

Silent Heart Disease in Patients With Sleep Apnea-Hypopnea Syndrome: Usefulness of the Myocardial Performance Index

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OBJECTIVE: Sleep apnea-hypopnea syndrome (SAHS) is an emerging disease with considerable cardiovascular impact. The myocardial performance index (MPI) is an echocardiographic parameter that is useful in the assessment of global myocardial function. The purpose of this study was to identify any differences in the MPI between patients with and without SAHS.

PATIENTS AND METHODS: We studied 120 consecutive patients referred to our department for suspected SAHS. Following the overnight sleep study and after excluding all patients with hypertension, heart disease, or invalid recordings, 54 patients with SAHS and 13 patients without the disease matched for age and body mass were analyzed. A blinded cardiologist performed Doppler echocardiography, measuring parameters related to ventricular hypertrophy, systolic function, diastolic function, and the MPI. The data were compared by χ^2 and analysis of variance.

RESULTS: Mean (SD) ventricular mass was greater in patients with SAHS (183.17 [40.5] g) than in those without that diagnosis (149 [26] g) ($P=0.005$). No differences were observed in systolic function (78.5% [8.95%] vs 81.6% [7%]) ($P=0.2$), although a higher percentage of patients with SAHS had abnormal diastolic function (71.2% vs 38.5%) ($P=0.049$). The MPI was significantly higher in SAHS patients (0.54 [0.12] vs 0.46 [0.07]) ($P=0.028$).

CONCLUSIONS: On its own, SAHS leads to left ventricular hypertrophy. Diastolic involvement is common in these patients, although a large number of healthy individuals who are obese also present it. The MPI is higher in SAHS and could be a useful parameter to identify patients with silent heart disease before it progresses.

Key words: Sleep apnea-hypopnea syndrome. Doppler echocardiography. Hypertrophy. Left ventricular dysfunction.

Disfunción miocárdica silente en pacientes con síndrome de apneas-hipopneas durante el sueño. Valor del índice de rendimiento miocárdico

OBJETIVO: El síndrome de apneas-hipopneas durante el sueño (SAHS) es una enfermedad emergente con importante repercusión cardiovascular. El índice de rendimiento miocárdico (IRM) es un parámetro ecocardiográfico útil en la valoración de la función miocárdica global. El objetivo del estudio ha sido analizar si hay diferencias en el IRM entre pacientes con SAHS y un grupo control.

PACIENTES Y MÉTODOS: Hemos estudiado a 120 pacientes consecutivos remitidos por sospecha de SAHS a nuestra unidad. Una vez realizado el estudio nocturno y excluidos los hipertensos, cardiopatas o registros inadecuados, analizamos a 54 pacientes y 13 controles de similar edad e índice de masa corporal. Un cardiólogo que desconocía la asignación les realizó un ecocardiograma Doppler. Se midieron parámetros de hipertrofia ventricular, función sistólica, función diastólica y el IRM. Los datos se compararon mediante el test de la χ^2 y ANOVA.

RESULTADOS: Los pacientes con SAHS presentaron mayor masa ventricular que el grupo control (media \pm desviación estándar: 183,17 \pm 40,5 frente a 149 \pm 26 g; $p = 0,005$). No se apreciaron diferencias entre ambos grupos en la función sistólica (un 78,5 \pm 8,95 frente al 81,6 \pm 7%; $p = 0,2$), pero un mayor porcentaje de pacientes con SAHS tenía alterada la función diastólica (un 71,2 frente al 38,5%; $p = 0,049$). El IRM fue significativamente mayor en el grupo con SAHS (0,54 \pm 0,12 frente a 0,46 \pm 0,07; $p = 0,028$).

CONCLUSIONES: El SAHS por sí mismo produce hipertrofia ventricular izquierda. La afectación diastólica es importante en este grupo, pero también la presenta un número importante de personas sanas con obesidad. El IRM está incrementado en el SAHS y podría ser útil para identificar a los pacientes con disfunción miocárdica silente antes de su progresión.

Palabras clave: Síndrome de apneas-hipopneas durante el sueño. Ecocardiografía Doppler. Hipertrofia. Disfunción ventricular izquierda.

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Introduction

Sleep apnea-hypopnea syndrome (SAHS) is a highly prevalent illness that affects 4% to 6% of middle-aged men and 2% to 4% of middle-aged women, and prevalence

increases with age.^{1,2} The syndrome is characterized by excessive sleepiness and cognitive-behavioral, respiratory, cardiac, metabolic, or inflammatory disorders secondary to repeated episodes of upper airway obstruction during sleep.³ Moreover, the syndrome has important cardiovascular consequences⁴⁻⁶ (among them, heart failure) that affect the long-term prognosis.⁷⁻⁸

The myocardial performance index (MPI) relates ventricular systolic and diastolic function, is independent of heart rate and blood pressure, and does not require normalization.⁹ Whenever dysfunction is present, the value is higher. The combination of diastolic and systolic function parameters provides more information on ventricular dysfunction than measurements of either function alone.^{10,11}

The purpose of this study was to assess the use of the MPI in a population of hypertension-free patients with or without SAHS matched for age and body mass index (BMI) to obviate the effect of these confounding factors.

Patients and Methods

Patients

We studied 105 consecutive patients with a diagnosis of SAHS and indication of continuous positive airway pressure therapy (CPAP) from a sleep clinic. All subjects agreed to participate in the study, which was approved by the clinical research ethics committee and the research committee of the hospital.

Overnight Sleep Study

SAHS was diagnosed by respiratory polygraphy with an EMBLETTA polygraph (ResMed, Inc; San Diego, California, USA) validated against conventional polysomnography.¹² Nasal flow was recorded using a pressure transducer, oxygen saturation and heart rate were measured with a digital pulse oximeter, snoring and number of apneas according to patient position were determined with a body position sensor, and chest and abdominal movements were detected by an elastic band with a piezoelectric sensor. All studies were manually reviewed by the same pulmonologist.

Obstructive apnea was considered to be an absence or decrease of more than 90% of the respiratory signal for more than 10 seconds in the presence of respiratory effort detected by the thoracoabdominal bands; central apnea was an absence or decrease of more than 90% in the respiratory signal for more than 10 seconds in the absence of respiratory effort, and mixed apnea was considered to be present when the respiratory event usually started with a central component and ended in an obstructive component.³ Hypopnea was defined as a noticeable decrease (>30% and <90%) in the respiratory signal amplitude lasting more than 10 seconds, as detected by thermistors, nasal cannulae, or pneumotachograph and accompanied by desaturation ($\geq 3\%$) or a microarousal in the electroencephalogram of the polysomnographic recording.³ The apnea-hypopnea index (AHI) was defined as the number of respiratory episodes (apneas or hypopneas) recorded per hour in bed. Studies recorded for less than 4 hours or with sensor disconnections were considered invalid. SAHS was defined by an AHI of 10 or more, along with excessive daytime sleepiness (Epworth score $>10^{13}$).

Polysomnography was performed when the results of polygraphy were considered negative for a diagnosis of SAHS but the symptoms were highly suggestive of this diagnosis.³ The

patient was referred to a sleep clinic at a reference facility for that purpose.

CPAP was prescribed when the AHI was 30 or more. CPAP was also considered when the AHI was 10 or more and other factors, such as excessive sleepiness, cardiovascular risk factors or known cardiovascular disease, were present.³

Doppler Echocardiography

All patients underwent Doppler echocardiography at baseline, before CPAP therapy and within the first 2 weeks of diagnosis. An HP Sonos 5500 with a 2.5-MHz probe (Philips, Eindhoven, the Netherlands) was used for the study. A blinded specialist in echocardiography performed all examinations.

In accordance with established guidelines,¹⁴ the morphological measurements were taken in M-mode, using a long-axis parasternal view as a reference. The ejection fraction was calculated from these measurements using the Teichholz method. The diastolic function parameters were obtained by pulsed Doppler between the borders of the mitral valves with an apical 4-chamber view, and aortic flow was measured in the aortic valve plane. Each individual value was the mean of 3 measurements.

The following parameters were recorded:

1. Left ventricular hypertrophy (LVH): left ventricular mass¹⁵
2. Systolic function: left ventricular ejection fraction
3. Diastolic function: morphology of ventricular filling pattern, defined as normal or abnormal (occurring spontaneously or caused by a Valsalva maneuver)
4. Myocardial performance: MPI (Figure 1)^{16,17}

Exclusion Criteria

The exclusion criteria for the study were as follows: failure to obtain patient consent, presence of hypertension (defined as $>140/90$ mm Hg in 3 morning blood pressure measurements taken at the usual location by expert nurses or as pharmacological therapy for hypertension),¹⁸ SAHS patients under CPAP therapy, presence of atrial fibrillation on echocardiography, patients with heart disease, invalid recordings (<4 hours of recording time or problems with device disconnections), and insufficient reliability of the acoustic window. Once the exclusion criteria were applied, the final analysis was performed on data for 54 patients. Figure 2 shows the study design, specifying the reasons for exclusion.

Comparison Group of Patients Without SAHS

We assessed 15 consecutive patients with no cardiovascular history who were referred to the sleep clinic. They were matched for BMI and age to the SAHS patients, but the results of polygraphy indicated they did not have the disease. Two patients were excluded due to elevated blood pressure. All were screened for heart disease according to medical history, physical examination, chest radiography, electrocardiogram, and Doppler echocardiography.

Statistical Analysis

Numerical variables were expressed as mean (SD) and categorical variables, as percentages. The groups were compared by analysis of variance. Statistical significance was set at P values of .05. The SPSS 12.0 (SPSS Inc, Chicago, Illinois, USA) was used.

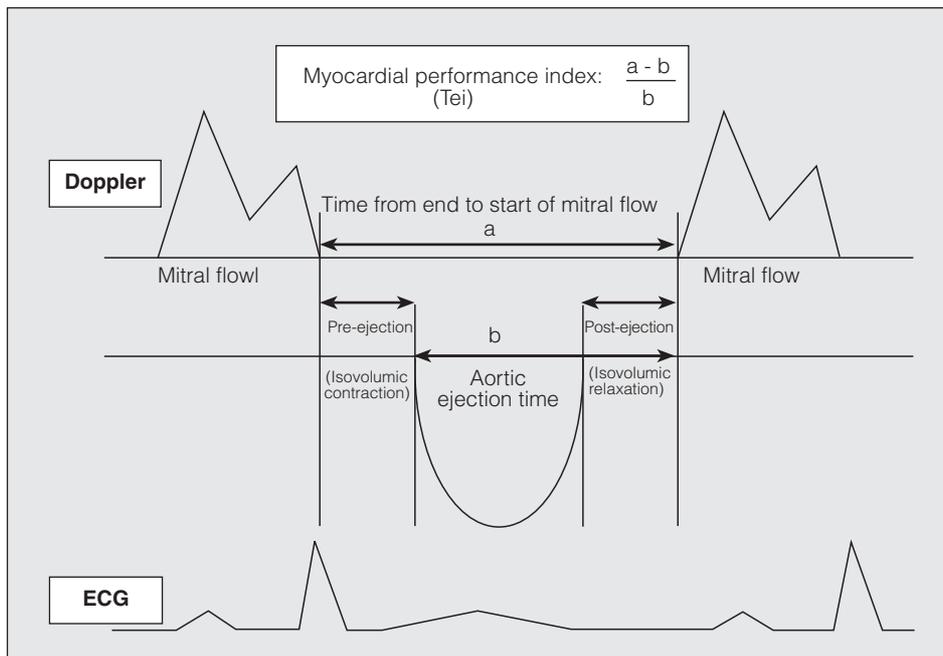


Figure 1. Left ventricular Tei index. The calculation is performed using the formula: $(a - b)/b$ or $(ICT + IRT)/ET$, where ICT is the isovolumic contraction time; IRT, the isovolumic relaxation time, and ET, the aortic ejection time. ECG indicates electrocardiogram.

Results

Clinical Profile of the Study Population

The clinical characteristics of the SAHS population and the control group were similar, except for a higher percentage of men in the patient population, a longer history of suspected SAHS symptoms (reports of apneas or daytime sleepiness), and higher overnight sleep study values (Table).

Echocardiographic Variables

The intraobserver variability was calculated from the 3 values obtained for each measurement. In all cases, the index of agreement (κ statistic) was higher than 0.8. The

Pearson coefficient of variation was 1.8% for the morphological variables and 0.9% for the Doppler variables.

A statistically significant difference was observed in the left ventricular hypertrophy parameters: patients with SAHS presented greater ventricular mass than patients without SAHS (mean [SD] mass, 183.17 [40.5] g vs 149 [26] g; $P=.005$). Figure 3 shows the results of the analysis of left ventricular function: a significantly higher percentage of patients with SAHS had abnormal diastolic function (71.2% vs 38.5%, $P=.049$) and there was a trend toward lower systolic function (78.5 [8.95] vs 81.6 [7%]; $P=.2$). MPI was significantly higher in the patients with SAHS (0.54 [0.12] vs 0.46 [0.07]; $P=.028$).

Discussion

SAHS is commonly associated with obesity, hypertension, and other factors implicated in the pathogenesis of heart failure.¹⁹ The Sleep Heart Health Study²⁰ found that patients diagnosed with SAHS had a relative risk for heart failure of 2.38, a level that was higher than that found for patients with hypertension, ischemic heart disease, or stroke. Given the prognostic implications of the development of heart failure, early diagnosis of SAHS is essential. Doppler echocardiography is a simple, low-cost, innocuous procedure that is readily available in the hospital setting. Its use in patients with SAHS has allowed detection of structural abnormalities²¹ and systolic and diastolic dysfunction.^{22,23}

Hedner et al²¹ compared LVH in 61 patients with SAHS and 61 controls. Weight was significantly higher in the patient group in that study, however, and 50% of patients with SAHS had hypertension compared with 7 in the control group. As a result, this confounding factor is present in their study. In our study, however, there were no

TABLE
Clinical Characteristics of Patients With and Without Sleep ypopnea Apnea-H Syndrome^a

	With SAHS	Without SAHS	P
Number	54	13	
Age (SD), y	48.5 (12.5)	53.0 (8.4)	.22
Male sex	94%	54%	.001 ^b
BMI (SD), kg/m ²	30.8 (4.1)	29.5 (2.4)	.28
Duration of symptoms (SD), y	4.6 (3.0)	2.2 (1.4)	.01 ^b
Epworth score	13.0 (4.2)	12.7 (3.8)	.81
AHI	40.8 (18.7)	7.3 (2.5)	<.0001 ^b
CT90	16.6 (21.7)	0.08 (0.21)	<.0001 ^b

Abbreviations: AHI, apnea-hypopnea index; BMI, body mass index; CT90, cumulative time with saturation below 90%.

^aThe values are expressed as mean (SD).

^b $P \leq .05$.

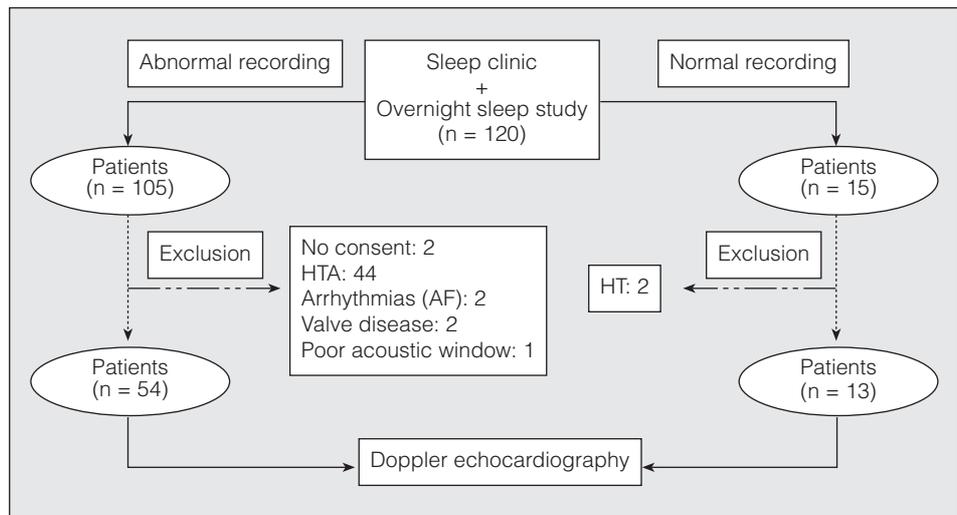


Figure 2. Study flow chart. AF indicates atrial fibrillation; HT, hypertension.

significant differences in BMI between patients with or without SAHS, and SAHS patients without hypertension had LVH, defined as a significantly higher ventricular mass index.

In the patient group, we found a trend toward lower systolic function in comparison with subjects without SAHS, although the intergroup difference was not significant. This finding is not consistent with reports from other studies.^{22,24} We believe the discrepancy could be due to a shorter history of disease in our series, an aspect which is probably highly relevant but not described by most authors. The harmful effects of SAHS on ventricular function are probably related to the time the myocardium is exposed to the chronic stress of the disease.

An analysis of diastolic function in both groups by means of the ventricular filling pattern showed that a significantly higher percentage of SAHS patients had abnormalities (71.8% vs 38.5%; $P=.049$). Such values are consistent with those of other studies carried out using more complex techniques, such as tissue Doppler.²⁴ These data, along with increased left ventricular mass, are consistent with the various pathophysiologic mechanisms whereby SAHS would be able to affect the myocardium by increasing ventricular afterload.²⁵

The MPI is an echocardiographic parameter that is readily obtained and combines systolic and diastolic function. Therefore, it provides a more complete overall picture than do the measurements of the two functions separately.^{10,11} However, MPI is only relatively independent of preload and afterload and, therefore, of hypertension.²⁶ Only a few studies have analyzed this aspect and excluded patients with daytime hypertension,²⁷ and in fact, most series analyze single populations of patients with SAHS.^{24,28} In our study, we controlled for this confounding factor by adding a patient group without SAHS matched for age and BMI, a step which allowed us to exclude other variables that could influence diastolic cardiac function, such as age and obesity. Our results showed that the patients with SAHS had significantly higher MPI than those without the diagnosis (0.54 [0.12] vs 0.46 [0.07]; $P=.028$), a finding which indicated the presence of

myocardial dysfunction. As we mentioned when analyzing diastolic function, the repeated increases in afterload that result from SAHS are accompanied by compensatory myocardial hypertrophy. This mechanism resembles the one seen in hypertensive heart disease and implies difficulty in heart muscle relaxation and thus diastolic dysfunction. If the stimulus persists, dysfunction is established and even progresses, systolic function is impaired, and the symptoms of heart failure subsequently appear.^{29,30} Given the morphometric features characteristic of SAHS patients, in whom elevated BMI and daytime hypertension are common (in 50%-80%, according to the literature²⁶), impaired ventricular relaxation is usually observed. In fact, almost 40% of the SAHS-free subjects matched for BMI presented an abnormal pattern, indicating that an abnormal finding alone does not suggest myocardial involvement directly related to SAHS. The MPI or Tei index could play an important role in providing more complete information on cardiac function^{10,11} and identify patients with progressive (but subclinical) heart disease who do not yet exhibit systolic dysfunction.

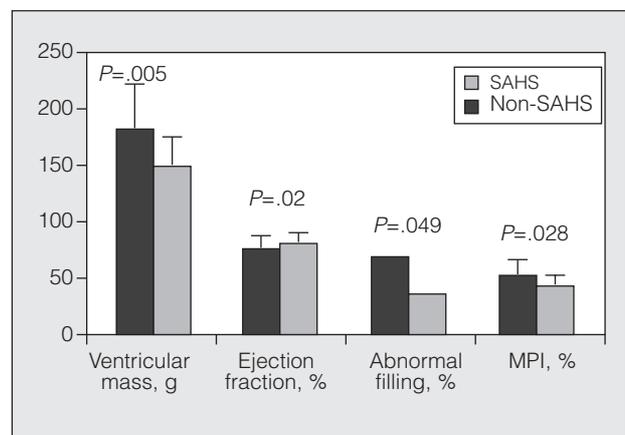


Figure 3. Plot of echocardiographic variables. MPI indicates myocardial performance index; SAHS, sleep apnea-hypopnea syndrome.

The present study had several limitations. A larger comparative group of subjects without SAHS would have been desirable; however, it was difficult to find matched patients who did not have illnesses that represent major confounding factors. Performing polysomnography in all subjects would have ensured greater diagnostic accuracy, but sleep clinics are currently working at capacity and respiratory polygraphy is commonly used to diagnose SAHS. Therefore, we feel that this was not a significant limitation. Blood pressure recordings over a 24-hour period would also have identified nondippers, who are more likely to present cardiovascular complications and organ injury.³¹ We used the criteria accepted by the international community to define hypertension,¹⁸ however, and believe they were adequate for our study.

The subjects without SAHS in our series had Epworth scores that were not significantly different from those of the SAHS patients (Table). In this regard, obesity can be confounding factor, since it has been independently associated with the onset of excessive daytime sleepiness in individuals without SAHS.³² The most common reason for such sleepiness is inadequate sleep—when sleep time during the work week is 2 hours shorter than sleep time on nonworking days.³ Daytime sleepiness was commonly reported by the subjects without SAHS and one of the main reasons for consultation, along with the need to rule out illness for work-related purposes.

In view of our results, SAHS carries a risk of initially silent heart disease. MPI would be a useful, easy-to-measure parameter for early screening of this abnormality while patients are in the subclinical phase, before objective signs of impaired systolic function are observed.

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