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Echocardiographic Abnormalities in Patients with Sleep Apnea Syndrome

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Background: Obstructive sleep apnea (OSA) is a common sleep disease. It is associated not only with hypertension but also with other cardiac complications. Thus, the early detection of cardiac disorders is very useful.
Objectives: We sought to evaluate different echocardiographic parameters.
Patients and Methods: This cross-sectional study was done on 55 patients with OSA. The patients were divided into three groups: mild, moderate, and severe according to the apnea hypopnea index (AHI) and all underwent echocardiography. Analysis was done by SPSS 18 as well as the chi-squared and one-way ANOVA tests.
Results: The mean age of the study population was 51.16 ± 12.88 years old and 36 (65.5%) patients were male. Right Tei index mean was 0.383 ± 0.213, which was abnormal in 19.1% of the patients. Left Tei index mean was 0.378 ± 0.230 and was abnormal in 52.9% of the patients. Pulmonary artery pressure mean was 18.32 ± 8.91 and was normal in 39 (70.9%) patients. Only basal septum strain (P = 0.015) and basal septum strain rate (P = 0.005) changes were associated with OSA severity.
Conclusions: The main findings of this study were relative left ventricular systolic and diastolic dysfunction as well as dysfunction in some parameters of the right ventricle. The prevalence of these disorders and what constitutes the best echocardiographic parameter for their diagnosis are controversial and require further research.

Keywords: Obstructive Sleep Apnea; Echocardiography; Cardiovascular Diseases

1. Background

Obstructive sleep apnea (OSA) is a syndrome with recurrent episodes of the obstruction of the upper airways and subsequent decrease in arterial blood oxygen (1). OAS is defined by apnea (complete cessation of breathing) or hypopnea (partial cessation of breathing) more than 5 times per hour (2). The prevalence of this syndrome has increased in recent years, and it currently affects 4-6% of men, 2-4% of middle-aged women (3), and 0.7 to 3% of children. OAS is allied to functional and structural changes in the heart (4, 5). Indeed, cardiovascular diseases are the main complications of OAS (1). Although the exact mechanism of cardiovascular complications is unknown, they seem to have a multifactorial pathogenesis. Echocardiography is the most common noninvasive imaging method for assessing myocardial function and evaluating the effects of OSA on the heart.

2. Objectives

Given the existing controversies about systolic or diastolic dysfunction in OSA patients, we sought to evaluate cardiac function in these patients using tissue doppler imaging (TDI), strain, strain rate, and Tei.

3. Patients and Methods

This cross-sectional study was conducted on 55 patients, whose disease had been confirmed by a pulmonologist using polysomnography over a 24-hour period in hospital in a sleep room. Inclusion criterion was a definite diagnosis of OSA and exclusion criterion was central sleep apnea. The patients were selected by using the archived records of the sleep room and were invited for echocardiography. The AHI, calculated by dividing the number of events by the number of hours of sleep, is the most useful and objective way of classifying the severity of the disease (6). After history taking and physical examination, the patients underwent echocardiography, which was performed in the left lateral decubitus position. Images were obtained in different views (parasternal long-axis as well as apical four-chamber, two-chamber, and three-chamber) and saved for

Implications for health policy/practice/research/medical education:
In light of the results of our study, we would recommend that strain, strain rate, tissue doppler imaging, and Tei be used for the initial screening of patients with obstructive sleep apnea.

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later offline analysis. The machine used was VIVID 7 dimension (GE), with the M4S probe. Demographic characteristics and echocardiographic parameters were measured and recorded in a datasheet for all the patients. The data were saved in SPSS 18 database and were subsequently analyzed using the chi squared and one-way ANOVA statistical tests. A $P < 0.05$ was considered as the significant level.

3.1. Ethical Issues

Because echocardiography is a noninvasive method, the only ethical issue was the patients' consent to undergo echocardiography and this was resolved due to their voluntary participation in the study.

4. Results

In this study, 55 patients with apnea-hypopnea syndrome were divided into three groups with mild [5 ≤ AHI < 15 (40%)], moderate [15 ≤ AHI < 30 (18.2%)], and severe OAS [30 ≤ AHI (41%)] (6). The demographic characteristics of the patients are depicted in Table 1. There were no statistically significant differences between the groups with respect to age, gender, and body mass index (BMI). Mean AHI was 9.06 ± 3.41 for the patients with mild OSA, 21 ± 4.22 for those with moderate OSA, and 51.03 ± 21.81 for the ones with severe OSA; total mean was 28.78 ± 4.12.

Out of the data available on 47 patients, 9 (19.1%) patients had abnormal right Tei and 38 (80.9%) had normal right Tei (0.24). Out of 51 patients, 27 (52.9%) patients had abnormal left Tei and 24 (47.1 %) had normal left Tei (0.34) (Table 2). There were no significant differences between the three groups in terms of right Tei and left Tei. Left ventricular ejection fraction (LVEF) and pulmonary artery pressure as well as echocardiographic data related to TDI, strain, and strain rate are given in Table 2, which shows that only basal septal strain (P = 0.15) and basal septal strain rate (P = 0.005) had a significant relationship with the severity of the disease. Because of the effect of hypertension and ischemic heart disease in cardiac structure and function, we studied the pure effect of OSA on echocardiographic variables. As is shown in Table 2, only left strain in the patients with hypertension and/or ischemic heart disease (P = 0.002) and left strain rate in those with OSA and without hypertension and/or ischemic heart disease were significant.

Table 1. Demographic Characteristics[a]

	Mild Group	Moderate Group	Severe Group	All Groups	P value
Age, y	12.38 ± 48.72	14.46 ± 51.3	12.81 ± 53.4	12.885 ± 51.16	0.48
Male, %	63.6	70	65.2	65.5	0.58
BMI[b], kg/m^2	66.50 ± 31.3	5.08 ± 30.88	7.16 ± 34.56	6.676 ± 32.59	0.177

[a] Data are presented as mean ± SD.
[b] Abbreviation: BMI, body mass index

Table 2. Two-Dimensional, TDI, Strain and Strain Rate Echocardiography Information[a,b]

	Mild Group	Moderate Group	Severe Group	Total	P value	P value HTN and/or IHD	P value Only OSA
LV TDI BS Sm, cm/s	6.22 ± 2.30	7.12 ± 1.33	5.95 ± 1.97	6.26 ± 2.01	0.389	0.432	0.254
LV TDI BS Em, cm/s	6.13 ± 3.06	5.38 ± 2.55	5.14 ± 3.08	5.56 ± 2.95	0.597	0.126	0.293
LV TDI BS Am, cm/s	7.31	8.42 ± 1.46	7.43 ± 2.50	7.5 ± 2.36	0.534	0.464	0.835
LV TDI BL S, cm/s	6.28 ± 2.07	5.90 ± 2.18	4.73 ± 2.50	5.49 ± 2.22	0.184	0.196	0.743
LV TDI BL E, cm/s	7.34 ± 3.90	5.38 ± 3.63	4.34 ± 3.32	5.63 ± 3.75	0.117	0.201	0.501
LV TDI BL A, cm/s	6.28 ± 2.07	8.12 ± 0.74	5.89 ± 2.83	6.59 ± 2.78	0.291	0.902	0.573
RVTDIB LS, cm/s	8.92 ± 2.76	11.23 ± 4.18	9.75 ± 2.65	9.77 ± 2.77	0.053	0. 358	0.199
RVTDIB LE, cm/s	7.37 ± 3.49	7.42 ± 2.79	6.22 ± 3.09	6.50 ± 3.17	0.668	0.219	0.184
RVTDIB LA, cm/s	6.37 ± 3.49	11.23 ± 4.18	9.79 ± 4.91	9.39 ± 4.01	0.171	0.456	0.137
Left BS strain rate	1.78 ± 0.50	0.49 ± 0.27	1.10 ± 0.68	2.34 ± 4.36	0.005	0.280	0.006
Right BL strain rate	1.30 ± 1.49	0.75 ± 0.54	1.25 ± 0.71	1.18 ± 1.02	0.605	0.617	0.196
Left BS strain	24.86 ± 13.61	-17.76 ± 9.40	-11.04 ± 4.47	-17.19 ± 11.82	0.015	0.002	0.749
Right BL strain	-17.69 ± 13.09	-19.75 ± 10.78	-13.86 ± 7.94	-16.15 ± 10.36	0.531	0.280	0.472
Right Tei	0.439 ± 0.236	0.400 ± 0.166	0.340 ± 0.193	0.392 ± 0.208	0.353	0.397	0.716
Left Tei	0.4011 ± 0.236	0.360 ± 0.246	0364 ± 0.257	0.387 ± 0.230	0.853	0.863	0.569
LVEF, %	52.63 ± 4.96	52.90 ± 2.51	52.78 ± 3.61	52.74 ± 3.99	0.435	0.479	0.634
PAP, mm Hg	17.86 ± 5.19	18.60 ± 11.10	18.65 ± 10.89	18.32 ± 7.91	0.953	0.363	0.309

[a] Data are presented as mean ± SD
[b] Abbreviations: AI, aortic insufficiency, Am, A´wave by tissue doppler; BL, basal lateral; BS, basal septal; Em, E´ wave by tissue doppler; L, Lateral; LV, left ventricular; LVEF, left ventricular ejection fraction; PAP, pulmonary artery pressure; RVTDIB, right ventricle tissue doppler of base of lateral RV wall; S, strain; Sm, S´wave by tissue doppler; SI, strain imaging; TDI, tissue doppler imaging

5. Discussion

The main findings of this study are relative LV systolic and diastolic dysfunction as well as disorders of some right ventricular (RV) parameters. Research shows that obstructive sleep apnea-hypopnea syndrome (OSAHS) results in LV diastolic dysfunction before the appearance of clinical symptoms and morphological changes (1, 7-9). Hypoxic episodes during OSAHS can increase the O_2 demand of the myocardium and this in turn results in ischemia and subclinical LV systolic dysfunction (1). Presence or lack of LV systolic dysfunction due to OSAHS is disputed (7, 8, 10). This is the issue with RV function too, and the results of the previous studies on the effect of OSAHS on RV function are contradictory (2). In a study by BM Sanner (11), RV dysfunction was detected by using radionuclide ventriculography, after adjusting a large number of variables. There is currently disagreement on whether or not OSAHS independently affects cardiac function (7, 10). Among the reasons for these disagreements are the existence of some concurrent diseases such as hypertension, diabetes mellitus, chronic obstructive pulmonary disease, ischemic heart disease, and myocardial infarction, each of which can independently affect the function of the heart. Be that as it may, these concurrent diseases have been omitted in some studies (2). Another reason for such discordance in results is the employment of dissimilar methods by different studies. For example, while some studies have used only two-dimensional (2D) echocardiography and Doppler (12), others have utilized DTI and 2D-speckle tracking echocardiography. The next issue is the different parts on which the researchers have focused. Indeed, different studies have been performed on the apex fibers of the septum and the lateral wall, and because these parts are affected with different degrees, the results would be different too.

A large number of studies have confirmed that OSAHS exerts no effect on LVEF owing to the fact the lateral fibers grow without change in the circular fibers in early stages of the disease and compensation of longitudinal fibers preserves LVEF. In advanced stages of the disease, the dysfunction is evident due to the involvement of all fibers. Some studies have reported a significant drop in LVEF in severe disease (10, 12). In our study, LVEF in 36.4% of the patients was lower than the normal level. We evaluated strain and strain rate for the longitudinal fibers of basal septum and right side basal lateral (RV free wall) longitudinal fibers. Septum dysfunction was more than the right side, and it had a significant relation with the intensity of the disease. The advantage of evaluating the longitudinal fibers is that they are the most vulnerable fibers due to their position in the subendocardium and their evaluation help earlier detection of myocardial dysfunction (1). Many studies, similar to the present study, have reported dysfunction in left strain and left strain rate with a significant correlation with disease severity (1, 4, 13). In one study, thinner and more trabecula fibers in the apical RV were more sensitive to stress compared to the basal part (14). Accordingly, the changes in the basal fibers are diagnosed in later stages of the disease, and this may be a reason for the relative normal value of these criteria in our study.

TDI has been utilized more commonly in recent years because it confers a better diagnosis of the abnormalities of the myocardium in OSAHS. Based on some studies, however, the limitations of TDI are its load and angle dependency (15). In various studies, changes in these criteria are subject to disagreement and conflict (9, 10, 14, 16). Tei or myocardial performance index (MPI) is a simple, noninvasive, repeatable and functional index for assessing the global function of the heart. As systolic dysfunction and diastolic dysfunction of the heart are usually concurrent, these criteria are drawn upon frequently for assessing patients with OSAHS (10, 17). In some studies, Tei is disrupted in OSA patients (13, 18-20). Our results demonstrated relative disruption in Tei: right Tei was abnormal in 19.1% of our patients, which was irrelevant to the severity of the disease. (There was no significant difference between the groups and we recommend further studies in the Iranian population with OSA.) Various studies have reported pulmonary artery hypertension in OSA patients (15). It seems that, with the effects of OSAHS on the pulmonary system as a result of frequent hypoxia and hypercapnia, the changes in pulmonary pressure are unavoidable. In a series of studies, pulmonary artery pressure was reported borderline normal and it had no significant relationship with the severity of the disease (4, 12). The direct effect of OSAHS should be studied independently from the effect of other diseases on pulmonary artery pressure. We did not detect a significant rise in the pulmonary artery pressure of our study population. Although the presence of pulmonary artery hypertension is not characteristic of patients with OSA, one explanation is the beginning of treatment for the patients by our pulmonologist.

The following points should be taken into consideration in the interpretation of the results of the present study:

The criterion for omitting patients from the study was only the existence of central sleep apnea and the individuals affected with chronic obstructive pulmonary disease, diabetes mellitus, cerebrovascular accident, ischemic heart disease, and hypertension were entered in the study. However, the existence of these criteria somewhat precludes the generalization of the results to the whole population (15).

We did not study the heart apex and only studied the longitudinal fibers, which are of course the most sensitive fibers.

Finally, we did not know the duration of the affliction of OSA patients with or without treatment, and these different durations may be associated with different effects (10).

The principal finding of the present study was dysfunction in criteria in both ventricles, especially the left ventricle. Apart from the effects of concurrent diseases, it has been proved that OSAHS alone affects cardiovascular func-

tion. Therefore, early diagnosis of this dysfunction can be very helpful in slowing the progression of these complications. Further research with larger study populations, control groups, and more exclusion criteria is required to shed sufficient light on this issue. Moreover, transesophageal echocardiography (TEE) can be used for patients with poor echo window who have high levels of BMI if they could tolerate it. As the apical part is more sensitive, we would recommend that strain rate, strain, and TDI be studied in all segments. Finally, other methods for investigating the structure and function of the heart such as magnetic resonance imaging (MRI) can be used for comparison.

5.1. Recommendations

We would recommend that strain, strain rate, TDI, and Tei be used for the initial evaluation of these patients and that the relationship between echocardiographic criteria and clinical symptoms be explored in further studies.

5.2. Limitations

First and foremost among the limitations of the present study was the absence of the follow-up of the study population due to incorrect telephone numbers and considerable distance between the patients' place of residence and our hospital.

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Authors' Contribution

Maryam Moshkani Farahani: Conceived and designed the study, collected the data, and read and approved the final version. Ensie Vahedi: Conceived and designed the study, interpreted the data, and read and approved the final version. Iman Lotfan: Designed the study, collected the data, drafted the manuscript, critically revised the manuscript for intellectual content, and read and approved the final version. Mahdi Motashaker-Arai: Conducted statistical analysis, analyzed and interpreted the data, drafted the manuscript, and read and approved the final version.

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