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Clinical Research

Assessment of Right Ventricular Function in Obstructive Sleep Apnea Syndrome and Effects of Continuous Positive Airway Pressure Therapy: A Pilot Study

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See editorial by Raisinghani, et al., pages 821-822 of this issue.

ABSTRACT

Background: It is known that obstructive sleep apnea syndrome (OSAS) can affect right ventricular (RV) performance even in the absence of systemic hypertension and other known cardiac or obstructive pulmonary disease. The purpose of the present study was to assess RV function in OSAS using 3-D echocardiography and speckle tracking echocardiography (STE) and evaluate changes after continuous positive airway pressure (CPAP) treatment.

Methods: Thirty-seven patients with OSAS without comorbidities and thirty control subjects were studied using 3-D echocardiography and STE. Fifteen patients underwent CPAP therapy and were studied before and after treatment. RV 3-D ejection fraction was calculated. Peak systolic strain was determined. RV dyssynchrony was defined as SD of the 6 time to peak systolic strain values.

Results: 3-D RV ejection fraction was lower and RV dyssynchrony was greater in patients with moderate-severe OSAS compared with control

RÉSUMÉ

Introduction : On sait que le syndrome de l'apnée obstructive du sommeil (SAOS) peut affecter la performance du ventricule droit (VD) même en l'absence d'hypertension systémique et d'autres maladies cardiaques ou pulmonaires obstructives. Le but de la présente étude était d'évaluer la fonction du VD lors du SAOS à l'aide de l'échocardiographie 3D et de l'échocardiographie *Speckle Tracking* (suivi de pixel; EST) et les changements après le traitement par pression positive expiratoire continue (CPAP).

Méthodes : Trente-sept patients souffrant du SAOS sans comorbidités et 30 sujets témoins ont été étudiés à l'aide de l'échocardiographie 3D et de l'EST. Quinze patients ont subi la thérapie CPAP et ont été étudiés avant et après le traitement. La fraction d'éjection du VD en 3D a été calculée. La déformation systolique maximale a été déterminée. La dyssynchronie du VD a été définie comme étant suérieure de 6 fois l'ET des valeurs maximales de déformation systolique.

Obstructive sleep apnea syndrome (OSAS) is the most common form of sleep-disordered breathing characterized by excessive daytime sleepiness, choking or gasping during sleep, recurrent awakenings from sleep, unrefreshing sleep, and sleep monitoring demonstrating 5 or more obstructive apneas/hypopneas per hour during sleep.[1,2] Definitions of OSAS are based on respiratory and neurophysiologic indices but recent reports showed that cardiovascular sequelae could be more important because complications such as coronary artery disease, heart failure, systemic and pulmonary hypertension (PH), and arrhythmias increase morbidity and mortality. Studies on this subject have assessed the effects of OSAS on the left ventricle (LV) and tested the effect of OSAS treatment with continuous positive airway pressure (CPAP) on LV changes.[3-7] Early determination of right ventricular (RV) dysfunction in patients with OSAS and PH is also important in preventing progression to heart failure even in the absence of overlapping chronic lung disease, morbid obesity, or left-sided heart disease.[8-10] However, data on RV dysfunction and structural changes in patients with OSAS are not always clear as the effects of CPAP therapy on this chamber.[9-11]

Moreover, because the right ventricle has a complex crescent shape and is wrapped around the LV, it is difficult to assess RV functions with conventional 2-dimensional (2D) echocardiography. The 2D speckle tracking echocardiography (STE) is a new 2D technique that assesses myocardial deformation and deformation rate by tracking speckles in the

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subjects in the presence and absence of pulmonary hypertension. 3-D RV ejection fraction and RV dyssynchrony were independently associated with apnea-hypopnea index. Patients treated with CPAP had significant changes in RV parameters.

Conclusions: 3-D RV ejection fraction and RV dyssynchrony were abnormal in OSAS patients compared with control subjects and associated with OSAS severity. RV 3-D STE abnormalities improved after chronic application of CPAP.

Résultats : La fraction d'éjection du VD en 3D était plus faible et la dyssynchronie du VD était plus grande chez les patients souffrant du SAOS modéré à grave que chez les sujets témoins en présence ou en l'absence d'hypertension pulmonaire. La fraction d'éjection du VD en 3D et la dyssynchronie du VD étaient indépendamment associées à l'index d'apnées-hypopnées. Les patients traités par CPAP montraient des changements significatifs dans les paramètres du VD.

Conclusions : La fraction d'éjection du VD en 3D et la dyssynchronie du VD étaient anormales chez les patients souffrant du SAOS comparativement aux sujets témoins et associées à la gravité du SAOS. Les anomalies du VD en 3D à l'EST s'amélioraient après l'application à long terme du CPAP.

myocardium on greyscale (B-mode) images and can be used to evaluate global and regional myocardial wall strain.[12,13] Three-dimensional echocardiography (3DE) is also regarded as a promising tool for quantifying RV volumes and function with good correlation to magnetic resonance imaging (MRI), and is a robust, accurate, and reproducible modality for RV volume and function measurements.[14]

In the literature, although there are several studies in which the effects of CPAP therapy on RV myocardial performance in patients with OSAS were determined with conventional echocardiography,[11] there are only few reports that assessed them with STE[12,13] and 3DE[14] and a comparative analysis has not been performed. We hypothesized that in patients with OSAS the use of new echocardiographic techniques improves the assessment of RV dysfunction. The purpose of the present study was twofold: first, we aimed to evaluate the association between OSAS severity and these new RV function parameters, and second to establish whether RV function abnormalities are reversible with CPAP therapy.

Methods

For detailed methodological information and statistical analysis, see the *Methods* section of the Supplementary Material.

A cohort of 37 sleep apnea patients without comorbidities and 30 control subjects were examined with polysomnography[15] and echocardiography. Established echocardiographic criteria were used for assessment of right chambers.[16-23] Three-dimensional echocardiographic images (Fig. 1) were stored digitally for off-line analysis using dedicated software. STE acquisitions were also obtained, with analyses being performed retrospectively and off-line. The general principles that underlie STE modalities have been previously described.[24-29]

All patients underwent overnight polysomnography using a standard technique. Apnea-hypopnea index (AHI) was defined as the number of apneas and/or hypopneas per hour. OSAS was defined as $\geq$ 5 AHI events per hour in the presence of clinical symptoms suggesting OSAS.[15,30,31] On the basis of AHI, patients were classified[1,2] into mild ($>$ 5 to $<$ 15), moderate ($>$ 15 to $<$ 30), and severe OSAS ($\geq$ 30). Fifteen compliant patients with OSAS who had CPAP and complete 3-D and strain analyses were studied before and after treatment. After baseline echocardiography, patients were instructed to use the CPAP device every night for at least 6 hours. Patients received nightly CPAP therapy for at least 4 months and echocardiography was repeated the day after the last nocturnal CPAP treatment while patients were awake.

Results

Thirty-seven of 44 initially evaluated OSAS patients were included in the study. 3DE images of the right ventricle were successfully analyzed in 41 of 44 patients. Longitudinal 2D RV strain measurement from all segments because of adequate tracking quality was possible in 42 of 44 patients. 3-D feasibility was 93%, and 2D strain feasibility was 95%. Tricuspid regurgitation to estimate right-sided pressure was found in 37 of 44 patients (84%). The intraobserver and interobserver reproducibility of 3-D and strain parameters was shown to be acceptable. Intraobserver variability (mean absolute difference between measurements) was 4.4 $\pm$ 2.1% for 3-D RV end-diastolic volume, 5.2 $\pm$ 2.5% for 3-D RV end-systolic volume, 6.8 $\pm$ 3.7% for 3-D RV ejection fraction (RVEF), 8.2 $\pm$ 3.8% for global RV longitudinal strain (RVLS), 4.7 $\pm$ 3.1% for global free-wall RVLS, and 7.1 $\pm$ 3.2% for RV dyssynchrony (SD of the 6 time to peak systolic strain values; SD6). Interobserver variability was 4.8 $\pm$ 3.8% for 3-D RV end-diastolic volume, 7.7 $\pm$ 3.6% for 3-D RV end-systolic volume, 7.1 $\pm$ 4.1% for 3-D RVEF, 8.8 $\pm$ 4.2% for global RVLS, 5.3 $\pm$ 3.9% for global free-wall RVLS, and 7.9 $\pm$ 3.1% for RV SD6.

The baseline characteristics of OSAS patients and control subjects are given in Table 1. No patient had systemic hypertension. There was a statistical trend for significance for body mass index (BMI; $P = 0.06$) to be greater in the severe OSAS group compared with the control group. Daytime hypercapnia (partial pressure of arterial carbon dioxide $\geq$ 45 mm Hg) was present in 7 of 37 (18.9%) patients with OSAS. Three of them had BMI $\geq$ 30.

Echocardiographic parameters

LV ejection fraction was not significantly different in OSAS patients and control subjects, and was in normal limits (Table 2). RV systolic pressure (RVSP), pulmonary vascular resistance, and RV wall thickness were greater in severe OSAS than in control subjects. 3-D RVEF and strain values in patients with moderate-severe OSAS showed a highly significant difference from normal. There was no significant difference in 3-D and RV strains between patients with mild OSAS and control subjects.