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Original research

CONTINUOUS POSITIVE AIRWAY PRESSURE TREATMENT IN OBSTRUCTIVE SLEEP APNEA SYNDROME PATIENTS WITH HYPERTENSION

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ABSTRACT

Aims: *To assess the prevalence and general characteristics of obstructive sleep apnea syndrome in patients with hypertension, investigate the relationship between obstructive sleep apnea syndrome and blood pressure, and the effectiveness of continuous positive pressure ventilation treatment after 1 month in hypertensive patients with obstructive sleep apnea.*

Methods: *Cross-sectional descriptive study with follow-up after 1 month in hypertensive patients treated at the Hue University of Medicine and Pharmacy Hospital with respiratory polygraphy from January 2021 to June 2023. Patients were given history, clinical examination, anthropometric measurements, Lipid profile test, intravenous glucose, Epworth scale assessment, CPAP treatment and re-evaluated after 1 month.*

Results: *134 patients were registered for the study from 01/2021 to 06/2023. Hypertensive patients with OSAS were 73.13%. BMI in the OSAS (+) group was 22.84 ± 3.04 kg/m2 and was statistically significantly greater than the OSAS (-) group: 22.79 ± 3.07 kg/m2 (p<0.05). Neck circumference in the OSAS (+) group was 37.45 ± 2.44 cm, which was statistically significantly larger than the OSAS (-) group: 36.36 ± 1.57 cm (p<0.05). The rate of loud snoring during sleep and excessive daytime sleepiness in the OSAS patient group was statistically significantly higher than in the group without this syndrome (p<0.05 and p<0.01). The average systolic blood pressure in the OSAS (+) group was 154.79 ± 13.32 mm Hg and was statistically significantly higher than the OSAS (-) group (p<0.01). AHI has a moderate positive correlation with systolic blood pressure (r = 0.45, p<0.01) and diastolic blood pressure (r = 0.34, p<0.01). CPAP treatment improved systolic and diastolic blood pressure and symptoms of excessive daytime sleepiness.*

Conclusion: *There is a relationship between obstructive sleep apnea syndrome and hypertension. CPAP treatment improves blood pressure and daytime sleepiness.*

Keywords: *Hypertension, respiratory polygraphy, Obstructive sleep apnea syndrome, OSAS.*

I. INTRODUCTION

Sleep apnea syndrome is a sleep breathing disorder with 3 types: obstructive sleep apnea syndrome, central sleep apnea syndrome, and mixed sleep apnea syndrome. The most common one is obstructive sleep apnea syndrome (OSAS), characterized by repeated partial or complete blockage of the upper airway. This syndrome leads to frequent awakenings at night and a decrease in the patient's blood oxygen saturation. The frequency of obstructive sleep apnea syndrome in Western countries is 4% in men and 2% in women [1]. In Hong Kong, the prevalence of this syndrome is 4.1% [2].

Obstructive sleep apnea (OSA) is a chronic sleep-related breathing disorder characterized by recurrent partial or complete cessation of airflow due to upper airway obstruction during sleep that results in sleep fragmentation, intermittent hypoxia, and hypercapnia, leading to increased sympathetic nervous system activity. This syndrome causes many negative consequences for patients, such as poor sleep quality, daytime drowsiness and fatigue, leading to

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neurophysiological changes such as reduced memory and ability to concentrate and increased risk of cardiovascular disease.

Many studies have shown a relationship between obstructive sleep apnea syndrome and hypertension, coronary artery disease, arrhythmia, and heart failure [3,4]. However, in Vietnam, few studies evaluate the effectiveness of CPAP treatment on hypertensive patients. Based on this situation, we conducted a study that aims to survey some clinical and subclinical characteristics in hypertensive patients with obstructive sleep apnea syndrome; and evaluate the relationship between obstructive sleep apnea syndrome and blood pressure and investigate the effectiveness of CPAP treatment in hypertensive patients.

II. MATERIAL AND METHODS

2.1. Subjects

134 patients were diagnosed with hypertension and treated at the Cardiology Department of the Hue University of Medicine and Pharmacy Hospital from 01/2021 to 06/2023.

OSA Diagnostic Criteria were recommended by the American Academy of Sleep Medicine 2008 (AASM: American Academy of Sleep Medicine) [5]. The patient suspected of OSAS must fulfill criterion A or B, plus criterion C. These are as follows:

A. Excessive daytime sleepiness that is not better explained by other factors.

B. Two or more of the following that are not better explained by other factors: (1) Choking or gasping during sleep. (2) Recurrent awakenings from sleep. (3) Unrefreshing sleep. (4) Daytime fatigue. (5) Impaired concentration

C. Overnight monitoring demonstrates five or more obstructed breathing events per hour during sleep. These events may include any combination of obstructive apneas/hypopneas or respiratory effort–related arousals, as defined below.

Inclusion criteria were all subjects over 15 years old and meeting the diagnostic criteria for hypertension according to the 2020 International Society of Hypertension global hypertension practice guidelines were included in the study.

Table 1: Criteria for hypertension based on office blood pressure, ambulatory blood pressure, and home blood pressure measurement [6].

Criteria for hypertension		**SBP/DBP (mmHg)**
Office BP		≥ 140 and/or ≥ 90
ABPM	24h average	≥ 130 and/or ≥ 80
	Daytime (or awake) average	≥ 135 and/or ≥ 85
	Nighttime (or asleep) average	≥ 120 and/or ≥ 70
HBPM		≥ 135 and/or ≥ 85

Exclusion criteria were patients with acute and severe diseases, chronic obstructive pulmonary disease or chronic respiratory failure, and cerebral diseases such as cerebral tumors, meningitis, and encephalitis; Patients who do not agree or cannot participate in the study; The patient is taking drugs that affect respiratory polygraph.

2.2. Methods

A descriptive cross-sectional study was conducted on 134 participants from January 2018 to June 2019. Vascular risk factors, medications, clinical symptoms, and Epworth were abstracted from the medical record for each participant. The study sample included 98 hypertensive patients with OSAS and 36 patients without OSAS. 30 hypertensive patients with moderate and severe OSAS received CPAP treatment, 36 hypertensive patients with moderate and severe OSAS did not receive CPAP treatment and assessed outcomes at 1 month after CPAP treatment by face-to-face, visit or telephone.

Anthropometry: Patients were weighed using a calibrated scale to the nearest 0.1 kg, and height (to 0.1cm) was measured with a stadiometer (Medisol, Vietnam). Body mass index (BMI) was classed by WHO in adult Asians in 2006 [7].

Respiratory polygraphy: The respiratory polygraphy system used in the study is the Embletta GOLD. Embletta GOLD recorded nasal airflow, snoring using a nasal pressure cannula, blood oxygen saturation, heart rate by pulse oximetry, and respiratory effort using a thoracic piezoelectric chest belt.

The device will be provided to patients with an explanation of how to use it in advance and precise instructions on correctly positioning the equipment's sensors and monitoring. Patients will also conduct several tests to familiarize themselves with the instrument's operating instructions. When the device is returned the next day, raw data files will be uploaded to a computer and recorded automatically and manually by trained physicians from the Study Group. A respiratory polygraphy recording will be deemed valid if the recording lasts≥5 hours. Sections with artifacts or poor signals will be excluded from the analysis. If a respiratory polygraphy is not valid, it will be repeated within the next 7 days.

CPAP: Resmed S9 Escape Auto was the standard auto-adjusting device in ResMed's S9™ platform, designed to help patients comfortably adjust to therapy to encourage long-term compliance.

The machine featured a sleek design, user-friendly interface, and advanced comfort technologies, the S9 Escape Auto combined an intelligent algorithm with Easy-Breathe expiratory pressure relief (EPR™) to deliver maximum comfort. In addition, it offers a choice between automatic positive airway pressure (APAP) or fixed CPAP mode (with or without EPR) to ensure patients receive appropriate therapy.

OSA Criteria: The diagnostic criteria for adult OSA are defined by the American Academy of Sleep Medicine [5].

Overnight monitoring demonstrates five or more obstructed breathing events per hour during sleep. These events may include any combination of obstructive apneas/hypopneas or respiratory effort–related arousals, as defined below.

This report also proposed a grading of severity of OSAS based on the frequency of abnormal respiratory events during sleep: Mild: ≥ 5 but <15 events/hour of sleep; Moderate: 15–30 events/hour of sleep; Severe: More than 30 events/hour of sleep.

Data collection: All data on age, gender, height, weight, BMI, medical and family history, clinical characteristics, and respiratory polygraphy parameters (AHI, SpO2, pulse, and frequency of snoring) of the study subjects were collected for statistical analyses.

Statistical analysis: SPSS 22.0 software (IBM Corporation, Armonk, NY, USA) was used to analyze these collected data. Qualitative data are expressed as percentages or rates and compared with the Chi-squared test. Continuous variables were presented as mean ± standard deviation (SD) and compared with a t-test between 2 groups and a 1-way analysis of variance among groups, followed by paired comparison with the least-significant difference test. A value of $p<0.05$ was considered statistically significant.

III. RESULTS

134 hypertensive patients were measured with respiratory polygraphy at the Cardiovascular Center, Hue University of Medicine and Pharmacy Hospital, from January 2021 to June 2023. There were 98 patients suffering from obstructive sleep apnea syndrome, accounting for 73.13%.

3.1. General, clinical and paraclinical characteristics

Table 2: General and clinical characteristics

		Non-OSAS (n=36)	OSAS (n=98)	Total	P
Age (years)		61.64 ± 11.9	63.61 ± 10.46	62.17 ± 11.53	0.38
Gender	Male	18 (13.4%)	46 (34.3%)	64 (47.8%)	0.1
	Female	18 (13.4%)	52 (38.8%)	70 (52.2%)	
BMI (kg/m^2)		21.77 ± 2.40	22.96 ± 3.00	22.64 ± 2.89	0.94
Neck circumference (cm)		36.36 ± 1.57	37.45 ± 2.44	37.16 ± 2.29	0.003
Waist circumference (cm)		86.61 ± 5.52	85.13 ± 5.51	84.99 ± 5.5	0.63
Smoke		7 (5.22%)	21 (15.67%)	28 (20.90%)	0.06

Abbreviations: BMI: body mass index, OSAS: Obstructive Sleep Apnea Syndrome

The OSAS group was statistically higher in neck circumference than the group without OSAS ($p < 0.05$).

Table 3: Symptoms of obstructive sleep apnea

	Non-OSAS (n=36)	**OSAS (n=98)**	**P**
Loud snoring during sleep	15 (11.19%)	49 (36.57%)	0.035
Excessive daytime sleepiness	18 (13.43%)	50 (37.31%)	0.003
Waking up a lot during the night	8 (5.97%)	26 (19.40%)	0.61
Morning headache	9 (6.71%)	34 (25.37%)	0.29
Poor memory	13 (9.7%)	43 (32.09%)	0.42
Epworth Sleepiness Scale	7.81 ± 3.34	10.17 ± 3.47	0.001

The OSAS group was statistically higher in loud snoring during sleep, excessive daytime sleepiness, and Epworth Sleepiness Scale than the group without OSAS ($p < 0.05$).

Table 4: Paraclinical characteristics

	Non-OSAS (n=36)	**OSAS (n=98)**	**P**
Total cholesterol (mmol/l)	4.13 ± 0.98	4.51 ± 1.43	0.15
HDL-C (mmol/l)	1.1 ± 0.57	1.17 ± 0.65	0.59
LDL-C (mmol/l)	2.35 ± 0.82	2.65 ± 1.08	0.14
Triglyceride (mmol/l)	1.79 ± 0.98	1.71 ± 1.42	0.75
AHI	2.99 ± 0.94	21.32 ± 10.35	<0.01
SpO2 reduction index (%)	4.73 ± 8.68	20.34 ± 15.20	<0.01
EF	68.73 ± 9.44	66.82 ± 10.91	0.35
Glucose	6.12 ± 2.03	6.3 ± 2.8	0.72

Abbreviations: HDL-C: High-density lipoprotein cholesterol, LDL-C: Low-density lipoprotein cholesterol, EF: Ejection fraction.

The OSAS group was statistically higher in SpO2 reduction index than the group without OSAS ($p < 0.01$).

The severity of OSA based on AHI results measured from respiratory polygraphs. According to our research, the moderate OSA group had the highest rate of 48.9%; the mild and severe OSA groups accounted for 32.65% and 18.37% (data not shown).

Table 5: Comorbidities

	Non-OSAS (n=36)	**OSAS (n=98)**	**P**
Dyslipidemia	5 (3.73%)	16 (11.94)	0.68
Heart failure	1 (0.75%)	6 (4.48%)	0.67

	Non-OSAS (n=36)	OSAS (n=98)	P
Coronary artery disease	15 (11.19%)	24 (17.91%)	0.052
Atrial fibrillation	1 (0.75%)	3 (2.24%)	0.93
Cerebral infarction	1 (0.7%)	16 (11.94%)	0.037
Diabetes	3 (2.24%)	9 (6.72%)	0.88

The OSAS group was statistically higher in Cerebral infarction than the group without OSAS ($p < 0.05$).

3.2. The relationship between Obstructive sleep apnea syndrome and Hypertension

Table 6: Blood pressure characteristics in patients with OSAS

	Non-OSAS (n=36)	OSAS (n=98)	P
Heart rate (beats/minute)	77.39 ± 11.98	80.78 ± 7.51	0.43
Systolic blood pressure (mmHg)	147.92 ± 8.73	154.79 ± 13.32	0.001
Diastolic blood pressure (mmHg)	90.28 ± 5.06	92.6 ± 8.95	0.06

We found that Systolic blood pressure in the OSAS group was statistically higher than in the non-OSAS group ($p < 0.01$).

There is a moderate positive correlation between AHI and Systolic blood pressure ($r = 0.45$, $p < 0.01$). A moderate positive correlation exists between AHI and Diastolic blood pressure ($r = 0.34$, $p < 0.01$) (data not shown).

Table 7: Blood pressure and clinical symptoms of CPAP and non-CPAP groups after 1 month

Characteristic	CPAP (n=30)	Non-CPAP (n=36)	P
Systolic blood pressure (mmHg)	136.8 ± 14.2	147.83 ± 11.47	< 0.01
Diastolic blood pressure (mmHg)	80.67 ± 7.71	89.58 ± 8.71	< 0.01
Systolic blood pressure difference	18.87 ± 14.67	12 ± 8.24	0.032
Diastolic blood pressure difference	14.33 ± 8.21	4.03 ± 4.3	0.048
Epworth	10.14 ± 3.09	6 ± 2.18	< 0.01
Epworth difference	4.93 ± 2.65	1.56 ± 1.05	< 0.01

Systolic and diastolic blood pressure in the group receiving CPAP treatment were statistically significantly lower than those without CPAP treatment ($p < 0.01$).

The difference in systolic and diastolic blood pressure in the CPAP treatment group was statistically significantly higher than in the non-CPAP treatment group ($p < 0.05$).

The Epworth score in the group receiving CPAP treatment was statistically significantly lower than the group not receiving CPAP treatment ($p < 0.01$).

IV. DISCUSSION

4.1. General, clinical and paraclinical characteristics

Regarding general characteristics of the study subjects, female patients accounted for 52.2% and had no statistically significant difference compared to men. This result is consistent with a number of studies: Alaa Ali Mohammed Hamdan's study had a male rate of 59.8%, and author Wei Xia gave the result that this ratio is 60/46 and there is no difference between men and women [8,9]. In the literature, the prevalence of OSAS is higher in men than women. Most population-based studies show a 2-to-3-fold higher prevalence of OSAS in men. Men are also more likely to be clinically evaluated for OSAS, as doctors seem to have a higher suspicion when considering OSAS disorders in men. This trend may contribute to the decrease in the diagnosis of OSAS in women in clinical practice. In fact, women often do not present with the classic symptoms of OSAS (loud snoring, sleep apnea and excessive sleepiness). They mainly complain of lack of energy and fatigue. Besides, sex hormones may also play an important role in the pathogenesis of OSAS. OSAS is more common in postmenopausal women than premenopausal women, and hormone replacement therapy in postmenopausal women may protect against this disorder [10,11].

In our study, the neck circumference in the OSAS (+) group was 37.45 ± 2.44 (cm) and was higher than the OSAS (-) group. This result can be explained because neck circumference is one of the manifestations of upper body fat and one of the important factors of sleep breathing disorders. Therefore, neck circumference is a better predictor of OSAS than waist circumference or other metabolic syndrome factors. However, the direct role of neck circumference in the pathogenesis of OSAS has not been determined [12]. Meanwhile, the results of waist circumference research showed no difference between the two groups. This may be because waist circumference is affected by more factors than neck circumference.

In our study, the rate of loud snoring during sleep and excessive daytime sleepiness in the OSAS (+) group was higher than in the OSAS (-) group. Factors associated with snoring include male gender, obesity, smoking and bronchial asthma. Additionally, snoring is strongly associated with increased all-cause mortality [13,14]. The study's results also showed that excessive daytime sleepiness in the OSAS (+) group was higher than in the OSAS (-) group. This symptom is essential and common in OSAS. Daytime sleepiness can mean loss of alertness or falling asleep under inappropriate circumstances. The cause of this symptom is poor night sleep quality combined with snoring symptoms. A person is considered excessively sleepy when not alert enough to complete daily living tasks [15].

In our study, the rate of OSAS in hypertensive patients was 73.13%. This result is not statistically different from some studies, such as the study by Asha'ari and Zamzil Amin, which found that the rate of OSAS among young hypertensive patients was 78.3%. In a study by author Wei Xia, the overall rate of hypertensive patients with OSAS was 42,45% [8,16].

4.2. The relationship between obstructive sleep apnea syndrome and hypertension and evaluating the effectiveness of CPAP treatment

In our study, the two groups had no statistically significant difference in mean heart rate or diastolic blood pressure. However, systolic blood pressure in the group with OSAS was statistically significantly higher than in the OSAS group (-). This result is similar to Alaa Ali Mohammed Hamdan's study when in this study there was a significant reduction in both SBP (137±8.3 mmHg vs. 148±11.5 mmHg; P. value=0.000) and DBP (83.8±7.3 mmHg vs. 90.6±6.2 mmHg; P. value=0.000) among CPAP group patients compared to non-CPAP group patients [9].

Our study also shows a moderate positive correlation between AHI and systolic blood pressure ($r= 0.45$; $p<0.01$) and a moderate positive correlation between diastolic blood pressure and average SpO2 ($r= 0.34$; $p < 0.05$). OSAS patients have apnea, leading to continuous O2 deficiency, causing the increased sympathetic tone and secretion of substances such as Angiotensin II, Noradrenaline, and Isoproterenol. These things cause endothelial dysfunction, vascular restructuring, vasoconstriction, and increasing the thickness of the inner layer of the artery, thereby causing hypertension [17].

In our study, there were 66 patients with moderate or severe OSAS, of whom 30 patients agreed to use CPAP and 36 did not agree to use CPAP or were intolerant to CPAP. After 1 month, the research team re-evaluated both groups for Blood Pressure and symptoms of excessive daytime sleepiness reflected by Epworth scores. The results showed that systolic blood pressure and diastolic blood pressure in the group using CPAP were statistically significantly lower than in the group not using CPAP ($p < 0.01$). At the same time, the reduction in diastolic and systolic blood pressure in the group with CPAP treatment was statistically greater than in the group without CPAP treatment ($p<0.05$). However, this result is not consistent with other domestic and world studies. In a meta-analytic review of randomized controlled trials by Gonzalo Labarca et al., no benefit was found in improved arterial stiffness, but it did lead to a slight reduction in aldosterone secretion. CPAP therapy improved this population's blood pressure, especially nighttime blood pressure [18]. Meanwhile, the study by Cheng et al. showed that CPAP treatment did not show a significant antihypertensive effect in patients with moderate-severe OSAS and nocturnal hypertension. However, it may effectively lower daytime blood pressure in patients with faster heart rates [19]. This difference suggests that a large multicenter study is needed to demonstrate the effect of CPAP on blood pressure in OSAS patients with concomitant hypertension.

Our study also showed that CPAP significantly improved daytime sleepiness, evidenced by lower Epworth scores and a statistically significantly lower reduction in Epworth scores in the CPAP-treated group ($p < 0.01$). This result is similar to some studies such as: The study by Venkatnarayan K. found that the Epworth score decreased statistically significantly after 1 month of CPAP treatment, 11.31 ± 5.6 and 2.54 ± 1.26, respectively ($p = 0.0001$) [20]. The study by Bonsignore M. R. et al. had 4,852 OSA patients on CPAP treatment at the first follow-up visit, after 5 months, the average Epworth score on CPAP treatment was lower than 6 (3-10), $p < 0.0001$ [21].

V. CONCLUSION

There is an association between OSAS and hypertension. Research shows that symptoms of loud snoring during sleep and excessive daytime sleepiness are closely related to this syndrome. At the same time, the study also indicates that treating OSAS with CPAP improves blood pressure and symptoms of excessive daytime sleepiness.

Conflict of Interest

The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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Ethics approval and consent to participate

The study protocol was approved by our institution's ethics committee, and informed consent for the procedure was obtained from each participant.

REFERENCES

1. Ip MS, Lam B, Lauder IJ, Tsang KW, Chung K-f, Mok Y-w, et al. A community study of sleep-disordered breathing in middle-aged Chinese men in Hong Kong. 2001;119(1):62-9.
2. Mirrakhimov AE, Sooronbaev T, Mirrakhimov EMJBpm. Prevalence of obstructive sleep apnea in Asian adults: a systematic review of the literature. 2013;13:1-10.
3. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology (ESC) and the European Society of Hypertension (ESH). European Heart Journal. 2018;39(33):3021-104.
4. McEvoy RD, Antic NA, Heeley E, Luo Y, Ou Q, Zhang X, et al. CPAP for prevention of cardiovascular events in obstructive sleep apnea. 2016;375(10):919-31.
5. American Academy of Sleep Medicine Task Force. Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. 1999;22(5):667.
6. Unger T, Borghi C, Charchar F, Khan NA, Poulter NR, Prabhakaran D, et al. 2020 International Society of Hypertension global hypertension practice guidelines. 2020;75(6):1334-57.
7. Inoue S, Zimmet P, Caterson I, Chunming C, Ikeda Y, Khalid A, et al. The Asia-Pacific perspective: redefining obesity and its treatment. 2000. doi: 10.4082/kjfm.2016.37.6.309

8. Xia W, Jing Y, Yuan C. Correlation between Obstructive Sleep Apnea Syndrome (OSAS) and Cognitive Dysfunction in Elderly Patients with Hypertension. 2023;22(4).
9. Hamdan AAM, Babiker AB, Alhag OAM, Ahmed KAHM. The Impact of Continuous Positive Airway Pressure on Controlling Hypertension in Patients Diagnosed with Obstructive Sleep Apnea: An Observational Prospective Cohort study. 2023.
10. Punjabi, NM, The epidemiology of adult obstructive sleep apnea. 2008;5(2):136-43.
11. Lipford MC. Book Review: Principles and Practice of Sleep Medicine. LWW; 2017.
12. Ahbab S, Ataoğlu HE, Tuna M, Karasulu L, Çetin F, Temiz LÜ, et al. Neck circumference, metabolic syndrome and obstructive sleep apnea syndrome; evaluation of possible linkage. 2013;19:111.
13. Al-Jewair TS, Nazir MA, Al-Masoud NN, Alqahtani NDJSmj. Prevalence and risks of habitual snoring and obstructive sleep apnea symptoms in adult dental patients. 2016;37(2):183.
14. Huang Z, Aarab G, Chattrattrai T, Su N, Volgenant CM, Hilgevoord AA, et al. Associated factors of primary snoring and obstructive sleep apnoea in patients with sleep bruxism: A questionnaire study. 2022;49(10):970-9.
15. Lal C, Weaver TE, Bae CJ, Strohl KPJAotATS. Excessive daytime sleepiness in obstructive sleep apnea. Mechanisms and clinical management. 2021;18(5):757-68.
16. Asha'ari ZA, Hasmoni MH, Ab Rahman J, Yusof RA, Lope Ahmad RARJTL. The association between sleep apnea and young adults with hypertension. 2012;122(10):2337-42.
17. Monahan K, Redline SJCoic. Role of obstructive sleep apnea in cardiovascular disease.2011;26(6):541.
18. Labarca G, Schmidt A, Dreyse J, Jorquera J, Enos D, Torres G, et al. Efficacy of continuous positive airway pressure (CPAP) in patients with obstructive sleep apnea (OSA) and resistant hypertension (RH): Systematic review and meta-analysis. 2021;58:101446.
19. Chen Q, Cheng Y-B, Shen M, Yin B, Yi H-H, Feng J, et al. A randomized controlled trial on ambulatory blood pressure lowering effect of CPAP in patients with obstructive sleep apnea and nocturnal hypertension. 2020;29(1):21-30.
20. Venkatnarayan K, Devaraj U, Veluthat C, Louis V, Ramachandran P, D'Souza G, et al. The effect of CPAP therapy on excessive daytime sleepiness and quality of life in subjects with obstructive sleep apnoea: an AB design study. 2021;25:1351-7.
21. Bonsignore MR, Pepin JL, Cibella F, Barbera CD, Marrone O, Verbraecken J, et al. Excessive daytime sleepiness in obstructive sleep apnea patients treated with continuous positive airway pressure: data from the European sleep apnea database. 2021;12:690008.