RESPIRATORY CARE Paper in Press. Published on February 19, 2013 as DOI: 10.4187/respcare.02176

FACTORS AFFECTING POSITIVE AIRWAY PRESSURE THERAPY ACCEPTANCE IN ELDERLY PATIENTS WITH OBSTRUCTIVE SLEEP APNEA IN TAIWAN

Running title: PAP acceptance in the elderly with OSA

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RESPIRATORY CARE Paper in Press. Published on February 19, 2013 as DOI: 10.4187/respcare.02176

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ABSTRACT

Background: The prevalence of obstructive sleep apnea (OSA) increases with age. Treatment often includes positive airway pressure (PAP) therapy. Previous studies have shown that continuous PAP use is correlated with disease severity and symptoms. We hypothesized that PAP acceptance rates in elderly patients with OSA would be lower than in younger patients with OSA and examined factors associated with acceptance.

Methods: We reviewed the charts of 315 patients with OSA (apnea-hypopnea index $\geq$ 5) who were treated at our hospital from 2008 to 2011 with PAP therapy. All underwent PAP titration testing before PAP prescription. Patients were grouped by their age: young (25-40 years, n = 35), middle (41-65 years, n = 169), and elderly group (> 65 years, n = 111). Demographic variables, excessive daytime sleepiness (EDS), overnight polysomnography (PSG) study variables, PAP acceptance, and PAP adherence were compared. Regression analysis was performed to identify factors associated with acceptance.

Results: Elderly patients with OSA experienced less excessive daytime sleepiness and less pronounced alterations in overnight PSG variables than patients in the other groups, but had more cardiovascular comorbidities. The PAP acceptance rate (overall 125/315, 39.7%) was significantly lower in the elderly group compared with the young group (31.5% vs. 60%, *P* = 0.011). PAP acceptance was associated with fewer comorbidities, higher EDS, and higher AHI severity, but not age. PAP adherence was not associate with age.

Conclusions: PAP acceptance is low in elderly patients in Taiwan. PAP acceptance, instead of PAP adherence, is the critical issue in clinical practice concerning elderly patients with OSA. Future studies are needed to resolve the key obstacles to PAP acceptance among elderly patients with OSA.

Keywords: elderly; obstructive sleep apnea; continuous positive airway pressure; adherence; acceptance.

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ABBREVIATIONS

AHI, apnea-hypopnea index

APAP, auto-adjusted positive airway pressure

BPAP, bi-level positive airway pressure

BMI, body mass index

BP, blood pressure

CAD, coronary artery disease

COAD, chronic obstructive airway disease

CPAP, continuous positive airway pressure

CVA, cerebrovascular accident

CVD, cardiovascular disease

dBP, diastolic blood pressure

DM, diabetes mellitus

EDS, excessive daytime sleepiness

ESS, Epworth Sleepiness Scale

HTN, hypertension

MBP, mean arterial blood pressure

OSA, obstructive sleep apnea

PAP, positive airway pressure

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PSG, polysomnography

REM, rapid eye movement

sBP, systolic blood pressure

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INTRODUCTION

The prevalence of obstructive sleep apnea (OSA) increases with age [1-3]. Physiological sleep alterations that increase with age include reduced sleep efficiency, delayed onset of sleep, less slow-wave sleep, a higher percentage of light sleep (Stage 1 [S1] and S2), lower Epworth Sleepiness Scale (ESS) scores, and less excessive daytime sleepiness (EDS) [3-6]. These changes in sleep patterns may not be recognized as OSA because the symptoms of fatigue, hypersomnolence, and morning headache are often ascribed to other diseases or to aging itself [6]. However, OSA, especially in the elderly, can reduce physical functioning in daily tasks, lessen memory recall, and increase the risk of fall and the associated consequences, including mortality [5]. OSA is a significant risk factor for the occurrence of cardiovascular and cerebrovascular disorders [7]. Simon et al recently suggested that cardiovascular-related disease may indicate a higher risk for sleep apnea and that elderly patients with cardiovascular disease should be screened for sleep apnea [8].

Interventions for OSA include weight loss, altered sleeping positioning, and the use of positive airway pressure (PAP) devices [9]. Elderly patients who use PAP therapy to treat their OSA have increased alertness, improved neurobehavioral outcomes in cognitive processing, memory, and executive function, and decreased sleep disruption [10]. However, many elderly patients have difficulty accepting and tolerating nightly PAP therapy, and frequently cease therapy [11, 12]. It must be noted, however, that cessation of PAP therapy is

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also a problem in younger patients with OSA; indeed, there does not appear to be any marked difference in the rate of adherence / compliance with PAP therapy among different age groups [11, 13, 14]. Factors associated with poorer acceptance in the elderly include living alone, minor symptoms (especially hypersomnia), fewer skills or alteration of cognitive abilities, comorbidities, and neurological deficits [15].

PAP adherence in middle aged patients with OSA patients was found to be associated with higher age, female gender, and lower ESS scores [16]. Adherence in elderly male patients was improved with attendance to a PAP education and support group, while nonadherence was associated with benign prostatic hyperplasia in elderly men [11]. As the signs and symptoms of OSA in the elderly are less severe [17] and the impact of the disease may be less pronounced [18] than in younger individuals, we hypothesized that the rate of PAP acceptance may be lower in elderly patients with OSA than acceptance in younger patients with OSA. We also hypothesized that different factors may be associated with PAP acceptance and adherence in elderly patients with OSA compared with younger patients with OSA. To test these hypotheses, we retrospectively reviewed medical records of 315 patients with newly diagnosed OSA and polysomnography (PSG) test results to determine the rates of acceptance and adherence to PAP therapy with OSA and to investigate the independent factors associated with PAP acceptance and adherence.

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METHODS

The retrospective review of medical records of the Chest Clinic from January 2008 to December 2011 was approved by the Buddhist Tzu Chi General Hospital, Taipei Branch Institutional Review Board (New Taipei City, Taiwan). The Chest Clinic educates patients about OSA and PAP therapy, and is involved in the monitoring and assisting of patients during treatment. Written informed consents were waived.

A total of 496 patients without previous diagnosis of OSA were referred from the Chest Clinic for suggested overnight PSG study due to suspected OSA. Of these patients, 452 patients underwent overnight PSG study (44 patients refused). Exclusion criteria for subsequent analysis included split-night PSG study (n = 47), lost to follow up (n = 13) and normal overnight PSG results (n = 69). Split-night PSG is ordered for patients who have severe signs and symptoms, suggesting severe OSA. As these patients may therefore be more likely to accept PAP therapy, they were excluded. In addition, split-night PSG can underestimate the apnea-hypopnea index (AHI). Patients with predominantly central events were excluded. Eight of the 323 patients had mild OSA ($5 < AHI < 15$), but did not have excessive daytime sleepiness or cardiovascular complications; hence, PAP treatment was not required. The remaining 315 OSA patients ($AHI \geq 5$) who were symptomatic or had cardiovascular complications completed a PAP titration test before PAP was prescribed and were included in final analyses (Figure 1). These patients were categorized into 3 age groups:

young (n = 35, age: 25-40 years); middle-aged (n = 169, age: 41-65 years); and elderly (n = 111, age: > 65 years).

Assessment of baseline demographic and clinical characteristics

Medical history and physical included body weight, body height, body mass index (BMI), neck circumference, waist and hip circumference, waist to hip ratio, smoking status, and co-morbidity factors (hypertension (HTN), coronary artery disease (CAD), arrhythmia, cerebrovascular accidents (CVA), chronic obstructive airway disease (COAD, chronic obstructive pulmonary disease or asthma) and diabetes mellitus (DM). Cardiovascular disease (CVD) was defined as patients who had HTN, CAD, or CVA. Body composition was scored as underweight (BMI < 19.5 kg/m^2), normal (19.5 kg/m^2 ≤ BMI < 25.0 kg/m^2), overweight (25.0 kg/m^2 ≤ BMI < 30.0 kg/m^2) or obese (BMI ≥ 30.0 kg/m^2). Morning and evening blood pressure was monitored (Supplementary Methods 1).

Assessments of daytime sleepiness

Daytime sleepiness was subjectively evaluated using the ESS at the sleep center before overnight PSG study [19, 20]. EDS was defined as an ESS score of ≧ 11.

Overnight PSG study

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Trained sleep technicians performed standard overnight PSG study on patients for at least 6 hours at sleep center with standard monitoring (Supplementary Methods 1). All technicians had received appropriate training from the Taiwan Society of Sleep Medicine and had at least one year of experience. PSG data were analyzed by manual scoring for every 30-seconds epoch. Sleep stage was scored by trained sleep technicians according to the standard criteria of Rechtschaffen and Kales [21]. Apnea events were categorized into obstructive apnea, central apnea, mixed apnea, or hypopnea events, as previously described (Supplementary Methods 1). The AHI was calculated as the total number of apnea and hypopnea events per hour of sleep. The desaturation index was defined as the number of desaturations $\geq$ 3% per hour of recording. Arousal index was defined as the number of arousal episodes per hour. Sleep efficiency was defined as the fraction of total sleep time to total recording time. Sleep latency was defined as the time from lights off to the first identifiable sleep stage. Rapid eye movement (REM) latency was defined as the time from the first identifiable sleep stage to the first REM sleep.

PAP titration test

Thirty nine patients refused the PAP titration test. The PAP titration test was performed on the remaining 276 patients. Mask fitting was optimized for all patients before the test. Pressure was adjusted to eliminate 95% of apneas, hypopneas, snoring, and to achieve minimal oxygen saturation > 90% and AHI < 5 in patients during REM sleep in a supine position.

PAP therapy and follow-up

After determining optimal PAP pressure by the PAP titration test, PAP therapy was suggested and prescribed. Patients had choice of five manufacturers of PAP devices with built-in counters to objectively assess the adherence profile. Patients were assisted in device selection to according to individual needs and preferences. Auto-adjusted PAP (APAP) and Continuous PAP (CPAP) devices were available from ResMed (S8 Elite, S8 AutoSet Spirit, S9 Elite, S9 AutoSet; Bella Vista, New South Wales, Australia), Respironics (REMstar Auto M Series with A-Flex 510M, REMstar Auto M Series 501M; Murrysville, Pennsylvania, USA), Fisher and Paykel (SleepStyle 250 Auto Series, Model 254, ; East Tamaki, New Zealand), Puritan Bennett (GoodKnight 420E, GoodKnight 420S; Overland Park, Kansas, USA), and BreaS (iSleep 20i; Mölnlycke, Sweden). Bi-level PAP (BPAP) devices were available from ResMed (VPAP III ST, VPAP IV ST) and Respironics (BiPAP Synchrony, BiPAP Auto M Series 701M). In this study, BPAP was prescribed if patients: (1) could not tolerate CPAP because of persistent massive nasal mask air leakage, very high pressure, or discomfort exhaling against positive pressure; (2) had concomitant nocturnal breathing disorders, including restrictive thoracic disorders, COAD, or nocturnal hypoventilation; (3) or had central sleep apnea that was unresponsive to CPAP. After patients accepted, purchased and started long-term PAP therapy at home, they were followed-up after one month, and then every three months. Patients brought their data card or PAP equipment to each follow-up visit at our outpatient department and the adherence profile was downloaded. Data from the last follow-up visit only are presented in this manuscript.

PAP acceptance and adherence

PAP acceptance was defined as a patient who used PAP device and took the PAP device to try out for at least two weeks [22]. Patients who refused the PAP titration test (n = 39), who did not complete follow-up after CPAP titration test (n = 24), who refused PAP therapy after suggestion or prescription (n = 125), or who chose positional therapy for their positional OSA (n = 2), were scored as non-acceptors of PAP therapy. PAP adherence indicated use of PAP for ≧ 4hours every night for ≧ 70% of the nights monitored based on the built-in counter for the last follow-up [23, 24].

Statistical analysis

The three continuous variables of neck circumference, waist-to-hip ratio, and S2 were normally distributed and are presented as mean and standard deviation (standard deviation). Normally distributed variables were compared by one-way analysis of variance. The

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remaining continuous variables were non-normal distributed and are presented by median and inter-quartile range (the range between the 25th and 75th percentile). Non-normally distributed variables were compared by non-parametric Kruskal-Wallis test. Categorical variables are expressed by count and percentage and were compared by Fisher's exact test. Bonferroni correction was used in the post-hoc tests for pair-wise group comparisons. Comparisons between pre-PSG and post-PSG in systolic blood pressure (sBP), diastolic blood pressure (dBP), mean blood pressure (MBP) within age groups were made using nonparametric Wilcoxon signed ranks test. Univariable and multivariable logistic regression analyses were performed to evaluate the independent factors associated with PAP acceptance and adherence. All significant factors identified in the univariable analyses, except for those that had collinearity with other variables, were entered into a multivariable logistic regression model. All statistical assessments were two-sided and were evaluated at the $P < 0.05$ level of statistical significance. Statistical analyses were performed using SPSS 15.0 statistics software (SPSS Inc, Chicago, IL).

RESULTS

Baseline demographic and clinical characteristics

A total of 315 subjects with OSA were enrolled in the study, including 240 (76.2%) males and 75 (23.8%) females. The demographic and clinical characteristics of the patients are summarized in Table 1. The three age groups significantly differed in gender distribution, smoking habit and comorbidities. A significantly higher proportion of patients in the elderly group had cardiovascular disease, including HTN, CAD, and arrhythmia. Significantly more patients in the elderly group suffered from COAD and DM than in the other groups.

Physical characteristics were significantly different between the groups. Neck circumference was significantly lower in the elderly group, but BMI and the prevalence of obesity were significantly lower in the middle-aged and elderly groups (Table 1). Although the hipline in the middle-aged and elderly groups were significantly lower, the waist to hip ratio was significantly higher in the elderly group compared with the middle-aged group.

Daytime sleepiness and overnight PSG results

Daytime sleepiness and overnight PSG results differed with age (Table 2). The young group had significantly higher ESS, EDS, AHI, and desaturation index than the middle and elderly groups. Significantly lower sleep efficiency and longer sleep latency were observed in the elderly group (Table 2). Significantly higher S1, lower S2, and lower SaO_2-mean were

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observed in the elderly group compared with the middle group. S34 was significantly lower in the elderly group compared with the two other groups.

Blood pressure measurement

There was a significant difference between morning and evening median dBP in the young group (Table 3). In the middle-aged and elderly groups, median morning sBP, dBP, and MBP were all significantly increased compared with the corresponding evening values (Table 3). Evening and morning dBP were both significantly lower in the elderly group compared with the other groups. Median evening MBP, but not morning MBP, was significantly lower in the elderly group compared with the other groups.

PAP acceptance

A total of 125 patients accepted PAP, including 21 (60.0%) in the young group, 69 (40.8%) in the middle group, and 35 (31.5%) in the elderly group. The proportion of patients accepting PAP was significantly lower in the elderly group compared with the young group (Table 2). The main reasons for non-acceptance were cost, belief that the device is uncomfortable, and not believing there was a need for treatment of OSA.

Factors associated with PAP acceptance

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Univariable analyses revealed that age, gender, number of comorbidity, EDS, AHI severity, neck circumference, waist to hip ratio, S1 stage, S34 stage, and REM stage were significantly associated with PAP acceptance (Table 4). Most of these variables (age, gender, neck circumference, waist to hip ratio, S1 stage, S34 stage, and REM stage) were not found to be significantly associated with acceptance upon multivariable analysis (Table 4). Multivariable analyses revealed that EDS, AHI severity, and the number of comorbidities were significantly associated with PAP acceptance. After controlling for other factors in the multivariable analyses, patients with 1~2 comorbidities were found to be less likely to accept the PAP therapy than those with no comorbidities (OR: 0.43; P = 0.009). Conversely, patients with EDS (ESS ≥ 11) were more likely to accept PAP therapy than patients who did not experience EDS (OR: 1.95; P = 0.015). Patients with moderate and severe AHI were more likely to accept the PAP device than those with mild AHI (OR 8.13 and 18.29, respectively).

PAP adherence

The proportion of patients using different modes of PAP differed with age. Specifically, BPAP usage was significantly higher in the elderly patient group compared with the middle-age group (17.1% vs. 1.4%) (Table 5). Of the six patients who used BPAP in the elderly group, three could not tolerate CPAP because of the high pressure, one had severe

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mask leakage, one had moderate chronic obstructive pulmonary disease with additional desaturation during sleep, and one had central sleep apnea due to congestive heart failure.

Factors associated with PAP adherence

Univariable analyses revealed that smoking status was significantly associated with PAP adherence; smokers had lower adherence than non-smokers (OR: 0.33, *P* = 0.017, Table 6).

DISCUSSION

OSA can reduce physical functioning, lessen memory recall, and increase the risk of falling (and associated consequences, including mortality) in the elderly [5]. In this study, we found that OSA patients in the elderly group experienced fewer daytime symptoms, had a lower AHI, worse sleep efficiency, a longer sleep latency, higher stage 1, lower S2, and lower SaO_2-mean during the PSG study compared with OSA patients in the middle-aged and young groups. These findings are consistent with those previously reported [4, 5]. The lower basal SaO_2 in the elderly patients is interesting and may in part explain the less severe symptoms of OSA in this group. The lower basal SaO_2 levels may allow for easier attainment of the vertical part of the oxygen-hemoglobin dissociation curve and thus increased sensitivity to changes in oxygen and more rapid desaturation. In contrast, with the higher SaO_2 levels in the younger patients, saturation is in the plateau part of the oxygen-hemoglobin dissociation curve, rendering SaO_2 less sensitive to changes in oxygen.

Due to these less severe symptoms in the elderly, we had hypothesized that elderly patients with OSA would have a lower acceptance rate of PAP than younger OSA patients. Indeed, we did find this to be the case; PAP acceptance was significantly lower in the elderly group compared with the young group. The overall rate of PAP acceptance in our study was 39.7%, which is lower than PAP acceptance rates determined in studies conducted in Europe and the United States [16, 25, 26], but much higher than the rate (11%) reported in a study

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carried out in Poland [27]. Interestingly, inclusion of our patients who initially refused PSG or were not followed-up (n = 57) reduced the acceptance rate to 33.6%. There are a number of possible reasons for the low rate of acceptance in our cohort. Firstly, health care in Taiwan is very accessible, which may cause some individuals to take their health for granted and not take the time to understand their illness. Such individuals want to be seen, diagnosed, treated by taking medications; they do not want to go to the trouble of using a breathing apparatus for their condition. Secondly, PAP treatment is initiated and all education conducted by a physician at the outpatient clinic. Educating patients about CPAP takes considerable time and effort, for which, unfortunately, physicians in Taiwan are not reimbursed. Therefore, the physicians do not and cannot spend too much time educating individual patients about the importance of treatment

In a previous study, lower PAP acceptance was found to be associated with living alone, minor symptoms (especially hypersomnia), fewer skills, impaired cognitive abilities, comorbidities and neurological deficits [15]. In this study, greater PAP acceptance was associated with fewer comorbidities, higher EDS, and higher AHI. Given these findings, it is unsurprising that elderly patients, who had more comorbidities and lower AHI and EDS, had significantly lower rates of acceptance than patients in the other groups, who had higher AHI and EDS and fewer comorbidities.

One potentially confounding factor affecting PAP acceptance is income. The national and commercial health insurance systems in Taiwan do not cover the cost of PAP device (US$1500~3000 in Taiwan). This is of interest given the finding that supplying discounts on PAP equipment may increase PAP acceptance among low socioeconomic status patients with OSA [28]. Unfortunately we were not able to obtain information on patients' income levels in the present study. Further study is needed to determine whether income affects the rate of PAP acceptance.

Interestingly, our elderly patients with OSA had significantly higher rates of BPAP usage than the other groups. This may be because they had more comorbidities than patients in the other groups and were thus less able to tolerate CPAP. It must be noted, however, that no patients in young group used BPAP. Hence, these findings must be interpreted with caution. Further studies are needed to confirm our finding of potentially higher rates of BPAP usage in elderly patients with OSA.

The rate (64%) of PAP adherence in our cohort of Taiwanese patients with OSA is similar to rates reported in previous studies [22, 24, 29, 30]. Further, the rate of PAP adherence was generally similar for all three age groups. There was, however, a trend for adherence to be higher in the elderly group of patients, particularly when compared with the young group of patients. This may reflect the fact that patients in the elderly group had significantly more comorbidities and therefore may have been more concerned about their health status than the comparatively more healthy patients in the young group. It must be

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noted, however, that neither comorbidities nor age were found to be significantly associated with adherence. Indeed, the only factor associated with (poorer) adherence was smoking status. Clearly, further studies involving the assessment of other factors are needed to elucidate the mediators of patient adherence with PAP.

CONCLUSION

In summary, we found that the rate of PAP acceptance was very low in our cohort of elderly patients with OSA in Taiwan. Given the increasing number of elderly adults with OSA, health care professionals need to be more aware of elderly sleep disturbances to better enable them to assess and treat these patients. Improving PAP acceptance is paramount in managing OSA in elderly patients. Future studies are needed identify the key obstacles and solutions to PAP acceptance among the elderly. Education programs providing patients with OSA with precise information about the inherent risks of the disease and the benefits of treatment in terms of symptom relief and risk reduction are clearly needed to improve PAP acceptance and adherence.

CONFLICT OF INTEREST

The authors have no conflict of interests to declare.

FINANCIAL DISCLOSURES

None.

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FIGURE LEGEND

Figure 1. Flow chart of patients who had their medical charts were retrospectively screened (n = 315). AHI, apnea-hypopnea index; OSA, obstructive sleep apnea; PSG, polysomnography.

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Table 1. Summary of patients' demographics and clinical characteristics

		Young[4] (n = 35)	Middle-aged[4] (n = 169)	Elderly[4] (n = 111)	*P* value
Gender[1]	Male	33 (94.3%)	135 (79.9%)	72 (64.9%)†‡	< 0.001**
Smoke[1]	Non-smoker	17 (48.6%)	79 (46.7%)	48 (43.2%)	0.010*
	Past smoker	3 (8.6%)	54 (32.0%)†	39 (35.1%)†	
	Smoker	15 (42.9%)	36 (21.3%)†	24 (21.6%)†	
Co-morbidity	Total number of co-morbidities[2]	0.0 (0.0, 1.0)	1.0 (0.0, 2.0)	2.0 (1.0, 3.0) ††,‡‡	< 0.001**
	CVD[1]	11 (31.4%)	92 (54.4%)†	87 (78.4%)†‡	< 0.001**
	HTN[1]	11 (31.4%)	84 (49.7%)	83 (74.8%)†‡	< 0.001**
	CAD[1]	0 (0.0%)	16 (9.5%)	46 (41.4%)†‡	< 0.001**
	CVA[1]	1 (2.9%)	7 (4.1%)	12 (10.8%)	NS
	Arrhythmia[1]	0 (0.0%)	8 (4.7%)	22 (19.8%)†‡	< 0.001**
	COAD[1]	6 (17.1%)	24 (14.2%)	40 (36.0%)‡	< 0.001**
	DM[1]	2 (5.7%)	25 (14.8%)	30 (27.0%)†‡	0.005*
Body weight	Underweight[1]	0 (0.0%)	1 (0.6%)	4 (3.6%)	0.019*
	Normal weight[1]	6 (17.1%)	46 (27.2%)	34 (30.6%)	

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Overweight[1]	11 (31.4%)	74 (43.8%)	50 (45.0%)	
Obese[1]	18 (51.4%)	48 (28.4%)†	23 (20.7%)†	
BMI (kg/m2)[2]	30.1 (27.1, 33.8)	27.3 (24.7, 30.4)†	26.4 (24.2, 29.0)††	0.001*
Neck circumference (cm)[3]	40.7 ± 3.7	39.2 ± 3.4†	38.1 ± 3.0††,‡	< 0.001**
Waistline (cm)[2]	102.0 (92.0, 111.0)	96.0 (91.0, 103.0)	98.0 (90.0, 105.0)	NS
Hipline (cm)[2]	108.0 (102.0, 115.0)	102.0 (97.5, 108.0)††	100.0 (96.0, 108.0)††	< 0.001**
Waist-to-hip ratio[3]	0.938 ± 0.054	0.941 ± 0.053	0.959 ± 0.060‡	0.018*

BMI, body mass index; CAD, coronary artery disease; COAD, chronic obstructive airway disease; CVA, cerebrovascular accident; CVD, cardiovascular disease; DM, diabetes mellitus; HTN, hypertension; NS, not significant.

Underweight: BMI < 19.5 kg/m^2; normal: 19.5 kg/m^2 ≤ BMI < 25.0 kg/m^2; overweight: 25.0 kg/m^2 ≤ BMI < 30.0 kg/m^2; obesity: BMI ≥ 30.0 kg/m^2.

[1]Data are expressed as count and percentage; [2]Data are expressed as median and inter-quartile range; [3]Data are expressed as mean and standard deviation;[4]Young, 25-40 year; middle-aged, 41-65 years; elderly, > 65 years.

Multiple comparisons were performed using the Bonferroni procedure with type-I error adjustment.

NS indicates not significantly different; * indicates a significant difference ($P < 0.05$) among the three age groups; ** indicates a significant difference ($P < 0.001$) among the three age groups.

†indicates a significant difference ($P < 0.018$) compared with the young group; ††indicates a significant difference ($P < 0.001$) compared with the young group.

‡indicates a significant difference ($P < 0.\ 018$) compared with the middle group; ‡‡ indicates a significant difference ($P < 0.001$) compared with the middle group.

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Table 2. Summary of daytime sleepiness measurements, overnight PSG results, and acceptance of PAP by patient age group

	Young[4] (n = 35)	Middle-aged[4] (n = 169)	Elderly[4] (n = 111)	*P* value
Daytime sleepiness				
EDS (ESS ≥ 11) [1]	26 (74.3%)	79 (46.7%)†	48 (43.2%)†	0.004*
ESS[2]	13.0 (10.0, 15.0)	10.0 (7.0, 14.0)†	9.0 (5.0, 14.0)††	< 0.001*
Overnight PSG results				
AHI (episodes/hour) [2]	52.6 (20.6, 73.5)	35.5 (23.1, 56.0)†	34.3 (21.9, 50.5)†	0.017*
Desaturation index (episodes/hours) [2]	50.0 (12.4, 71.8)	23.9 (11.8, 46.8)†	22.7 (7.7, 39.4)†	0.013*
Arousal index (episodes/hours) [2]	58.0 (23.0, 78.0)	43.0 (26.0, 63.0)	43.0 (28.0, 60.0)	NS
Sleep efficiency (%)[2]	88.0 (80.0, 91.0)	84.0 (75.0, 90.0)	68.0 (53.0, 81.0)††,‡‡	< 0.001**
Sleep latency (minutes)[2]	13.0 (10.0, 22.0)	14.0 (8.0, 22.0)	22.0 (11.0, 38.0) †,‡‡	< 0.001**
REM latency (minutes)[2]	106.5 (81.0, 151.0)	102.0 (75.5, 178.0)	111.0 (82.0, 180.0)	NS

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S1 stage (%)[2]	28.0 (15.0, 49.0)	27.0 (17.0, 38.0)	34.0 (23.0, 50.0)‡‡	0.003*
S2 stage (%)[3]	52.0 ± 14.0	56.2 ± 14.1	50.5 ± 16.4‡	0.006*
S34 stage (%)[2]	2.0 (0.0, 9.0)	0.0 (0.0, 3.0)	0.0 (0.0, 0.0)††,‡	< 0.001**
NREM stage (%)[2]	91.0 (83.0, 94.0)	88.0 (83.0, 94.0)	91.0 (85.0, 96.0)	NS
REM stage (%)[2]	9.0 (6.0, 17.0)	12.0 (6.0, 17.0)	9.0 (4.0, 15.0)	NS
SaO_2-mean (%)[2]	92.0 (88.0, 95.0)	93.0 (90.0, 95.0)	91.0 (90.0, 93.0)‡‡	< 0.001**
SaO_2-minimal (%)[2]	79.0 (65.0, 83.0)	81.0 (73.0, 86.0)	81.0 (76.0, 86.0)	NS
PAP acceptance [1]	21 (60.0%)	69 (40.8%)	35 (31.5%)†	0.011*

AHI, apnea-hypopnea index; BMI, body mass index; CI, confidence interval; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; NS, not significant; OR, odds ratio; PAP, positive airway pressure; PSG, polysomnography; REM, rapid eye movement.

NREM stage S1+S2+S34.

[1]Data are expressed as count and percentage; [2]Data are expressed as median and inter-quartile range; [3]Data are expressed as mean and standard deviation; [4]Young, 25-40 year; middle-aged, 41-65 years; elderly, > 65 years.

Multiple comparisons were performed using the Bonferroni procedure with type-I error

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adjustment.

* indicates a significant difference ($P < 0.05$) among the three age groups; ** indicates a significant difference ($P < 0.001$) among the three age groups.

†indicates a significant difference ($P < 0.018$) compared with the young group; ††indicates a significant difference ($P < 0.001$) compared with the young group.

‡indicates a significant difference ($P < 0.018$) compared with the middle group; ‡‡ indicates a significant difference ($P < 0.001$) compared with the middle group.

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Table 3. Summary of evening and morning blood pressure measurements by patient age group

	Young[1] (n = 35)	Middle-aged[1] (n = 169)	Elderly[1] (n = 111)	*P* value
sBP (mmHg)				
Evening	131.0 (122.0, 143.0)	124.0 (116.0, 134.0)	129.0 (119.0, 136.0)	0.017*
Morning	132.0 (123.0, 141.0)	126.0 (119.0, 137.0)	131.0 (121.0, 141.0)	NS
***P* value**	NS	0.005§	0.008§	
dBP (mmHg)				
Evening	83.0 (75.0, 88.0)	78.0 (71.0, 85.0)	74.0 (68.0, 80.0)††,‡‡	< 0.001**
Morning	84.0 (76.0, 96.0)	82.0 (75.0, 91.0)	79.0 (72.0, 85.0)†‡	0.002*
***P* value**	0.035§	< 0.001§§	< 0.001§§	
MBP (mmHg)				
Evening	99.7 (92.0, 105.0)	93.7 (86.0, 100.3)	91.3 (85.7, 98.3)†	0.007*
Morning	99.7 (90.7, 112.0)	97.3 (90.3, 106.3)	97.3 (89.3, 102.3)	NS
***P* value**	NS	< 0.001§§	< 0.001§§	

dBP, diastolic blood pressure; MPB, mean blood pressure; NS, not significant; sBP, systolic blood pressure.

Data are expressed as median and inter-quartile range.

Multiple comparisons were performed using the Bonferroni procedure with type-I error adjustment.

[1]Young, 25-40 year; middle-aged, 41-65 years; elderly, > 65 years.

* indicates a significant difference (P < 0.05) among the three age groups; ** indicates a significant difference (P < 0.001) among the three age groups.

†indicates a significant difference (P < 0.0167) compared with the young group; ††indicates a significant difference (P < 0.001) compared with the young group.

‡indicates a significant difference (P < 0. 018) compared with the middle group; ‡‡ indicates a significant difference (P < 0.001) compared with the middle group.

§indicates a significant difference (P < 0.05) between evening and morning blood pressures within age groups; §§indicates a significant difference (P < 0.001) between evening and morning blood pressures within age groups.

Table 4. Summary of the factors associated with PAP acceptance

		Univariate analysis		Multivariate analysis	
		OR (95% CI)	***P* value**	**OR (95% CI)**	***P* value**
Age[1]	Young	Reference		Reference	
	Middle-aged	0.46 (0.22, 0.97)	0.040*	0.53 (0.21, 1.33)	NS
	Elderly	0.31 (0.14, 0.67)	0.003*	0.41 (0.14, 1.21)	NS
Gender	Male	2.33 (1.31, 4.16)	0.004*	1.31 (0.62, 2.77)	NS
	Female	Reference			
Smoking status	Non-smoker	Reference			
	Past smoker	1.03 (0.61, 1.75)	NS		
	Smoker	1.11 (0.63, 1.96)	NS		
Number of comorbidities	None	Reference		Reference	
	1 - 2	0.44 (0.26, 0.73)	0.002*	0.43 (0.23, 0.81)	0.009*
	3 - 6	0.32 (0.15, 0.69)	0.004*	0.38 (0.14, 1.06)	NS
Work status	Unemployed	Reference			
	Retired	0.84 (0.16, 4.53)	NS		
	Employed	0.70 (0.14, 3.55)	NS		
	Homemaker	0.38 (0.07, 2.09)	NS		

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EDS (ESS ≥ 11)		1.93 (1.22, 3.05)	0.005*	1.95 (1.14, 3.33)	0.015*
OSA severity	Mild (AHI 5 to < 15)	Reference		Reference	
	Moderate (AHI ≥ 15 to ≤ 30)	5.60 (1.56, 20.16)	0.008*	8.13 (2.13, 31.02)	0.002*
	Severe (AHI > 30)	17.17 (5.16, 57.07)	< 0.001**	18.29 (5.07, 66.02)	< 0.001**
BMI (kg/m^2)		1.02 (0.97, 1.07)	NS		
Neck circumference (cm)		1.08 (1.01, 1.16)	0.022*	0.96 (0.87, 1.07)	NS
Waist to hip ratio¶		1.57 (1.04, 2.37)	0.033*	1.43 (0.81, 2.53)	NS
Sleep efficiency (%)		1.01 (0.99, 1.02)	NS		
Sleep latency (minutes)		1.00 (0.99, 1.01)	NS		
S1 stage (%)		1.02 (1.00, 1.03)	0.013*	1.00 (0.98, 1.02)	NS
S2 stage (%)		0.99 (0.98, 1.01)	NS		
S34 stage (%)		0.93 (0.88, 0.98)	0.012*	0.94 (0.88, 1.01)	NS
REM stage (%)		0.96 (0.93, 0.99)	0.008*	0.99 (0.95, 1.04)	NS

AHI, apnea-hypopnea index; BMI, body mass index; CI, confidence interval; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; OR, odds ratio; NS, not significant; REM, rapid eye movement. The ORs for continuous variables indicate that the probability of accepting PAP was increased (OR > 1) or decreased (OR < 1) by every 1 unit increase in the corresponding variable, except for ¶ the OR of waist to hip ratio, which indicates that the probability of accepting PAP was increased by every 0.1 unit increase in waist to hip ratio.

[1]Young, 25-40 year; middle-aged, 41-65 years; elderly, > 65 years.

* indicates a significant association (P < 0.05) with PAP acceptance; ** indicates a significant association (P < 0.001) with PAP acceptance.

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Table 5. Summary of PAP mode and PAP adherence (N = 125)

		Young[4] (n = 21)	**Middle-aged[4]** (n = 69)	**Elderly[4]** (n = 35)	***P* value**
PAP mode[1]	APAP	15 (71.4%)	37 (53.6%)	19 (54.3%)	0.013*
	BPAP	0 (0.0%)	1 (1.4%)	6 (17.1%)‡	
	CPAP	6 (28.6%)	31 (44.9%)	10 (28.6%)	
PAP adherence profiles					
Follow up duration (months)[2]		5.5 (3.0, 13.0)	10.5 (3.5, 15.5)	9.0 (3.0, 16.0)	NS
PAP usage (average hours/night)[2]		4.8 (4.2, 5.7)	5.5 (3.8, 6.5)	5.8 (4.5, 6.9)	NS
PAP adherence[1]	High adherence	11 (52.4%)	45 (65.2%)	24 (68.6%)	NS
	Low adherence	10 (47.6%)	24 (34.8%)	11 (31.4%)	
PAP use[1]	Continuous[3]	15 (71.4%)	46 (66.7%)	26 (74.3%)	NS
	Discontinuous[3]	6 (28.6%)	23 (33.3%)	9 (25.7%)	

BPAP, bi-level positive airway pressure; CPAP, continuous positive airway pressure; NS, not significant; PAP, positive airway pressure.

PAP adherence indicated use of PAP for ≧ 4hours every night for ≧ 70% of the nights monitored based on the built-in counter for the last follow-up.

[1]Data are expressed as count and percentage; [2]Data are expressed as median and inter-quartile range; [3]Usage was determined by examining data recorded by the PAP device. Continuous

use was defined as using the PAP device every night. Discontinuous use was defined as not using the PAP device every night; [4]Young, 25-40 years; middle-aged, 41-65 years; elderly, > 65 years.

Multiple comparisons were performed using the Bonferroni procedure with type-I error adjustment.

* indicates a significant difference ($P < 0.05$) among the three age groups.

‡ indicates a significant difference ($P < 0.\ 018$) compared with the middle group.

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Table 6. Summary of factors associated with PAP adherence

		Univariate analysis	
		OR (95% CI)	*P* value
Age[1]	Young	Reference	
	Middle-aged	1.70 (0.63,4.58)	NS
	Elderly	1.98 (0.65,6.05)	NS
Gender	Male	0.42 (0.13,1.36)	NS
	Female	Reference	
Smoking status	Non-smoker	Reference	
	Past smoker	0.87 (0.35,2.12)	NS
	Smoker	0.33 (0.13,0.82)	0.017*
Number of comorbidity	None	Reference	
	1 - 2	1.55 (0.71,3.37)	NS
	3 - 6	1.12 (0.32,3.90)	NS
Work status	Unemployed	Reference	
	Retired	7.00 (0.54,91.11)	NS
	Employed	2.65 (0.23,30.41)	NS
	Homemaker	8.67 (0.58,130.11)	NS
EDS (ESS ≥ 11)		1.04 (0.50,2.18)	0.916

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AHI severity	Mild	Reference	
	Moderate	7.5 (0.53,105.28)	NS
	Severe	3.28 (0.29,37.4)	NS
BMI (kg/m^2)		0.96 (0.89,1.04)	NS
Neck circumference (cm)		0.93 (0.83,1.03)	NS
Waist to hip ratio¶		1.37 (0.66, 2.85)	NS
Sleep efficiency (%)		1.01 (0.98,1.03)	NS
Sleep latency (minutes)		0.99 (0.98,1.01)	NS
S1 stage (%)		1.00 (0.98,1.02)	NS
S2 stage (%)		1.01 (0.99,1.04)	NS
S34 stage (%)		0.96 (0.87,1.06)	NS
REM stage (%)		0.97 (0.91,1.02)	NS

AHI, apnea-hypopnea index; BMI, body mass index; CI, confidence interval; EDS, excessive daytime sleepiness; ESS, Epworth Sleepiness Scale; NS, not significant; OR, odds ratio; REM, rapid eye movement.

The ORs for continuous variables indicate that the probability of PAP adherence was increased (OR > 1) or decreased (OR < 1) by every 1 unit increase in the corresponding variable, except for ¶ the OR of waist to hip ratio, which indicates that the probability of accepting PAP was increased by every 0.1 unit increase in waist to hip ratio.

[1]Young, 25-40 year; middle-aged, 41-65 years; elderly, > 65 years.

* indicates a significant association ($P < 0.05$) with PAP adherence.

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Figure 1

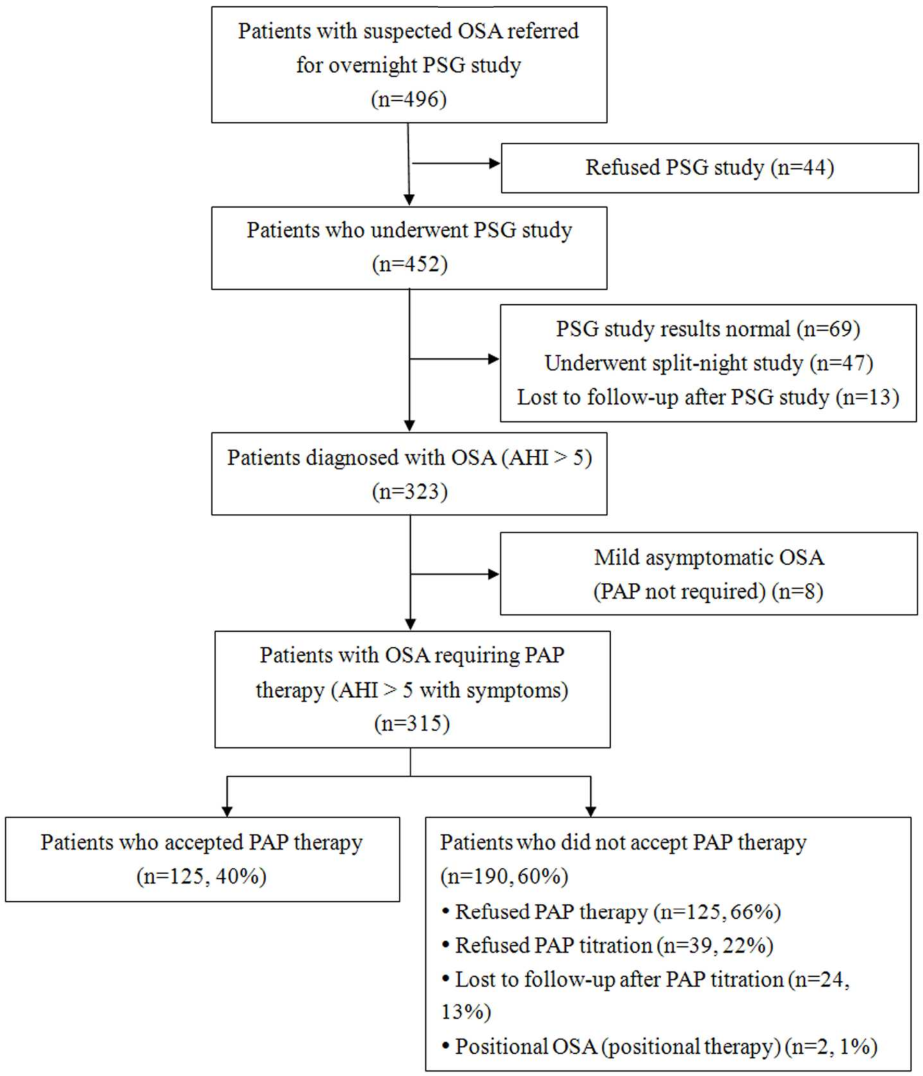

Figure 1
102x122mm (600 x 600 DPI)