The effect of continuous positive airway pressure on blood pressure and left ventricular structure in male patients with obstructive sleep apnea

Obstrüktif uyku apneli erkek hastalarda sürekli pozitif havayolu basıncı tedavisinin kan basıncı ve sol ventrikül yapısı üzerine etkileri

Dursun Dursunoğlu, M.D.,[1] Neşe Dursunoğlu, M.D.,[2] Ömür Kuru, M.D.,[1] Sibel Özkurt, M.D.,[2] Şükrü Gür, M.D.,[1] Göksel Kiter, M.D.,[2] Fatma Evyapan, M.D.,[2] Mustafa Kılıç, M.D.[1]

Departments of [1]Cardiology and [2]Pulmonary Diseases, Medicine Faculty of Pamukkale University, Denizli

Objectives: We investigated the effect of nasal continuous positive airway pressure (CPAP) on blood pressure (BP) and left ventricular structure in male patients with severe obstructive sleep apnea (OSA).

Study design: Thirty-three male patients with severe OSA underwent CPAP treatment for six months. Compliance was defined as the use of CPAP for at least 3.5 hours per night during treatment; thus, 25 patients (mean age 47.9±8.2 years) were compliant with a mean of 5.3±1.9 hours, and eight patients (mean age 48.6±8.4 years) were noncompliant with a mean of 1.0±0.8 hours. Before and after CPAP, echocardiographic assessments were made to determine left ventricular structure (interventricular septum thickness, left ventricular posterior wall thickness, left ventricular mass, and left ventricular mass index) and function (E/A ratio, isovolumic relaxation time, mitral deceleration time, and velocity of mitral flow propagation), and systolic and diastolic blood pressures were measured. In the compliant group, 20 patients had hypertension, 22 patients had diastolic dysfunction, and 16 patients had left ventricular hypertrophy (LVH). All noncompliant patients were hypertensive, four had diastolic dysfunction, and four had LVH.

Results: Systolic and diastolic BPs significantly decreased after CPAP treatment, the decreases being more pronounced in the compliant group ($p<0.001$ *vs* $p<0.01$). Parameters of left ventricular structure and diastolic function significantly improved in compliant patients following CPAP. Left ventricular hypertrophy improved in nine patients (56.3%, $p<0.0001$) and diastolic dysfunction improved in 11 patients (50%, $p<0.001$). However, in the noncompliant group, parameters of left ventricular structure and diastolic functions did not differ significantly and the number of patients having LVH or diastolic dysfunction did not change.

Conclusion: In severe OSA, CPAP treatment significantly decreases BP and left ventricular wall thickness, and improves left ventricular diastolic function.

Key words: Blood pressure; continuous positive airway pressure; echocardiography; hypertension; hypertrophy, left ventricular; polysomnography; sleep apnea, obstructive/therapy.

Amaç: Şiddetli derecede obstrüktif uyku apnesi (OSA) olan erkek hastalarda nazal sürekli havayolu basıncı (SHB) tedavisinin kan basıncı ve sol ventrikül yapısı üzerine etkileri incelendi.

Çalışma planı: Şiddetli derecede OSA saptanan 33 erkek hasta altı ay süreyle SHB ile tedavi edildi. Hastaların tedaviye uyumu, SHB'nin her gece en az 3.5 saatlik kullanımı olarak tanımlandığında, 25 hasta (ort. yaş 47.9±8.2) uyumlu (ort. 5.3±1.9 saat), sekiz hasta (ort. yaş 48.6±8.4) uyumsuz (ort. 1.0±0.8 saat) bulundu. Tedavi öncesi ve sonrasında, sol ventrikül yapısı (interventriküler septum kalınlığı, sol ventrikül posterior duvar kalınlığı, sol ventrikül kütlesi, sol ventrikül kütle indeksi) ve fonksiyonunu (E/A oranı, izovolümetrik gevşeme zamanı, mitral akım hızı yavaşlama zamanı, mitral akım propagasyon hızı) belirlemek için ekokardiyografik ölçümler yapıldı ve sistolik ve diyastolik kan basınçları ölçüldü. Tedaviye uyumlu grupta 20 hastada hipertansiyon, 22 hastada diyastolik disfonksiyon, 16 hastada sol ventrikül hipertrofisi (SVH) vardı. Uyumlu olmayan hastaların tümünde hipertansiyon, dördünde diyastolik disfonksiyon, dördünde SVH vardı.

Bulgular: Tedavi sonrasında sistolik ve diyastolik kan basınçları her iki grupta da anlamlı düşüş gösterdi; ancak, bu düşüşler tedaviye uyumlu grupta daha belirgindi ($p<0.001$ ve $p<0.01$). Sol ventrikül yapısı ve diyastolik fonksiyonla ilgili göstergelerin tümü tedaviye uyumlu hastalarda anlamlı derecede düzelme gösterdi. Sol ventrikül hipertrofisi dokuz hastada (%56.3, $p<0.0001$), diyastolik disfonksiyon 11 hastada (%50, $p<0.001$) iyileşti. Tedaviye uyum göstermeyen grupta ise, sol ventrikül yapısı ve diyastolik fonksiyonla ilgili göstergelerde anlamlı düzelme görülmedi ve SVH'li ve diyastolik disfonksiyonlu hasta sayısında değişiklik olmadı.

Sonuç: Şiddetli OSA'nın SHB ile tedavisi, kan basınçlarını ve sol ventrikül duvar kalınlığını anlamlı derecede düşürmekte ve sol ventrikül diyastolik disfonksiyonu iyileştirmektedir.

Anahtar sözcükler: Kan basıncı; sürekli pozitif havayolu basıncı; ekokardiyografi; hipertansiyon; hipertrofi, sol ventrikül; polisomnografi; uyku apnesi, obstrüktif/tedavi.

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Correspondence: Dr. Dursun Dursunoğlu. Pamukkale Üniversitesi Tıp Fakültesi, Kardiyoloji Anabilim Dalı, Kınıklı Kampüsü, 20200 Denizli. Tel: 0258 - 211 85 85 Fax: 0258 - 213 49 22 e-mail: dursundursunoglu@yahoo.com

Obstructive sleep apnea (OSA) affects approximately 5% of women and 15% of men in middle-aged adults, and leads to significant morbidity and mortality.[1] Cardiovascular disturbances such as heart failure, left/right ventricular dysfunction, acute myocardial infarction, arrhythmias, stroke, systemic hypertension, and pulmonary hypertension are the most serious complications of OSA.[2-14] According to the Seventh Report of the Joint National Committee (JNC), sleep apnea is one of the identifiable causes of hypertension.[15] Patients with OSA often have coexisting disorders such as obesity, systemic hypertension, and diabetes mellitus, which are associated with increased left ventricular mass (LVM) and diastolic dysfunction. Moreover, OSA contributes to the development of left ventricular hypertrophy (LVH), which is a major independent risk factor for morbidity and mortality from cardiovascular disease.[16,17]

Treatment of OSA with nasal continuous positive airway pressure (CPAP) has been shown to reduce blood pressure (BP),[18,19] and in patients with normal ventricular function, it has been shown to prevent apnea-related surges in muscle sympathetic activity and to improve BP during sleep.[20] However, in a previous study, we showed that CPAP therapy was not associated with acute decreases in systolic and diastolic BP and heart rate in patients with OSA and hypertension, but it might reduce the variability of these parameters during sleep, not during daytime.[21] Furthermore, CPAP therapy significantly decreases right ventricular free wall diameter and improves right ventricular diastolic and global functions in OSA patients without hypertension.[22]

In another study, we also showed that severe OSA patients had slight LVH and left ventricular global dysfunction.[4] Thus, it would be important to demonstrate whether CPAP treatment, in addition to reducing upper airway obstruction, would improve LVH and/or left ventricular dysfunction in patients with OSA, since regression of LVH has favorable prognostic implications for reduction in cardiovascular events.[23]

In the present study, we aimed to determine the effect of nasal CPAP therapy on BP and left ventricular structure in male patients with severe OSA.

PATIENTS AND METHODS

Patients. The study included 33 male patients who were admitted to sleep clinic with symptoms of nocturnal snoring and/or excessive daytime sleepiness and were diagnosed as having severe OSA. Exclusion criteria included any known cardiac (except for hypertension) or lung disease, diabetes mellitus, angina pectoris, atrial fibrillation or arrhythmias, chronic renal or hepatic disease, and serum electrolyte imbalances. A detailed sleep and cardiovascular history of the patients was recorded. Sleep cycle, nutritional status, medications, alcohol usage and family anamnesis were also questioned. Epworth Sleepiness Scale (ESS)[24] was administered to all the patients, and those having high scores (ESS ≥10) were taken into sleep study.

Physical examination was performed at baseline and six months after treatment. According to the ESH/ESC Hypertension Guidelines[25] and after at least five minutes of rest, systolic and diastolic BPs were measured in the right arm and in the sitting position using a sphygmomanometer (Erka, Kallmeyer Medizintechnik, Badtölz, Germany). The first appearance and disappearance (phase V) of Korotkoff sounds were used to define the pressures. Readings were recorded to the nearest even number and the mean of two recordings at a three-minute interval was computed. Hypertension was defined as BP ≥140/90 mmHg or the use of antihypertensive drugs. All hypertensive patients in the study group were taking several antihypertensive medications. Antihypertensive therapy was re-arranged in some patients who had uncontrolled BP (≥140/90 mmHg) at baseline. Heart rate was measured in the sitting position, and body mass index (BMI) was calculated as weight divided by height squared (kg/m^2).

Pulmonary function tests (Sensor Medics 2400, Bilthoven, The Netherlands) and arterial blood gas analysis (Radiometer ABL 30, Kopenhagen, Denmark) were performed in all the patients at rest. All the patients underwent 12-lead surface electrocardiography and treadmill exercise test for myocardial ischemia, both of which yielded normal results.

Polysomnography. All the patients underwent diagnostic polysomnography for an entire night while breathing room air, followed by a second night examination with nasal CPAP titration.[26] A limited sleep study was performed with the portable Embletta device[27] (Medcare, Reykjavik, Iceland) equipped with the following: nasal pressure detector using a nasal cannula/pressure transducer system to record the square root of pressure as an index of flow, thoraco-abdominal movement detection through two piezoelectric belts, finger pulse oximeter, and body position detection.

Apnea was defined as total obstruction of oronasal airflow for 10 seconds or longer, hypopnea was defined as decrease in airflow by at least 50%, and desaturation was defined as decrease in oxygen saturation by 4% or greater.[28] Desaturation index was defined as the number of oxygen desaturation events per hour of sleep. Subjects with the apnea-hypopnea index of 30 or higher were diagnosed as having severe OSA.[29]

Nasal continuous positive airway pressure (CPAP). Patients with severe OSA were administered nasal CPAP (REMstar Plus, Respironics, Pennsylvania, USA) with the use of a heated humidifier. In order to observe CPAP use/compliance at home, the CPAP machine was equipped with a compliance monitor that measured CPAP use. Routine troubleshooting was applied to maximize compliance with nasal CPAP. Patients were considered to be CPAP compliant if they used CPAP for an average of 3.5 hours or more per night during the six-month follow-up; thus, 25 patients were compliant with the CPAP therapy. Those who were not compliant (n=8) were regarded as controls.

Echocardiographic measurements. Echocardiograms were obtained following the diagnosis of OSA and prior to initiation of CPAP, and after six months of treatment. M-mode, two-dimensional and Doppler ultrasound echocardiography (Contron Sigma Iris, Contron Medical, Paris, France) was used with a 2.5-MHz probe, with the patient in the left lateral decubitus position. All measurements were performed by an experienced physician blinded to the clinical data of the patients. The duration of the examination was at least 20 minutes. Ventricular diameters, volumes, and functions were measured according to the recommendations of the American Society of Echocardiography.[30,31] Basic measurements of left ventricular dimensions in diastole and systole, thickness of the interventricular septum (IVS), left ventricular posterior wall (LVPW) and LVM were measured by the M-mode technique, and LVM was divided by body surface area to obtain left ventricular mass index (LVMI).[32,33] Left ventricular hypertrophy was defined as the presence the following: IVS or LVPW ≥12 mm, or LVM ≥294 g, or LVMI ≥134 g/m^2.

Left ventricular ejection fraction (LVEF) was calculated by the Simpson's biplane method using the following formula: (diastolic volume-systolic volume)/diastolic volume.[31] Early (E) and atrial (A) transmitral maximal flow velocities, E/A ratio, and deceleration time (DT) of E-wave were determined using Doppler. In addition, isovolumic relaxation time (IVRT) was measured by the continuous wave Doppler technique. The velocity of mitral flow propagation (VPR) was estimated using color Doppler M-mode.[34]

Statistical analyses. Measurements were expressed as mean±standard deviation (SD). Primary outcome variables of IVS, LVPW, LVM, LVMI, and ventricular functions obtained at baseline and six months after treatment were compared using the Wilcoxon test. Comparisons between compliant and noncompliant patients with regard to LVH and diastolic dysfunction at baseline and after six months of CPAP treatment were made with the McNemar chi-square test. A p value of less than 0.05 was regarded as significant.

RESULTS

Compliance with CPAP. At the end of the treatment, the mean daily CPAP use of 33 patients was 5.3±1.9 hours per night. In patients who were compliant with the therapy, the mean CPAP use was 6.1±2.4 hours per night, with an average CPAP pressure of 11.5±2.9 cmH_2O (Table 1). Noncompliant patients used CPAP for a mean of 1.0±0.8 hours per night, and their average CPAP pressure was 8.5±3.3 cmH_2O. Noncompliance mainly resulted from mask discomfort and pressure intolerance. All the patients were offered heated humidity, and efforts were made to improve comfort and compliance with the therapy. In compliant and noncompliant patients, the average CPAP pressure after six months of therapy did not change significantly from the baseline values of 10.9±2.3 cmH_2O and 11.0±2.3 cmH_2O, respectively (p>0.05).

Table 1. Characteristics of compliant patients (n=25) with severe obstructive sleep apnea, receiving continuous positive airway pressure (CPAP)

Mean age (years)	47.9±8.2
Body mass index (kg/m^2)	31.0±3.9
Blood pressure (mmHg)	
Systolic	145.7±14.1
Diastolic	93.8±9.6
Heart rate (pulse/min)	76.6±11.3
Hypertension (n, %)	20, 80%
Apnea hypopnea index (per hour)	52.8±11.6
Desaturation index (per hour)	39.3±20.7
Saturation of nocturnal arterial oxygen (%)	
Minimum	73.5±5.9
Average	81.1±3.4
The percentage of sleep duration with arterial oxygen saturation <90%	59.4
CPAP use (hour/night)	6.1±2.4
CPAP pressure (cmH_2O)	11.5±2.9

Table 2. Changes in baseline characteristics and left ventricular structure and function in compliant patients (n=25) after six months of continuous positive airway pressure (CPAP)

		CPAP treatment		
	Normal	Before	After	*p*
Body mass index (kg/m^2)	<30	31.0±3.9	30.1±3.7	NS
Blood pressure (mmHg)				
Systolic	<140	145.7±14.1	136.1±10.3	0.001
Diastolic	<90	93.8±9.6	87.2±7.8	0.001
Left ventricular structure				
Interventricular septum thickness (mm)	6-11	11.0±1.1	10.5±0.9	0.001
Left ventricular posterior wall thickness (mm)	6-11	11.0±1.0	10.4±0.7	0.0001
Left ventricular mass (g)	<294	299.8±88.0	291.4±76.2	0.0001
Left ventricular mass index (g/m^2)	<134	148.1±47.9	145.2±44.5	0.0001
Diastolic functions				
E/A ratio	>1	0.9±0.3	1.1±0.4	0.0001
Isovolumic relaxation time (ms)	<100	92.4±20.1	90.0±19.9	0.005
Mitral deceleration time (ms)	<220	222.8±55.9	207.4±53.1	0.0001
Velocity of mitral flow propagation (cm/s)	>55	39.3 ±11.8	42.2±9.7	0.001
Systolic function				
Left ventricular ejection fraction (%)	55-75	63.6±4.3	64.4±4.1	NS

NS: Not significant.

Compliant patients with severe OSA. The mean age of 25 compliant patients was 47.9±8.2 years. None were using alcohol, while 18 (72%) were smokers. Characteristics of this group are shown in Table 1. The patients had a high BMI (mean 31.0±3.9 kg/m^2). Twenty patients (80%) had hypertension, for which antihypertensive therapy was re-arranged in eight (40%) due to uncontrolled BP at baseline. Although there was no significant change in BMI after six months, systolic (145.7±14.1 mmHg *vs* 136.1±10.3 mmHg, p<0.001) and diastolic (93.8±9.6 mmHg *vs* 87.2±7.8 mmHg, p<0.001) BPs significantly decreased after CPAP therapy. Compared to noncompliant patients, these decreases were more pronounced in the compliant group (p<0.01 *vs* p<0.001). All hypertensive patients had diastolic dysfunction, and 16 (80%) had LVH. Of normotensive patients (n=5), none had LVH, two (40%) had diastolic dysfunction.

Changes in baseline characteristics and left ventricular structure and function in compliant patients after six months of CPAP treatment are shown in Table 2. Thicknesses of IVS and LVPW significantly decreased after six months of CPAP therapy (p<0.001 and p<0.0001, respectively; Table 2). In addition, LVM and LVMI significantly decreased after CPAP (p<0.0001; Table 2).

Although improvements in left ventricular diastolic function parameters such as E/A ratio, IVRT, DT, and VPR were significant following CPAP treatment, 11 patients (50%) with severe OSA still had left ventricular diastolic dysfunction (Table 2). On the other hand, change in LVEF after CPAP treatment was not significant (p>0.05).

Noncompliant patients with severe OSA. The mean age of eight noncompliant patients was 48.6±8.4 years. None were using alcohol, but all were smokers. These patients had a high BMI (mean 30.6±4.0 kg/m^2). All had hypertension, and had been taking at least two different groups of antihypertensive drugs. Antihypertensive therapy was re-arranged in seven patients (87.5%) due to uncontrolled BP at baseline.

Changes in baseline characteristics and left ventricular structure and function in noncompliant patients after six months of CPAP treatment are shown in Table 3. The mean BMI of noncompliant patients remained unchanged at the end of six months. Although systolic and diastolic BPs significantly decreased at the end of treatment, left ventricular structural (IVS, LVPW, LVM, and LVMI) and functional (E/A ratio, IVRT, DT, VPR, and LVEF) parameters did not change significantly. Despite normal LVEF values at baseline and at the end of treatment in all noncompliant patients, four patients (50%) had left ventricular diastolic dysfunction, and four patients (50%) had LVH.

Comparison between compliant and noncompliant patients with respect to LVH and left ventricular diastolic dysfunction. The number of compliant patients having LVH and left ventricular dysfunction significantly decreased following CPAP treatment

Table 3. Changes in baseline characteristics and left ventricular structure and function in noncompliant patients (n=8) after six months of continuous positive airway pressure (CPAP)

		CPAP treatment		
	Normal	Before	After	*p*
Body mass index (kg/m^2)	<30	30.6±4.0	30.2±4.4	NS
Blood pressure (mmHg)				
Systolic	<140	141.3±15.0	137.1±10.2	0.01
Diastolic	<90	92.1±9.8	89.0±7.4	0.01
Left ventricular structure				
Interventricular septum thickness (mm)	6-11	10.9±1.0	11.1±1.1	NS
Left ventricular posterior wall thickness (mm)	6-11	11.5±0.6	11.5±0.8	NS
Left ventricular mass (g)	<294	307.4±33.9	309.4±33.3	NS
Left ventricular mass index (g/m^2)	<134	149.5±14.2	149.7±15.3	NS
Diastolic functions				
E/A ratio	>1	0.8±0.4	0.8±0.3	NS
Isovolumic relaxation time (ms)	<100	80.0±31.6	79.4±29.6	NS
Mitral deceleration time (ms)	<220	226.3±71.8	227.0±68.7	NS
Velocity of mitral flow propagation (cm/s)	>55	37.5±11.5	37.0 ±12.0	NS
Systolic function				
Left ventricular ejection fraction (%)	55-75	63.9±5.4	63.0±5.3	NS

NS: Not significant.

(p<0.0001 and p<0.001, respectively; Table 4). In the complaint group, there were 16 patients (64%) and 22 patients (88%) with LVH and left ventricular diastolic dysfunction, of which nine patients (56.3%) and 11 patients (50%) benefited from CPAP treatment, respectively. However, in the noncompliant group, the number of patients having LVH or left ventricular diastolic dysfunction did not change at the end of treatment.

DISCUSSION

Patients with severe OSA often have coexisting disorders such as obesity, hypertension, coronary artery disease, and diabetes mellitus, which are associated with increased LVM and diastolic dysfunction. On the other hand, severe OSA is associated with left ventricular diastolic dysfunction, resulting in an increased risk for heart failure, since diastolic dysfunction may be accompanied by systolic dysfunction.[4,35] In our study, diabetes mellitus and coronary artery disease were excluded, but 20 of 25 compliant patients (80%) and all the noncompliant patients were hypertensive, and also all the patients had a high BMI. Of 33 patients, 20 patients had mild LVH, all had normal systolic function (normal LVEF), but 26 patients had diastolic dysfunction at baseline. Diastolic dysfunction was the most common echocardiographic finding. Only six (24%) of 25 compliant patients had completely normal left ventricular structure (IVS, LVPW) and functions.

In our study, we showed that treatment of OSA with six months of CPAP significantly improved IVS and LVPW, and left ventricular diastolic dysfunction. Despite significant improvements in left ventricular diastolic function parameters (E/A ratio, IVRT, DT, and VPR), some patients with severe OSA still had left ventricular diastolic dysfunction (Table 2). In the compliant group, the number of patients having LVH or diastolic dysfunction significantly decreased after six months of CPAP treatment, with nine patients (56.3%) and 11 patients (50%) having complete recovery from LVH and left ventricular diastolic dysfunction, respectively. However, in the noncompliant group, the number of patients with LVH or diastolic dysfunction remained unchanged, but these patients achieved a significant reduction in BP at the end of six months (Table 3). On the other hand, LVEF at

Table 4. Changes in the number of patients having left ventricular hypertrophy and left ventricular diastolic dysfunction after six months of continuous positive airway pressure (CPAP)

	Compliant with CPAP (n=25)*			Noncompliant with CPAP (n=8)**		
	Before	After	*p*	Before	After	*p*
Left ventricular hypertrophy (n, %)	16** (64.0)	7 (43.8)	0.0001	4 (50.0)	4 (50.0)	NS
Left ventricular diastolic dysfunction (n, %)	22* (88.0)	11 (50.0)	0.001	4 (50.0)	4 (50.0)	NS

*20 patients had hypertension. **All patients had hypertension. NS: Not significant.

baseline was in normal limits in all the patients and did not change significantly after six months of CPAP therapy.

Hedner et al.[36] examined 61 men with OSA in comparison with 61 male control subjects. Patients with OSA had a higher BMI and 50% had systemic hypertension. They reported that OSA resulted in LVH, and in a BMI-matched comparison, it was approximately 15% higher among normotensive OSA patients than in normotensive controls. Arabi et al.[37] showed that systemic hypertension developed in a hypoxic situation in normotensive cases, and that CPAP therapy was associated with a decrease in adrenergic mediators in patients with OSA. In our study, all the patients had severe OSA, with a significantly prolonged hypoxic duration and sleep duration below 90% saturation of nocturnal arterial oxygen.

Proposed causes of LVH in OSA include associated changes in left ventricular afterload, intermittent hypoxemia, and recurrent arousals during sleep.[1,8,38,39] During obstructive apnea, large negative intrathoracic pressures are generated during inspiratory efforts, which increase transmural pressures across the myocardium, thereby increasing afterload. The presence of hypoxemia decreases oxygen delivery to the myocardium, and also, frequent arousals from sleep lead to increased sympathetic activity. Other responsible mechanisms include impaired vagal activity, increased platelet aggregateness, insulin resistance, and endothelial dysfunction with reduced endogenous nitric oxide production.[8,39] In addition, several mechanisms may impair diastolic function in hypertension.[40] Decreased early diastolic filling in hypertensive patients has been correlated with increased afterload and increased muscle mass, as well.[40] Diastolic dysfunction in hypertensive patients may occur even in the absence of structural myocardial abnormalities and usually represents myocyte dysfunction with impaired isovolumic relaxation. Left ventricular diastolic filling is influenced by several factors, including left ventricular relaxation, left ventricular compliance, left atrium contraction force, heart rate, and systemic vascular resistance. Thus, left ventricular dysfunction might be the result of a variety of impairments.

Beneficial effect of CPAP on cardiac functions has been shown in many studies, which may be due to several factors such as improved myocardial oxygen delivery, decreased sympathetic activity, left ventricular transmural pressure, and afterload.[3,18-22,41,42] Further resolution of LVH occurs relatively slowly (≥3 years) and may reverse completely if BP is controlled. Cloward et al.[42] showed that LVH was present in high frequency (88%) in 25 patients with severe OSA and regressed after six months of nasal CPAP therapy. They concluded that the extent of regression of LVH and diastolic dysfunction by CPAP lied somewhere between the range afforded by angiotensin converting enzyme inhibitors and calcium channel blockers, but better than that obtained by diuretics and beta-blockers.

All hypertensive patients in our study group continued taking antihypertensive medications. Systolic and diastolic BPs of these patients significantly decreased after six months of CPAP treatment, especially in compliant patients. One reason for the improvement in left ventricular structure and function in compliant patients might be CPAP-associated decreases in BP, which were more pronounced compared to those of noncompliant patients. In addition, in the noncompliant group, there were no patients having complete improvement in spite of a significant reduction in BP. Thus, improvements in left ventricular structure and functions seen in compliant patients together with noticeable decreases in BP were well correlated with CPAP therapy rather than antihypertensive medications. Recent placebo-controlled trials of CPAP therapy reported decreases in systolic and diastolic pressures by up to 10 mmHg.[19,43,44]

In a long-term follow-up (7.5 years) study of 168 patients with OSA, it was shown that deaths from cardiovascular disease were more common in the untreated group than in the CPAP-treated group (14.8% *vs* 1.9%, respectively; $p<0.009$), but no significant differences were found with respect to the development of new cases of hypertension, cardiac disorder, or stroke.[45] In addition, total cardiovascular events were more common in the untreated group (31% *vs* 18%, respectively; $p<0.05$).

In our study, a very noticeable finding associated with only six-month of CPAP therapy was the improvement in left ventricular structure and diastolic function, together with a more significant decrease in BP.

Study limitations. Small patient number is an important limitation to determine the effects of CPAP on LVH, BP, and left ventricular dysfunction. Moreover, our sleep clinic population may not reflect the general community. Larger population-based studies would be helpful to determine the relative impor-

tance of such factors as obesity, age, apnea-hypopnea index, the degree of hypoxemia, and the presence or absence of 24-hour hypertension in relation to LVH, BP and left ventricular dysfunction.

In conclusion, sleep apnea is usually associated with hypertension and obesity, which may cause LVH and left ventricular dysfunction, both of which represent a high risk for heart failure in patients with severe OSA. In those patients, CPAP therapy significantly decreases BP and left ventricular wall thickness (IVS, LVPW) and improves left ventricular diastolic function, without having a significant effect on LVEF. Based on our findings of six-month treatment, it may be speculated that longer uses of CPAP therapy may be more beneficial to left ventricular structure and functions.

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