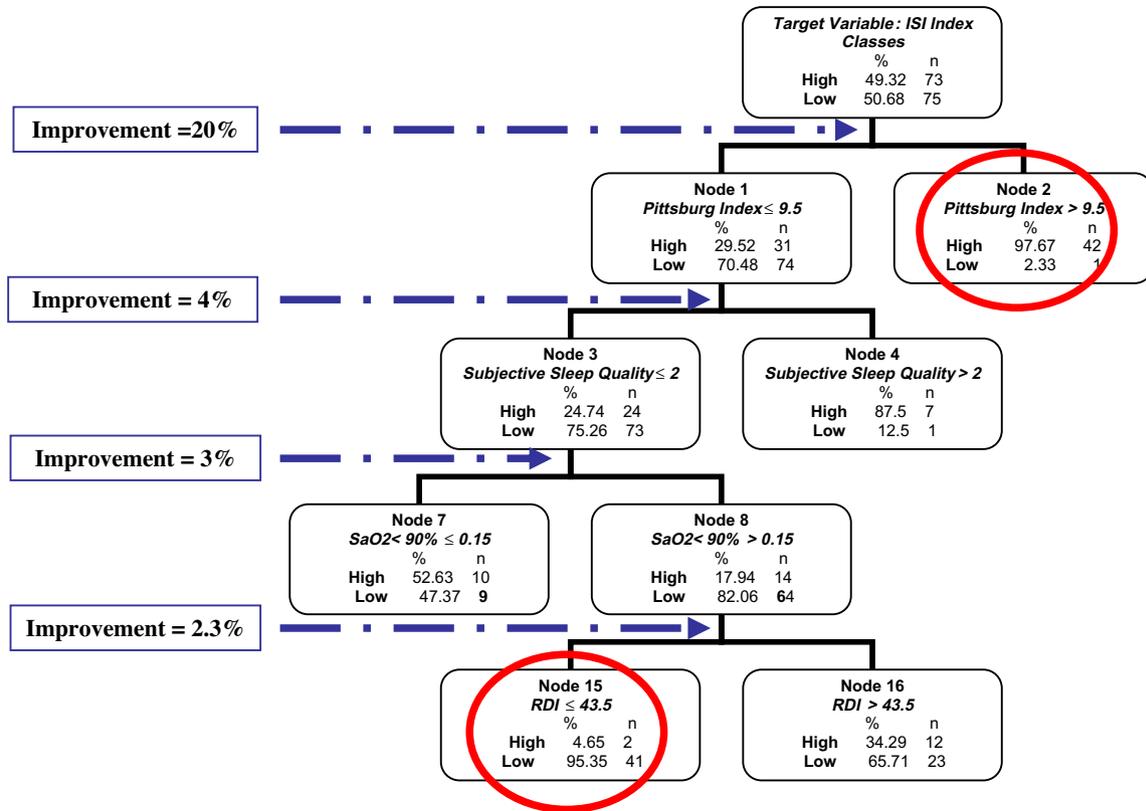


Fig. 2. Classification model of the ISI status – details of the decision tree.

a confidence level of 0.82. These results implied a reliability of this model suitable for clinical application.

4.2. Analysis of the six-month CPAP compliance

4.2.1. “Withdrawers” ($n = 29$) and “Still users” ($n = 119$) (see Table 2)

4.2.1.1. *Main characteristics.* Twenty-nine subjects, mean age = 56.7 ± 13.5 years, BMI = 28.7 ± 6.6 kg/m², RDI = 27.4 ± 11.3 events/h, % SaO₂ < 90% = 9.9 ± 17.6 , baseline Epworth Score = 10.6 ± 4.7 , ISI = 14.7 ± 4.2 , PSQI = 8 ± 3.2 , discarded the CPAP device after 101 ± 43 days of follow-up. Among them, 4 subjects never succeeded in using their CPAP devices. As compared to the 119 subjects still on CPAP therapy at six months of follow-up, patients who did not pursue CPAP had less severe sleep apnea syndrome according to the RDI and a reduced one month-CPAP use, these differences being statistically significant. There was no significant difference in ISI and PSQI. The Student test (with a high degree of significance [$p = 0.05$]) showed no significant difference of the means between the ISI and the two groups “Withdrawers” and “Still users.”

4.2.2. Data Mining analysis: classification model of CPAP continuation/discontinuation (see Fig. 3)

The target variable was the feature “Withdrawer” or “Still user,” which the terms OUT and IN, respectively stood for in Fig. 3. The most valuable predictors retained by the decision tree algorithm to define the “Withdrawers” were the RDI (mean value for the corresponding subgroup being 23.9 ± 8.2 events/h), with an “improvement” of 9.5%, the baseline Epworth Score (mean value for the corresponding subgroup being 8.6 ± 3.3) with an “improvement” of 4%, and the one month-CPAP use (mean value for the corresponding subgroup being 2.4 ± 2.0 h/night) with an “improvement” of 3.3%.

The RDI was a predictor of major importance for explaining the withdrawal from CPAP therapy.

The insomnia complaint was not a discriminant factor for CPAP rejection, as the ISI per se and the items of the ISI were not part of the decision tree.

As for the definition of the “Still users,” the most relevant predictors were first the RDI, with an “improvement” of 9.5% and mean value = 55.1 ± 17.4 events/h for the corresponding subgroup, and then the one-month-CPAP use, with an “improvement” of 4.8% and mean value = 5.0 ± 2.0 h/night for the corresponding subgroup.

4.3. Still users ($n = 119$)

4.3.1. Description of the “High Use” and “Low Use” subjects (see Table 3)

The median value of the CPAP use measured at month 6 was 4.38 h/night in the study sample. No significant difference in the baseline data was found between High and Low Use for age, BMI, Epworth Score, severity of the apnea syndrome according to the RDI or according to the percentage of time spent in an SaO₂ < 90%, the ISI and PSQI scores. Mean CPAP use at one month was 5.9 ± 1.7 h/night for High and 2.8 ± 1.9 h/night for Low Use ($p < 0.01$). At six months, mean CPAP use was 5.9 ± 1.1 and 1.8 ± 1.3 h/night, respectively for High and Low Use ($p < 0.01$). High Use used their CPAP $93.5 \pm 9.0\%$ of their sleep time at one month (vs. $73.6 \pm 29.5\%$ for Low Use) and $91.6 \pm 9.5\%$ of their sleep time at six months (vs. $52.2 \pm 28.4\%$ for Low Use) ($p < 0.01$).

4.3.2. Data Mining analysis: classification model of the 6th month CPAP use (see Fig. 4)

The decision tree obtained on the target variable with the two modalities “Low Use” and “High Use” led to identifying two homo-

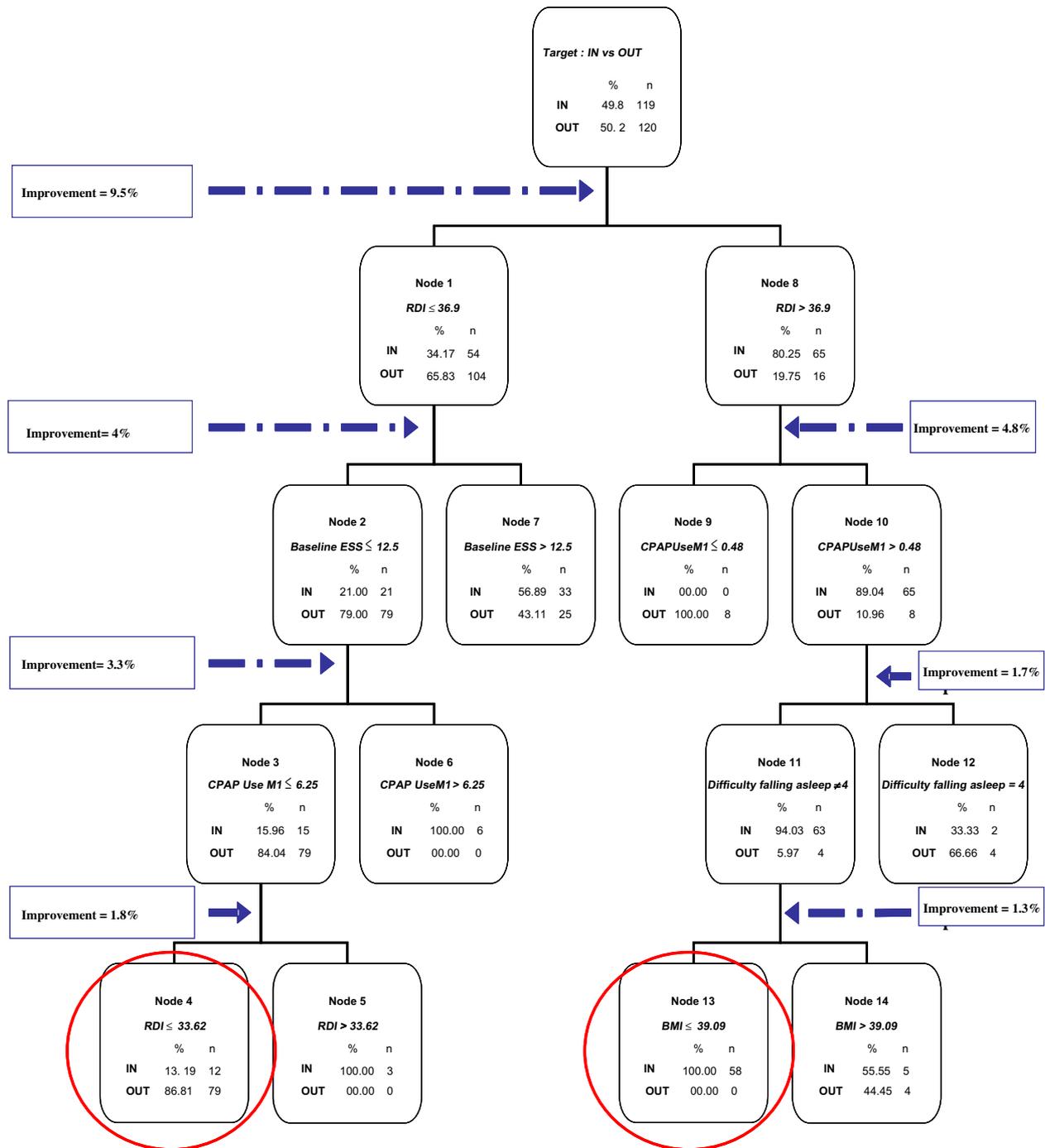


Fig. 3. Classification model of CPAP continuation/discontinuation – details of the decision tree. The number of subjects in the “OUT” sample in the first box of the tree is the number obtained after the overweighting process (using a 4.103 weighting factor, and $n = 120$ subjects being the sample size determined by the random function of the Data Mining algorithm).

geneous subgroups of patients. The only predictor retained by the decision tree algorithm to define “Low Use” subjects was the CPAP use measured at one month (mean value 1.9 ± 1.1 h/night in the “Low Use”), responsible for a major 19.7% improvement in the probability of appropriately classifying subjects. The major predictor defining the “High Use” was repeatedly the one month-CPAP use, with at first an improvement of 19.7% and mean value for the corresponding subgroup = 5.9 ± 1.4 h/night, and then an improvement of 3.4% , mean value = 6.6 ± 1.1 h/night for the corresponding subgroup.

The ISI and PSQI were not predictors for defining the “High” or “Low Use.” The reliability of this segmentation model was 78%,

meaning that patients were assigned to their category of high or low CPAP compliance with a confidence level of 0.78. These results implied a reliability of this model suitable for clinical application.

When an indicator of the insomnia complaint comprising the first three items of the ISI (i.e., “Difficulty falling asleep,” “Difficulty staying asleep” and “Problem waking up too early”) was used instead of the seven item ISI, and the same analysis was conducted, no change was observed in the different steps of the segmentation or in the values of “improvement”; the decision tree remained identical to the one shown in Fig. 4, meaning that considering the items pertaining to the specific sleep symptoms of insomnia was equivalent to considering the whole ISI score.

4.3.3. Multiple regression analysis

Pearson coefficients of correlation were $r = -0.168$ ($p = 0.07$, NS) between the ISI and the 6th month-CPAP use, $r = -0.125$ ($p = 0.20$, NS) between the ISI and the total number of hours of CPAP usage across the 6th month period, and $r = -0.065$ ($p = 0.49$, NS) between the ISI_{1,2,3} and the 6th month-CPAP use, confirming the insomnia complaint was not a contributor to a failure to use CPAP.

5. Discussion

Insomnia complaints were frequent in this sample of severe sleep-disordered breathing subjects, one out of two patients having an ISI score corresponding to moderate to severe insomnia. This high level of insomnia complaint was associated with higher hypnotic drug intake, poor subjective sleep quality according to the PSQI score, and a higher level of daytime somnolence at baseline, according to the Epworth Score. Its existence did not affect CPAP long-term compliance.

Our OSAS patients presented characteristics typical of this kind of population in clinical settings [28,29]. Because abnormal breathing events were quantified per hour of monitoring time as a RDI, the actual index of abnormal respiratory events was probably underestimated. Despite this limitation, the mean RDI was high in our sample.

The sleep data of our patients were not based on objective polysomnography data, but subjective data, derived from a robust questionnaire, the PSQI [30], which has been validated against PSG [31] and has been recognized as reliable for evaluating sleep in insomnia research.

Installing CPAP treatment and its follow-up were conducted in a way described previously [25]. The mechanical effectiveness of CPAP treatment was confirmed in all our patients by oximetry measures on CPAP treatment [32,33], with a mean ODI over 2 nights less than 5/h.

Table 1
Characteristics of High and Low ISI patients.

	High ISI (n = 73)	Low ISI (n = 75)	P (Z test)
ISI	18.1 ± 3.0	9.8 ± 3.5	<0.01
PSQI	9.9 ± 3.4	6.0 ± 2.0	<0.01
Use of sleep medication ^a	1.0 ± 1.3	0.4 ± 0.9	<0.01
Habitual sleep efficiency ^a	1.1 ± 1.2	0.5 ± 0.8	<0.01
Sleep latency ^a	1.1 ± 1.1	0.7 ± 0.8	<0.01
Sleep duration ^a	1.3 ± 0.9	0.8 ± 0.6	<0.01
Daytime dysfunction ^a	1.5 ± 1.0	1.1 ± 0.9	<0.01
Sleep disturbances ^a	1.8 ± 0.8	1.3 ± 0.6	<0.01
Subjective sleep quality ^a	2.2 ± 0.7	1.4 ± 0.6	<0.01
Sleep latency ^b (min)	26.4 ± 34.4	17.1 ± 17.1	<0.01
Total sleep time ^b (h)	6.1 ± 1.4	7.1 ± 1.4	<0.01
Epworth score	13.3 ± 5.3	11.4 ± 5.3	<0.01
Age (years)	53.4 ± 11.4	56.4 ± 12.1	ns
BMI (kg/m ²)	29.8 ± 6.2	28.1 ± 6.5	ns
RDI	38.9 ± 23.7	39.0 ± 19.3	ns
% SaO ₂	9.5 ± 13.5	15.5 ± 23.7	ns
CPAP use M1 (h/night)	3.8 ± 2.3	4.2 ± 2.6	ns
CPAP use M1/TST ^c (%)	78.3 ± 27.3	78.3 ± 30.4	ns
CPAP use M6 (h/night)	3.4 ± 2.3	4.4 ± 2.4	ns
CPAP use M6/TST ^c (%)	68.7 ± 30.7	75.5 ± 26.9	ns

^a Component of the PSQI score.
^b Raw data derived from the PSQI questionnaire.
^c Total sleep time.

We examined insomnia complaints in our sleep-disordered breathing patients, with the ISI questionnaire that was validated in apneic subjects [1,2]. The items making up the ISI score in fact reflect insomnia criteria according to the DSM-IV [34], consisting, on one hand, of classic items asking about the difficulties in falling and staying asleep, and, on the other hand, sleep dissatisfaction and repercussions on diurnal functioning. In our sample the median ISI score was 15, above the threshold of 14 proposed by Bastien et al. [20], for defining an at least moderate insomnia complaint. The ISI score was on average very high (18.1 ± 3) in the High ISI.

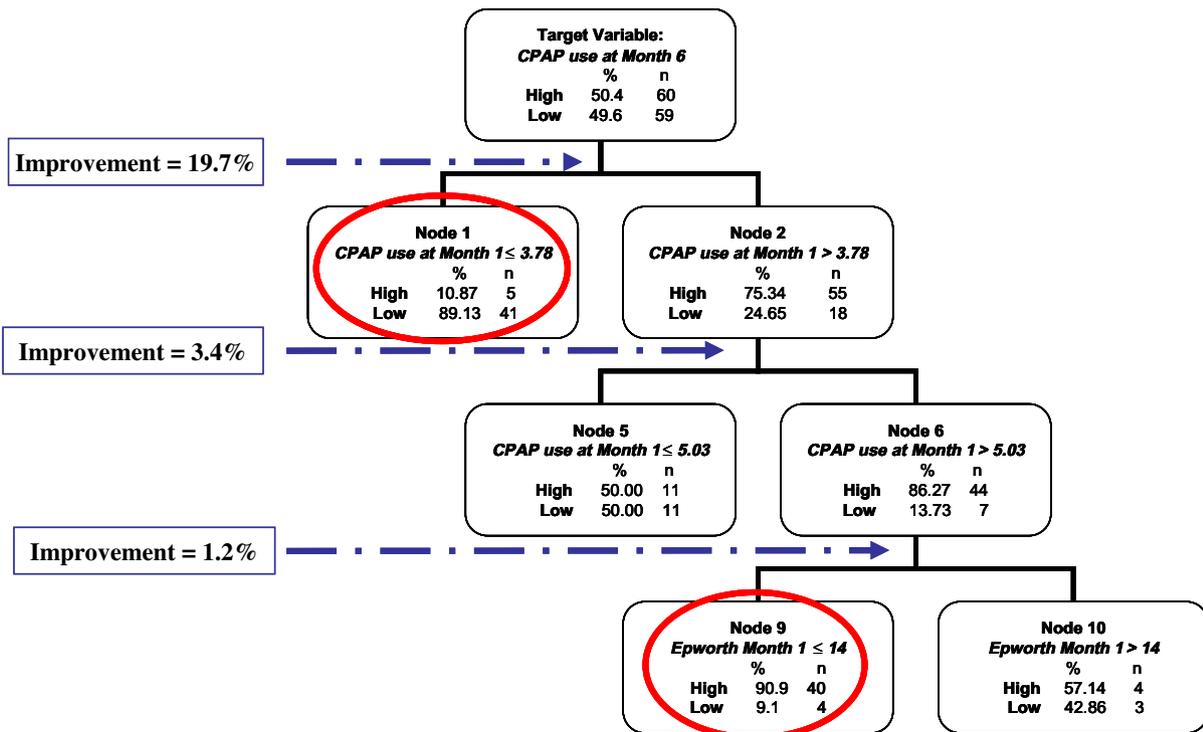


Fig. 4. Classification model of the 6th month CPAP use – details of the decision tree.

Table 2

Comparison between the 29 “Withdrawers” and the 119 “Still users”.

	Withdrawers (n = 29)	Still users (n = 119)	p (Z test)
ISI score	14.7 ± 4.2	13.7 ± 5.5	ns
PSQI index	8 ± 3.2	7.9 ± 3.5	ns
Epworth score	10.6 ± 4.7	12.7 ± 5.5	ns
Sleep latency (min)	18.4 ± 25	22.5 ± 27.8	ns
Sleep time (h)	6.8 ± 1.4	6.6 ± 1.5	ns
Age (years)	56.7 ± 13.5	54.5 ± 11.4	ns
BMI (kg/m ²)	28.7 ± 6.6	29.1 ± 6.4	ns
RDI (/h)	27.4 ± 11.3	41.8 ± 22.5	<0.01
% SaO ₂ < 90%	9.9 ± 17.6	13.3 ± 20.2	ns
CPAP use M1	2.4 ± 2.2	4.4 ± 2.4	<0.01
CPAP use/TST M1	57.7 ± 36.6	83.4 ± 24.2	<0.01

The prevalence of insomnia complaints in our study sample was close to what has been previously reported; while Krakow et al. [1] found a prevalence of 50% of insomnia symptoms in a population of sleep-disordered breathing patients using a 3-item scale to define insomnia, Smith et al. [2], who used self-rating questionnaires similar to ours, found a prevalence of 39%. We found in *High ISI*, extended sleep latency, reduced sleep duration and poor sleep quality, combined with significantly high scores on all PSQI dimensions. These findings confirm the reality of their insomnia complaint compared to the *Low ISI*. Yet, *Low ISI* also had disturbed baseline sleep quality, according to the PSQI, possibly related to OSAS consequences on sleep. The Epworth Score was also significantly higher for *High ISI*, as Ohayon and Lemoine [35] found. In our sample, the severity of the apnea syndrome was not, as described in an earlier study [1], associated with higher levels of insomnia complaint. The best predictor for explaining the high level of insomnia complaint was actually the PSQI, probably because of the redundancy of both questionnaires, exploring similar sleep disturbances. Psychotropic medication usage (31%) and hypnotic drug intake (11%) were, on average, higher in our apneic population than in the overall French population, where consumption estimates of these drugs are 12% for psychotropics and 6–8% for hypnotics [36,37]; the use of psychoactive drugs was significantly higher in *High ISI*: 38% vs. 20% in the *Low ISI*.

It is important to notice that this study was not designed to establish a causal relationship between OSAS and insomnia complaint, which could only be demonstrated by studying the development of the ISI score under CPAP treatment.

We can confirm the existence of moderate to severe insomnia complaint in half of our apneic patients. Given the high prevalence of patients with a sleep apnea syndrome recommended for CPAP treatment (0.5–1.5% of the population according to Stradling and Davies [38]), 50% of these apneic patients would justify a screening for insomnia symptoms and systematic cognitive-behavioral therapy prior to nasal CPAP, as Lavie has proposed [16]. This attitude would not only contribute to a rise in public health expenses, but also considerably delay the initiation of CPAP therapy, and does not seem reasonable, unless it was proven that insomnia had a negative impact on CPAP compliance.

The aim of the study was therefore to analyze the impact of insomnia complaint on long-term CPAP compliance. The major finding was that the insomnia complaint, as expressed by the ISI,

a validated tool for assessing insomnia in clinical settings [39], did not affect CPAP rejection, nor did it affect the CPAP use at six months.

Twenty-nine (19.6%) subjects withdrew from CPAP therapy within the first six months after a mean CPAP use-period of 101 ± 43 days, which is consistent with previous findings [13–15]. Those subjects had less severe sleep apnea syndrome [14,15,40,41], and their CPAP use measured at one month was significantly lower than in subjects who continued with CPAP, characteristics already described as associated with poor compliance [14,42]. The insomnia complaint was not an explanatory factor for CPAP withdrawal. The ISI and PSQI of the patients who had rejected CPAP were not significantly different from those of patients still on CPAP after six months. These findings were confirmed by the DM analysis: the ISI and PSQI were not predictors of the 6th month of compliance, the severity of the sleep apnea syndrome as expressed by the RDI being the major predictor (with a 9.5% improvement) for being a “withdrawer” from CPAP.

CPAP compliance was similar for the two groups *High* and *Low ISI*, in a simple comparative analysis after six months of use, and was comparable to that typically found in similar populations [43,44]. ISI and PSQI scores were not statistically different in “*High use*” and “*Low Use*” groups. These results were supported by the DM analysis: the ISI was not recognized as a predictor of the six month-CPAP use, nor were the components of the ISI, the one month-CPAP use being the strongest predictor of the six month-CPAP compliance, as has already been reported [15,42]. As for the ISI including items pertaining to daytime impairment (the last four items of the overall score, relative to the dissatisfaction of the current sleep pattern, the interference with daily functioning, the importance of the sleeping problem according to others, and the distress about the sleep problem), one could argue that high ISI scores were the result of sleep disturbances due to sleep apnea per se and not the consequences of a higher insomnia complaint. But the result of the Data Mining analysis remained valid, even when a more “traditional” indicator for the insomnia complaint [1,3] assessing sleep disturbances, such as the difficulties in initiating or maintaining sleep or the problems of early morning awakenings (the first three items of the ISI), was used. These findings do not support previous hypotheses [1,16] about the negative impact of insomnia complaint on CPAP compliance, implying that specific treatment of insomnia should not be systematic.

Finally, one might have thought that hypnotic drug intake would have potentially masked the CPAP compliance problem in patients most affected by insomnia symptoms by improving the sleep parameters [45,46]. It is true that in our sample psychotropic medication intake was more frequent in the *High ISI* patients, since 16% of them were regularly taking hypnotics, compared to 5% of *Low ISI*. Nevertheless, in the segmentation analysis, hypnotic intake, as well as anxiolytics or anti-depressants, or psychotropic intake, regardless of the category, did not emerge as an explanatory factor for compliance.

6. Conclusions

Insomnia complaint occurred frequently in OSAS patients and was consistently associated with poor sleep quality. But insomnia

Table 3Characteristics of “*High*” and “*Low Use*” subjects.

	ISI score	PSQI index	Epworth score	Age (years)	BMI (kg/m ²)	RDI (/h)	% SaO ₂ < 90%
High use	13.2 ± 5.2	7.8 ± 3.2	11.5 ± 5.9	56.8 ± 10.8	29.8 ± 7.3	46.3 ± 22.9	16.4 ± 24.1
Low use	14.3 ± 5.9	8.1 ± 3.7	13.7 ± 5.2	52.2 ± 11.8	28.4 ± 5.1	37.1 ± 20.7	10.4 ± 15.1
p (Z test)	ns	ns	ns	ns	ns	ns	ns

complaint was not related to the severity of the disease and had no impact on medium and long-term CPAP use.

Acknowledgments

We thank Charles M. Morin, PhD, Université Laval, École de Psychologie, Québec, Canada, for kindly allowing us to use the French version of the ISI questionnaire.

The authors declare no financial disclosure.

References

- [1] Krakow B, Melendrez D, Ferreira E, Clark J, Warner D, Sisley B, et al. Prevalence of insomnia symptoms in patients with sleep-disordered breathing. *Chest* 2001;120:1923–9.
- [2] Smith S, Sullivan K, Hopkins W, Douglas J. Frequency of insomnia report in patients with obstructive sleep apnoea/hypopnea syndrome (OSAHS). *Sleep Med* 2004;5(5):449–56.
- [3] Krell SB, Kapur VK. Insomnia complaints in patients evaluated for obstructive sleep apnea. *Sleep Breath* 2005;9(3):104–10.
- [4] Guilleminault C, Palombini L, Poyares D, Chowdhuri S. Chronic insomnia, postmenopausal women, and sleep disordered breathing: part 1. Frequency of sleep disordered breathing in a cohort. *J Psychosom Res* 2002;53(1):611–5.
- [5] Krakow B, Melendrez D, Lee SA, Warner TD, Clark JO, Sklar D. Refractory insomnia and sleep-disordered breathing: a pilot study. *Sleep Breath* 2004;8(1):15–29.
- [6] Bonnet MH, Arand DL. Physiological activation in patients with sleep state misperception. *Psychosom Med* 1997;59:533–40.
- [7] Nofzinger EA, Buysse DJ, Germain A, Price JC, Miewald JM, Kupfer DJ. Functional neuroimaging evidence for hyperarousal in insomnia. *Am J Psychiatry* 2004;161(11):2126–8.
- [8] Sullivan CE, Issa FG, Berthon-Jones M, Eves L. Reversal of obstructive sleep apnoea by continuous positive airway pressure applied through the nares. *Lancet* 1981;1(8225):862–5.
- [9] Engleman HM, Martin SE, Deary IJ, Douglas NJ. Effect of continuous positive airway pressure on daytime function in sleep apnoea/hypopnoea syndrome. *Lancet* 1994;343(8897):572–5.
- [10] Marin JM, Carrizo SJ, Vicente E, Agusti AG. Long-term cardiovascular outcomes in men with obstructive sleep apnoea–hypopnoea with or without treatment with continuous positive airway pressure: an observational study. *Lancet* 2005;365(9464):1046–53.
- [11] Doherty LS, Kiely JL, Swan V, McNicholas WT. Long-term effects of nasal continuous positive airway pressure therapy on cardiovascular outcomes in sleep apnea syndrome. *Chest* 2005;127(6):2076–84.
- [12] Weaver TE, Maislin G, Dinges DF, Bloxham T, George CF, Greenberg H. Relationship between hours of CPAP use and achieving normal levels of sleepiness and daily functioning. *Sleep* 2007;30(6):711–9.
- [13] Waldhorn RE, Herrick TW, Nguyen MC, O'Donnell AE, Sodero J, Potolicchio SJ. Long-term compliance with nasal continuous positive airway pressure therapy of obstructive sleep apnea. *Chest* 1990;97(1):33–8.
- [14] McArdle N, Devereux G, Heidarnejad H, Engleman HM, Mackay TW, Douglas NJ. Long-term use of CPAP therapy for sleep apnoea/hypopnea syndrome. *Am J Respir Crit Care Med* 1999;159(4 Pt 1):1108–14.
- [15] Popescu G, Latham M, Allgar V, Elliott MW. Continuous positive airway pressure for sleep apnoea/hypopnoea syndrome: usefulness of a 2 week trial to identify factors associated with long term use. *Thorax* 2001;56(9):727–33.
- [16] Lavie P. Insomnia and sleep-disordered breathing. *Sleep Med* 2007;8(Suppl. 4):S21–5.
- [17] Flemons WW, Littner MR, Rowley JA, Gay P, Anderson WM, Hudgel DW, et al. Home diagnosis of sleep apnea: a systematic review of the literature. *Chest* 2003;124(4):1535–42. An evidence review cosponsored by the American Academy of Sleep Medicine, the American College of Chest Physicians, and the American Thoracic Society.
- [18] ATS/ACCP/AASM Taskforce Steering Committee. *Am J Respir Crit Care Med* 2004;169(10):1160–3. Executive summary on the systematic review and practice parameters for portable monitoring in the investigation of suspected sleep apnea in adults.
- [19] Meslier N, Simon I, Kouatchet A, Oukel H, Person C, Racineux JL. Validation of a suprasternal pressure transducer for apnea classification during sleep. *Sleep* 2002;25(7):753–7.
- [20] Bastien CH, Vallières A, Morin CM. Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Med* 2001;2:297–307.
- [21] Buysse DJ, Reynolds III CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res* 1989;28:193–213.
- [22] Johns MW. A new method for measuring daytime sleepiness: the Epworth Sleepiness scale. *Sleep* 1991;14(6):540–5.
- [23] Punjabi NM, Bandeen-Roche K, Young T. Predictors of objective sleep tendency in the general population. *Sleep* 2003;26(6):678–83.
- [24] Lévy P, Pépin JL, Deschaux-Blanc C, Paramelle B, Brambilla C. Accuracy of oximetry for detection of respiratory disturbances in sleep apnea syndrome. *Chest* 1996;109(2):395–9.
- [25] Nguyễn XL, Rakotonanahary D, Chaskalovic J, Philippe C, Hausser-Hauw C, Lebeau B, et al. Residual subjective daytime sleepiness under CPAP treatment in initially somnolent apnea patients: a pilot study using Data Mining methods. *Sleep Med* 2008;9(5):511–6.
- [26] Salvatore D, Reagle D. *Statistics and econometrics*, Schaum's collection. Mc Graw Hill; 2002.
- [27] Rokach L, Maimon O. *Data Mining with decision trees: theory and applications*. World Scientific Publishing Company; 2001.
- [28] Massie CA, Hart RW. Clinical outcomes related to interface type in patients with obstructive sleep apnea/hypopnea syndrome who are using continuous positive airway pressure. *Chest* 2003;123(4):1112–8.
- [29] Berry RB, Hill G, Thompson L, McLaurin V. Portable monitoring and autotitration versus polysomnography for the diagnosis and treatment of sleep apnea. *Sleep* 2008;31(10):1423–31.
- [30] Knutson KL, Rathouz PJ, Yan LL, Liu K, Lauderdale DS. Stability of the Pittsburgh Sleep Quality Index and the Epworth Sleepiness Questionnaires over 1 year in early middle-aged adults: the CARDIA study. *Sleep* 2006;29(11):1503–6.
- [31] Backaus J, Junghanns K, Broocks A, Riemann D, Hohagen F. Test-retest reliability and validity of the Pittsburgh Sleep Quality Index in primary insomnia. *J Psychosom Res* 2002;53(3):737–40.
- [32] Stradling JR. Reducing the cost of treating obstructive sleep apnea: good news for patients. *Am J Respir Crit Care Med* 2004;170(11):1143–4.
- [33] Mulgrew AT, Fox N, Ayas NT, Ryan CF. Diagnosis and initial management of obstructive sleep apnea without polysomnography: a randomized validation study. *Ann Intern Med* 2007;146(3):157–66.
- [34] American Psychiatric Association. *Diagnostic and statistical manual of mental disorders (DSM-IV)*. Washington, DC: American Psychiatric Association; 1994.
- [35] Ohayon MM, Lemoine P. Daytime consequences of insomnia complaints in the French general population. *Encéphale* 2004;30(3):222–7.
- [36] Quera-Salva MA, Orluc A, Goldenberg F, Guilleminault C. Insomnia and use of hypnotics: study of a French population. *Sleep* 1991;14(5):386–91.
- [37] Ohayon M, Caulet M, Lemoine P. The elderly, sleep habits and use of psychotropic drugs by the French population. *Encéphale* 1996;22(5):337–50.
- [38] Stradling JR, Davies RJ. Obstructive sleep apnoea–hypopnoea syndrome: definitions, epidemiology, and natural history. *Thorax* 2004;59(1):73–8.
- [39] Morin CM, Vallières A, Guay B, Ivers H, Savard J, Mérette C, et al. Cognitive behavioral therapy, singly and combined with medication, for persistent insomnia: a randomized controlled trial. *JAMA* 2009;301(19):2005–15.
- [40] Richard W, Venker J, den Herder C, Kox D, van den Berg B, Laman M, et al. Acceptance and long-term compliance of nCPAP in obstructive sleep apnea. *Eur Arch Otorhinolaryngol* 2007;264(9):1081–6.
- [41] Pelletier-Fleury N, Rakotonanahary D, Fleury B. The age and other factors in the evaluation of compliance with nasal continuous positive airway pressure for obstructive sleep apnea syndrome. A Cox's proportional hazard analysis. *Sleep Med* 2001;2(3):225–32.
- [42] Kribbs NB, Pack AI, Kline LR, Smith PL, Schwartz AR, Schubert NM, et al. Objective measurements of patterns of nasal CPAP use by patients with obstructive sleep apnea. *Am Rev Respir Dis* 1993;147(4):887–95.
- [43] Noseda A, Jann E, Hoffman G, Linkowski P, Kerkhofs M. Compliance with nasal continuous positive airway pressure assessed with a pressure monitor: pattern of use and influence of sleep habits. *Respir Med* 2000;94(1):76–81.
- [44] Budhiraja R, Parthasarathy S, Drake CL, Roth T, Sharief I, Budhiraja P, et al. Early CPAP use identifies subsequent adherence to CPAP therapy. *Sleep* 2007;30(3):320–4.
- [45] Lettieri CJ, Quast TN, Eliasson AH, Andrada T. Eszopiclone improves overnight polysomnography and continuous positive airway pressure titration: a prospective, randomized, placebo-controlled trial. *Sleep* 2008;31(9):1310–6.
- [46] Collen J, Lettieri C, Kelly W, Roop S. Clinical and polysomnographic predictors of short-term continuous positive airway pressure compliance. *Chest* 2009;135(3):704–9.