Journal of Vascular Medicine & Surgery
ISSN: 2329-6925

Vo-Thi-Kim et al., Vasc Med Surg 2017, 5:4
DOI: 10.4172/2329-6925.1000327

Research Article Open Access

The Effect of Continuous Positive Airway Pressure (CPAP) in Treatment of Patients with Refractory High Blood Pressure Associated with Severe Obstructive Sleep Apnea (OSA)

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Abstract

Introduction: Obstructive sleep apnea is very common in patients with high blood pressure (HBP), especially in whom with refractory HBP (R-HBP). It has been suggested treatment with continuous positive airway pressure (CPAP) might ameliorate the blood pressure in these patients. This study was planned to evaluate the effect of CPAP for treatment of R-HBP patients with severe OSA.

Methods: It was a cross-sectional and descriptive study. All patients with R-HBP associated with clinical symptoms of OSA were included in this study. They underwent polysomnography (PSG) for diagnosis severe OSA. The patients with severe OSA (apnea-hypopnea index (AHI) >30/hour) were treated with CPAP. They had been followed-up during 3 months.

Result: There was 48 patients with R-HBP and symptoms of OSA had PSG. Thirty-nine patients had severe OSA (81.2%) and 32/39 (82.1%) accepted to treat with CPAP. The mean age was 54 ± 8 years (45-64 years) with male-female ratio was 1.6; mean BMI was 27.5 ± 4.6 kg/m2 (23.2-32.5 kg/m2); mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 160 ± 15 mmHg and 105 ± 10 mmHg, respectively. Epworth score was 16 ± 4 with AHI was 37 ± 5/hour. There were a significant reduction of SBP and DBP before and after 3 months treated with CPAP (P<0.01 and P<0.01; respectively). Epworth score was significant lower after 3 months with CPAP than at inclusion (P<0.01). Fasting glucose and total and LDL cholesterol were significantly reduced after treatment with CPAP (P<0.05 and P<0.05).

Conclusion: The prevalence of severe OSA is high in patients with R-HBP having clinical symptoms of OSA. This high prevalence is usually associated with overweight, a high risk factor for R-HBP and OSA. The treatment with CPAP might help to control of blood pressure in patients with R-HBP associated with severe OSA.

Keywords: High blood pressure; Refractory high blood pressure; Obstructive sleep apnea; Continuous positive airway pressure

Introduction

The prevalence of obstructive sleep apnea (OSA) is high in subjects with cardiovascular diseases. Previous studies showed that OSA has been associated with high blood pressure (HBP) in approximately 50% of cases, and vice versa, over 50% of subjects with HBP developed OSA [1,2]. In addition, these studies showed that there was a significant correlation the apnea-hypopnea index (AHI) diagnosed by polysomnography (PSG), and the severity of HBP. Moreover, HBP subjects with OSA had a higher risk of stroke than those without OSA [3-5].

The treatment of HBP is currently based on different classes of antihypertensive drugs as recommended by clinical guidelines to improve patient outcomes [6,7]. The pharmacologic treatment aims to lower systolic blood pressure (SBP) <140 mmHg and diastolic blood pressure (DBP) <90 mmHg. However, in HBP patients with OSA, the goal of treatment is still unclear. Generally, for this special population (patients with HBP-OSA), the pharmacologic treatment should be optimal to prevent cardiovascular events during sleep and in long-term follow-up [8]. Especially, in HBP patients with severe OSA (AHI >30/hour), the treatment option with antihypertensive drugs alone is not adequate and even though refractory in some patients [9,10].

Therefore, the appropriate diagnosis and treatment of patients with refractory HBP (R-HBP) having severe OSA is still a real challenge in clinical practice for physicians to reduce the morbidity and mortality related to cardiovascular events [11,12]. The aim of our study was to evaluate the short-term effect of continuous positive airway pressure (CPAP) in treatment of patients with R-HBP and their adherence to this therapy.

Materials and Methods

Patients

All uncontrolled and treated patients with refractory HBP (had

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Received July 24, 2017; **Accepted** August 08, 2017; **Published** August 16, 2017

Citation: Vo-Thi-Kim A, Nguyen-Xuan B, Dao-Van D, Duong-Quy S (2017) The Effect of Continuous Positive Airway Pressure (CPAP) in Treatment of Patients with Refractory High Blood Pressure Associated with Severe Obstructive Sleep Apnea (OSA). J Vasc Med Surg 5: 327. doi: 10.4172/2329-6925.1000327

been included in this study. They underwent polysomnography (PSG) at night to evaluate apnea-hypopnea index (AHI). For those with AHI >30/hour, the treatment with CPAP was prescribed. Refractory HBP (R-HBP) was defined as HBP that required 4 or more medications for treatment as recommended [13]; uncontrolled R-HBP was defined as systolic blood pressure (SBP) >140 mmHg or diastolic blood pressure (DBP) >90 mmHg at rest under treatment. Inclusion criteria: all patients with uncontrolled R-HBP after use of 4 or more medications and having severe OSA were included in the present study. Exclusion criteria: patients with other comorbidities such as severe kidney failure, diabetes mellitus, and heart failure with NYHA stage 3-4 were excluded in this study.

Methods

It was a descriptive and cross-sectional study. The anthropometric and clinical and functional parameters were recorded for analysis. All study subjects underwent clinical examination, blood pressure measurement, PSG, and biochemical blood tests. They completed a screening questionnaire about symptoms of OSA, sleep habits, sleep quality, and snoring. The severity of sleepiness was assessed by Epworth (0-24 points) for each patient.

Measure of blood pressure by sphygmanometer

The blood pressure (BP) measured at rest was realized in all study subjects with the standard procedure recommended by American Heart Association (AHA) and described previously [14,15]. BP was measured by mercury sphygmanometer with the auscultatory (Korotkoff's sound) technique. All patient seated comfortably with back supported, legs uncrossed, and upper arm was supported at heart level with cuff bladder encircled 2/3 of the circumference; cuff bladder was deflated at 2-3 mm per second; first and last audible sounds were recorded as systolic and diastolic pressure, respectively; neither the study subject nor the person taking the measurement could talk during the procedure.

Measure of apnea-hypopnea index (AHI) by polysomnography (PSG)

In-laboratory overnight PSG was performed for each study subject using Alice PSG (Philips, USA) as recommended by American Academy of Sleep Medicine and described previously [15-18]. The recording time was from 10 pm to 6 am of the day after. The recorded parameters were electroencephalography (EEG); chin electromyography (EMG); electrocardiography (ECG); air flows; thorax-abdomen movements; sleeping posture; apnea-hypopnea index (times/minutes); type of apnea (central apnea, obstructive apnea, or mixed apnea); mean oxygen saturation (SpO2), mean SpO_2 with desaturation, and minimum SpO2 (nadir SpO_2). The severity of OSA was defined by apnea - hypopnea index classified as mild OSA (AHI=5-15), moderate OSA (AHI=16-30), and severe OSA (AHI >30).

Statistical analyses

All study parameters were recorded and analyzed using IBM-SPSS 22.0 software (Chicago, Illinois, USA). Values were expressed as mean ± standard deviation (SD) for quantitative variables and percentage for qualitative variables. Normal distribution was tested by using the Skewness-Kurtosis manner. The comparison of quantitative parameters was done by Student's T test. P value <0.05 was considered as significant difference.

Results

Among 48 patients who had been diagnosed as refractory high blood pressure (R-HBP), there was 39/48 (81.2%) patients had severe obstructive sleep apnea and 32/39 (82.1%) patients accepted to treat with CPAP.

Clinical characteristics of study patients

The mean age of study patients with R-HBP was 54 ± 8 years (45-64 years; Table 1). The male-female ratio was 1.6. The mean BMI of study patients was 27.5 ± 4.6 kg/m^2 (23.2-32.5 kg/m^2; Table 1). The mean neck and abdomen perimeters were 40 ± 4 cm (35-44 cm) and 86 ± 9 cm (76-98 cm), respectively (Table 1). The mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 160 ± 15 (150-180) mmHg and 105 ± 10 (95-115) mmHg, respectively (Table 1). Epworth score of study patients with R-HBP and OSA was 16 ± 4 (12-22).

Functional and biochemical characteristics of study patients

Lung function parameters of study patients were in normal limits except there was a mild reduction of total lung capacity (TLC =84 ± 9% (74-95%); Table 2). The results of polysomnography (PSG) showed mean apnea-hypopnea index was 37 ± 5 (31-43)/hour with mean SpO_2 was 92 ± 3% (88-95%) and nadir SpO_2 was 83 ± 6% (77-89%) (Table 2).

Values	Study patients (N=32)	
	Mean ± SD	Min-Max
Anthropometric parameters		
Age, *years*	54 ± 8	45-64
Male/Female, *ratio*	1.6	-
Height, *cm*	164 ± 8	156-174
Weight, *kg*	68 ± 11	56-82
BMI, *kg/m^2*	27.5 ± 4.6	23.2-32.5
Neck perimeter, *cm*	40 ± 4	35-44
Abdomen perimeter, *cm*	86 ± 9	76-98
Blood pressure		
SBP, *mmHg*	160 ± 15	150-180
DBP, *mmHg*	105 ± 10	95-115
Daytime sleepiness		
Epworth score, *(0 -24)*	16 ± 4	12-22

R-HBP: Refractory High Blood Pressure; OSA: Obstructive Sleep Apnea; BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure.

Table 1: Clinical characteristics of study patients with R-HBP and OSA.

Parameters	Study patients (N=32)	
	Mean ± SD	Min-Max
Lung function test		
FEV_1, *%*	94 ± 8	90-103
FVC, *%*	96 ± 7	91-105
FEV_1/FVC, *%*	77 ± 5	72-84
TLC, *%*	84 ± 9	74-95
Polysomnography		
AHI, *times/hour*	37 ± 5	31-43
Mean SpO_2, *%*	92 ± 3	88-95
Nadir SpO_2, *%*	83 ± 6	77-89
Biological test		
Glucose, *mg/dL*	128 ± 7	120-138
Total cholesterol, *mmol/L*	6.8 ± 0.7	5.2-7.6
LDL cholesterol, m*g/dL*	184 ± 37	142-226
Triglycerides, m*g/dL*	176 ± 22	154-198
Creatinine, *g/dL*	1.3 ± 0.4	0.8-1.7
Uric acid, *mmol/L*	0.35 ± 0.14	0.22-0.48

FEV1: Forced Expiratory Volume in one Second; FVC: Forced Vital Capacity; TLC: Total Lung Capacity; AHI: Apnea-Hypopnea Index; LDL: Low-Density Lipoprotein.

Table 2: Functional and biochemical characteristics of study patients.

The results of biochemical blood test showed there was a mild increase of glucose, total and LDL cholesterol, and triglycerides (128 ± 7 mg/dL, 6.8 ± 0.7 mmol/L, 184 ± 37 mg/dL, and 176 ± 22 mg/dL; respectively; Table 2).

Clinical, functional, and biochemical characteristics of study patients after CPAP treatment

The results of present study for patients with R-HBP and OSA treated with continuous positive airway pressure (CPAP) showed there were no significant differences for anthropometric parameters (BMI and neck and abdomen perimeters) before and after 3 months with CPAP (Table 3). There were significantly different for systolic blood pressure (SBP) and diastolic blood pressure (DBP) before and after 3 months treated with CPAP (160 ± 15 mmHg vs. 135 ± 10 and 105 ± 10 vs. 85 ± 5; P <0.01 and P <0.01; respectively; Table 3). Epworth score was significant lower after 3 months with CPAP than at inclusion (10 ± 6 vs. 16 ± 4; P <0.01; Table 3).

There was any significant difference for lung function parameters before and after 3 months with CPAP treatment. After 3 months treated with CPAP, there was a significant reduction of fasting glucose and total and LDL cholesterol in compare to that at inclusion (112 ± 12 mg/dL vs. 128 ± 10 mg/dL, 5.9 ± 0.8 mmol/L vs. 6.8 ± 0.7 mmol/L, and 162 ± 26 mg/dL vs. 184 ± 37 mg/dL; P <0.05, P <0.05, and P <0.05; respectively; Table 3). There were no significant differences of triglycerides, creatinine, and uric acid before and after treatment with CPAP (P >0.05, P >0.05, and P >0.05; respectively; Table 3).

Discussion

The results of present study showed that

- Percentage of severe OSA in R-HBP was 81.2%;
- Patients with R-HBP and OSA had also increased glucose and total and LDL cholesterol;
- R-HBP patients with severe OSA treated with CPAP had a significant reduction of blood pressure.

Parameters	Study patients (N=32)		P
	Before CPAP	After CPAP	
Anthropometric parameters			
BMI, *kg/m²*	27.5 ± 4.6	26.4 ± 4.7	NS
Neck perimeter, *cm*	40 ± 4	40 ± 5	NS
Abdomen perimeter, *cm*	86 ± 9	84 - 10	NS
Blood pressure			
SBP, *mmHg*	160 ± 15	135 ± 10	<0.01
DBP, *mmHg*	105 ± 10	85 ± 5	<0.01
Daytime sleepiness			
Epworth score, *(0 -24)*	16 ± 4	10 ± 6	<0.01
Lung function test			
FEV1, *%*	94 ± 8	93 ± 7	NS
FVC, *%*	96 ± 7	96 ± 8	NS
FEV1/FVC, *%*	77 ± 5	76 ± 6	NS
TLC, *%*	84 ± 9	86 ± 10	NS
Biological test			
Glucose, *mg/dL*	128 ± 10	112 ± 12	<0.05
Total cholesterol, *mmol/L*	6.8 ± 0.7	5.9 ± 0.8	<0.05
LDL cholesterol, m*g/dL*	184 ± 37	162 ± 26	<0.05
Triglycerides, m*g/dL*	176 ± 22	169 ± 25	NS
Creatinine, *g/dL*	1.3 ± 0.4	1.2 ± 0.5	NS
Uric acid, *mmol/L*	0.35 ± 0.14	0.37 ± 0.12	NS

CPAP: Continuous Positive Airway Pressure; BMI: Body Mass Index; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; FEV1: Forced Expiratory Volume in one Second; FVC: Forced Vital Capacity; TLC: Total Lung Capacity; AHI: Apnea-Hypopnea Index; LDL: Low-Density Lipoprotein.

Table 3: Clinical, functional, and biochemical characteristics of study patients after CPAP treatment.

The high prevalence of OSA in patients with HBP has been reported previously [19-21]. This high prevalence is due to both diseases, HBP and OSA, share common risk factors such as overweight. Generally, overweight is frequent in subjects with HBP and in whom with OSA. However, the mechanism by which overweight develops OSA is different from what in HBP [22]. In subjects with obesity, overweight is always associated with high risk factor for OSA, due to the partial or total collapse of upper-airways during sleep. In the present study, patients having R-HBP were overweight (Table 1). They also had clinical symptom of OSA manifested by daytime sleepiness evaluated by Epworth score. In this study, 81.2% of patients with R-HBP had severe OSA. This high prevalence of severe OSA in these study patients suggests OSA should be screened in patients with R-HBP.

Beside clinical symptoms of OSA evaluated indirectly by daytime sleepiness via Epworth score, study patients had the features of metabolic syndrome with increasing fasting glucose and LDL cholesterol (Table 2). These features are also seen in subjects with HBP. In the present study, 82.1% of patients with R-HBP and severe OSA had been treated with CPAP and had an excellent adherence and tolerance. Especially, after 3 months, the means of systolic blood pressure (SBP) and diastolic blood pressure were significantly decreased and normalized in study patients (Table 3). This result suggests that CPAP might be an add-on treatment for patients with R-HBP and OSA. However, until now, there are no recommendations for the level of OSA severity should be treated with CPAP in patients with R-HBP. Moreover, the present study demonstrated that treatment with CPAP also reduced the level of fasting glucose and cholesterol in study subjects (Table 3).

Eventually, the effect of CPAP on metabolic syndrome has been demonstrated by previous studies [23]. The metabolic syndrome is also known as the consequence of OSA, related to oxidative stress producing by intermittent hypoxia during sleep [24]. The intermittent hypoxia is also the cause of diurnal HBP in subjects with OSA and it is due to sympathetic activity releasing on walk up. That why in some cases, treatment with CPAP might normalize blood pressure in subjects with OSA associated with HBP. The present study showed that treatment with CPAP in short-term follow-up (3 months) had a positive effect on R-HBP. This result suggests CPAP might be recommended for patients with R-HBP associated with severe OSA diagnosed by polysomnography (PSG). In patients with R-HBP having clinical symptom of OSA, PSG or respiratory polygraphy should be done routinely for screening severe OSA. However, due to a small number of study patients and with a short-term follow-up, the present study has some limitations related to the statistical methodology and subgroup analyses. More studies about the role of CPAP in R-HBP should be necessary in the future.

Conclusion

OSA is very common in patients with refractory high blood pressure (R-HBP). The screening of severe OSA in patients with R-HBP should be done systematically in daily practice, especially for patients with clinical symptoms of OSA. The treatment with CPAP in patients with R-HBP and severe OSA might reduce significantly blood pressure.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgements

The authors would like to thank all the Member of Clinical Research Unit of Lam Dong Medical College for their contribution to this work.

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