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An Oxygen Therapy Prevents Ventricular Arrhythmia in Patients with Diastolic Heart Failure and Sleep Apnea

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Abstract

The background and purpose

Diastolic and systolic heart failure (DHF and SHF) are the different clinical subsets. Because many heart failure patients have sleep apnea syndrome (SAS), oxygen supply improves the patient's prognosis. Thus, the purpose of this study was to compare the effects of oxygen treatment for premature ventricular contractions (PVCs) suppression in patients between DHF and SHF.

Methods and subjects

Patients with heart failure (BNP>80 pg/ml), SAS (AHI> 5) and frequent PVCs (>30/h) were admitted to the hospital for at least 2 consecutive nights. On the first night, the respiratory and Holter monitoring was performed without nasal oxygen treatment; the same monitor with nasal oxygen therapy (3 L/min) was performed on the second night.

Essential results

The DHF patients (more than 40% of LVEF, n=7) showed a significant decline of PVC numbers (63.1 ± 33.0% post/pre) compared to those (119.8 ± 45.3% post/pre, $p<0.05$) of the SHF patients (less than 40% of LVEF, n=8) by the oxygen treatment. The DHF patients also showed higher SDNN (253.0 ± 260.0 ms) levels compared to those of SHF patients (52.9 ± 22.4 ms, $p<0.05$). However, AHI and BNP levels were compatible between the two groups.

The principal conclusion

The oxygen treatment may be useful for prevention of ventricular arrhythmia in patients with DHF and SAS.

Keywords: Diastolic dysfunction; Premature ventricular contractions; Brain natriuretic peptide

Introduction

Diastolic heart failure (DHF) and systolic heart failure (SHF) are the different clinical subsets of chronic heart failure (CHF) that are most commonly encountered in clinical practice. Although the clinically overt DHF and SHF appear to be separated by distinctive morphologic and functional changes, clinical characteristics are similar [1]. Although the left ventricle is not dilated and the ejection fraction is preserved in DHF, it is dilated and the ejection fraction is reduced in SHF. The neurohormonal abnormalities including brain natriuretic peptide (BNP) in DHF and SHF are similar. Although ventricular arrhythmia is known to be major causes of poor prognosis in both SHF and DHF patients [2], the management and treatment of DHF has not yet been elucidated.

Sleep-related periodic breathing is known to occur in patients with CHF [3]. These breathing disorders are associated with arterial oxyhemoglobin desaturation and excessive arousals, resulting in sympathetic activation and arrhythmias [4]. Although home oxygen therapy [5], improved clinical conditions of sleep apnea syndrome (SAS) in CHF patients, few studies of SAS in DHF with ventricular arrhythmias have been reported. Thus, studies with detailed findings and laboratory examinations for arrhythmia in SAS and DHF are needed.

Methods

Patients

Fifty patients with CHF admitted to the Department of Cardiovascular Medicine of the Tokyo Medical and Dental University Hospital were candidates for the study. The patients were enrolled from January 2004 to December 2005. Patients <80 years of age were eligible if they met the following criteria: at least one episode of cardiac decompensation; and stable condition while receiving cardiac medication. This study was approved by the ethics committee in

Tokyo Medical and Dental University. Written informed consent was obtained from all participants. The patients were admitted to the hospital for at least 2 consecutive nights for this study. The following tests were also obtained: complete blood count, serum electrolytes, blood urea nitrogen, serum creatinine, brain natriuletic peptide (BNP), echocardiography, and chest X-ray.

Sleep study

Holter electrocardiogram and respiratory monitoring were performed using the Morpheus C system (Teijin Pharma Co. Tokyo, Japan) [6]. For each subject, the overnight sleep study was recorded between 9:30 PM and 5:30 AM. On the first night, the respiratory and Holter monitoring was performed without nasal oxygen treatment; the same monitor with nasal oxygen therapy (3 L/min) was performed on the second night. The data were automatically calculated the apnea hypopnea index (AHI) and the oxygen desaturation index (ODI); patients who had a score of 5 or more on the AHI were diagnosed as SAS [7].

Holter monitoring

All patients underwent Holter recording with 3-channel real-time recorders. For each patient, the total number of premature ventricular contractions (PVCs) was recorded. Heart rate variability (HRV) was assessed, both in time and frequency domains, on the Holter recordings after full revision of the electrocardiogram and editing of beats when indicated. Time-domain HRV variables included the mean of all R-R intervals for the entire recording; the standard deviation of all R-R intervals (SDNN) was measured [6,7].

Other studies

Left ventricular ejection fractions (LVEF) were calculated using echocardiogram by standard techniques. Chest X-ray and arterial blood samples were obtained according to strict criteria as previously reported [8].

Statistical analysis

We used the Wilcoxon rank-sum test to assess significant differences between the groups, since the data were not normally distributed. A value of $p<0.05$ was considered significant. Values are reported as mean ± SD.

Results

In this study, 37 of 50 patients were diagnosed with SAS (AHI > 5) and CHF (BNP >80 pg/ml); we analyzed arrhythmia in these 37 patients. According to our defined thresholds, there were 15 patients who had frequent PVCs (more than 30 PVCs/hour). The 15 patients with frequent PVCs in CHF and SAS were further divided into two groups. The 'SHF (n=8)' group included patients who had impaired LV systolic function (less than 40% of LVEF), frequent PVCs and SAS. The "DHF (n=7)" group included patients who had preserved LV systolic function (more than 40% of LVEF) and frequent PVCs and SAS. Between the two groups, average LVEF was statistically different; the SHF group showed a lower level (26.4 ± 6.9%) compared to that of the DHF group (56.4 ± 11.7%, $p<0.05$ vs. SHF). All other factors were statistically comparable between the two groups (Table 1).

The DHF patients showed a significant decline of PVC numbers (63.1 ± 33.0% post/pre) compared to that of the patients in the SHF group (119.8 ± 45.3 % post/pre, $p<0.05$) by the oxygen treatment. The DHF patients also showed higher SDNN (253.0 ± 260.0 ms) levels compared to the patients in the SHF group (52.9 ± 22.4 ms, $p<0.05$). All other factors including NYHA grading, background diseases, beta blocker treatment, ODI, AHI and BNP levels were statistically comparable between the two groups (Table 1).

Group	DHF	SHF	P
Patient Number	7	8	
Sex (M/F)	5/2	5/3	
Age	70.1 ± 7.5	63.3 ± 5.1	NS
NYHA class	2.6 ± 0.5	2.6 ± 0.7	NS
BNP (pg/mL)	678 ± 671	737 ± 838	NS
CTR in X-p (%)	61.2 ± 9.4	59.7 ± 7.9	NS
LVEF in UCG (%)	56.4 ± 11.7	26.4 ± 6.9	<.05
PVCs (%post/pre)	63.1 ± 33.0	119.8 ± 45.3	<.05
SDNN (no Oxygen)	253.0 ± 260.0	52.9 ± 22.4	<.05
SDNN(with Oxygen)	111.7 ± 24.1	79.8 ± 16.5	NS
AHI	27.2 ± 23.9	14.9 ± 12.5	NS
ODI	29.6 ± 24.0	20.0 ± 10.8	NS
Beta blocker Tx.	4/7	4/8	NS
Causes of CHF			

DCM	3	3	
Ischemic	3	4	
Valve	1	1	

Table 1: SHF or DHF patients with frequent PVCs and SAS

Discussion

In this paper, we have clearly shown that the oxygen treatment suppressed PVC numbers in the DHF patients compared to the SHF group. In our previous study, we confirmed that oxygen treatment to prevent PVCs is effective in patients with higher BNP levels, greater LVEF, and higher SDNN [9]. It has also been reported that asymptomatic DHF patients have a higher incidence of all-case mortality adjusted for age, sex, and LVEF. The diastolic dysfunction was associated with an increased risk of mortality [10]. However, the overall mortality of symptomatic patients with DHF or SHF is similar [11]. In SHF, the rate of sudden death is significantly higher compared to the general population. However, incidence of sudden cardiac death decreases with the increased severity of systolic heart failure [12]. These results suggest that the risk of mortality in DHF patients may be related to arrhythmia.

The pathophysiology of ventricular arrhythmia in DHF patients with SAS is complex and not completely understood. It has been shown that the frequency and severity of arrhythmia can increase in SAS patients [13]. Firstly, we clarified the difference of SDNN between the SHF and the DHF group in this study. This result demonstrated that the impairment of cardiac autonomic function in DHF patients with SAS might be a trigger for ventricular arrhythmia. Nasal oxygen therapy may be effective for the suppression of ventricular arrhythmia through the improvement of cardiac autonomic function. It has been reported that an altered autonomic balance has been suggested as a possible pathogenetic factor, and autonomic dysfunction is implicated in the subsequent development of heart failure patients with SAS [14]. From our results, nasal oxygen therapy may be effective to suppress PVCs in DHF patients with SAS when the patients have impaired autonomic function.

Secondly, we have also revealed that the DHF group showed comparable BNP levels to the SHF group. Recently, it was reported that plasma BNP level and cardiac autonomic function are closely related to prognosis in patients with heart failure. Plasma BNP levels are also known to be a strong predictor for mortality in heart failure patients. Thus, BNP levels are statistically related to cardiac sympathetic nerve innervations [15]. In this study, comparable BNP levels with preserved LVEF might be a condition of insufficient treatments of conservative therapies. It has been well known that conservative treatments of DHF improve the prognosis of the patients. However, these drugs cannot be used in some cases because of hypotension, bradycardia, and/or systemic adverse effects. Therefore, this oxygen therapy, an alternative treatment for DHF, should be considered to use in DHF patients with such conditions.

In conclusion, the oxygen treatment may be useful for prevention of ventricular arrhythmia in patients with DHF and SAS.

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