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Inspiratory flow-volume curve in snoring patients with and without obstructive sleep apnea

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Abstract

We analyzed the flow-volume curves of 50 patients with complaints of snoring and daytime sleepiness in treatment at the Pneumology Unit of the University Hospital of Brasília. The total group was divided into snorers without obstructive sleep apnea (OSA) (N = 19) and snorers with OSA (N = 31); the patients with OSA were subdivided into two groups according to the apnea/hypopnea index (AHI): AHI<20/h (N = 14) and AHI>20/h (N = 17). The control group (N = 10) consisted of nonsmoking subjects without complaints of snoring, daytime sleepiness or pulmonary diseases. The population studied (control and patients) consisted of males of similar age, height and body mass index (BMI); spirometric data were also similar in the four groups. There was no significative difference in the ratio of forced expiratory and inspiratory flows ($FEF_{50\%}/FIF_{50\%}$) in any group: control, 0.89; snorers, 1.11; snorers with OSA (AHI<20/h), 1.42, and snorers with OSA (AHI>20/h), 1.64. The FIF at 50% of vital capacity ($FIF_{50\%}$) of snoring patients with or without OSA was lower than the $FIF_{50\%}$ of the control group (P<0.05): snorers 4.30 l/s; snorers with OSA (AHI<20/h) 3.69 l/s; snorers with OSA (AHI>20/h) 3.17 l/s and control group 5.48 l/s. The $FIF_{50\%}$ of patients with severe OSA (AHI>20/h) was lower than the $FIF_{50\%}$ of snorers without OSA (P<0.05): 3.17 l/s and 4.30 l/s, respectively. We conclude that 1) the $FEF_{50\%}/FIF_{50\%}$ ratio is not useful for predicting OSA, and 2) $FIF_{50\%}$ is decreased in snoring patients with and without OSA, suggesting that these patients have increased upper airway resistance (UAR).

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Key words
- Sleep
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- Obstructive sleep apnea
- Snoring
- Upper airway resistance

Introduction

Patients with obstructive sleep apnea (OSA) show episodic obstructions of the upper airway during sleep. It is known that these patients present anatomic and functional alterations of the upper airway (1-3).

The flow-volume curve has been used to define standards that can identify patients with OSA. The parameters that have been used are the saw-tooth and the index of forced expiratory flow (FEF) to forced inspiratory flow (FIF) at 50% of vital capacity ($FEF_{50\%}/FIF_{50\%}$) (4-10). Although alterations in the inspiratory flow-volume curve have been reported to occur in patients with OSA, it is not possible to identify patients with OSA among snorers (5-7).

In the present study we analyzed the inspiratory and expiratory flow-volume curves in snorers with and without OSA and compared them to a control group.

Subjects and Methods

We reviewed the data of 50 patients under treatment at the sleep laboratory of the Pneumology Unit of the University Hospital of Brasília (HUB) with complaints of snoring and daytime hypersomnolence. After completing a detailed questionnaire about sleep disorders, all patients were submitted to polysomnography (PSG). The procedure consisted of continuously recording 3 channels of the electroencephalogram (EEG), 2 channels of the electrooculogram (EOG), and 1 channel of the submentonian electromyogram (EMG). The electrocardiogram (ECG) and oxygen saturation were also recorded, as well as the non-calibrated respiratory flow and the thoracic movements. The PSG was based on the method of Rechtschaffen and Kales (11), recently revised by Carskadon and Rechtschaffen (12). A 16-channel Berger polygraph model TW 102 (São Paulo, SP, Brazil) and a pulse oximeter (Biochem International Inc., Waukesha, WI, USA) were used to record sleep and oxygen saturation.

The patients were divided into snorers without OSA (N = 19) and snorers with OSA (31) according to the results of the PSG. The group of patients with OSA was further subdivided into 14 patients with an apnea/hypopnea index (AHI) <20/h and 17 patients with AHI>20/h. The patients were compared to the control group consisting of 10 non-smoking persons without complaints of snoring, daytime hypersomnolence, or pulmonary disease. Thus, 4 groups were studied.

After PSG the subjects underwent pulmonary function testing, which included spirometric evaluation with a Futuremed Spiro Analyzer ST-250 (New York, NY, USA), performed according to the standards of the American Thoracic Society (13), and arterial gasometry. The spirometric variables studied were forced vital capacity (FVC), forced expiratory volume in 1 s (FEV_1), and forced expiratory flow between 25 and 75% of FVC ($FEF_{25-75\%}$). The expiratory flow-volume curve provided peak expiratory flow (PEF), forced expiratory flow at 50% of FVC ($FEF_{50\%}$), and forced expiratory flow at 75% of FVC ($FEF_{75\%}$). The inspiratory flow-volume curve provided peak inspiratory flow (PIF), forced inspiratory flow at 50% of FVC ($FIF_{50\%}$), and the ratio $FEF_{50\%}$ to $FIF_{50\%}$ ($FEF_{50\%}/FIF_{50\%}$).

All subjects were males of similar age, height, and body mass index (BMI). Statistical significance was assessed by nonparametric ANOVA followed by the method of Dunn, and P<0.05 was considered to be statistically significant.

Table 1 - Anthropometric and spirometric data for the patients studied.

Data are reported as mean ± SD. OSA: Obstructive sleep apnea; AHI: apnea/hypopnea index; BMI: body mass index; FVC: forced vital capacity; FEV_1: forced expiratory volume in 1 s; $FEF_{25-75\%}$: forced expiratory flow between 25 and 75% of FVC.

	Control	Snorers	OSA (AHI<20/h)	OSA (AHI>20/h)
Age	45.90 ± 3.98	46.26 ± 9.87	43.42 ± 10.24	50.05 ± 9.50
Height	1.70 ± 0.06	1.71 ± 0.06	1.69 ± 0.06	1.71 ± 0.06
BMI	27.39 ± 0.08	28.11 ± 3.81	26.59 ± 2.74	30.47 ± 4.04
FVC	4.09 ± 0.48	4.14 ± 0.63	4.03 ± 0.84	3.87 ± 0.52
FEV_1	3.42 ± 0.41	3.41 ± 0.51	3.33 ± 0.83	3.15 ± 0.43
FEV_1/FVC%	83.66 ± 5.05	82.35 ± 4.22	81.81 ± 5.36	81.55 ± 5.91
$FEF_{25-75\%}$	3.69 ± 0.83	3.67 ± 0.89	3.44 ± 1.15	3.38 ± 1.09

Results

Table 1 shows the mean values of age, height, BMI and spirometric data in the four groups studied. Statistical analysis showed that the values were similar for all groups.

The parameters of the expiratory and inspiratory flow-volume curves and the $FEF_{50\%}/FIF_{50\%}$ ratio are given in Table 2. Regarding the $FEF_{50\%}/FIF_{50\%}$, no significant difference (P = 0.07) was observed between the 4 groups.

With respect to the expiratory loop of the curve, PEF, $FEF_{50\%}$ and $FEF_{75\%}$ were similar for all groups. With respect to the inspiratory loop, both groups of snorers with OSA (AHI<20/h and AHI>20/h) had a lower PIF than the control group ($P<0.05$), snorers with and without OSA had a lower $FIF_{50\%}$ than the control group ($P<0.05$), and snorers with severe OSA (AHI>20/h) had a lower $FIF_{50\%}$ than the group of snorers without OSA ($P<0.05$).

Discussion

Studies regarding pharynx geometry in awake patients with OSA have shown that the pharyngeal diameter of these subjects is smaller than normal (1). Studies of the pharyngeal muscles of awake patients with OSA have demonstrated that in these patients added inspiratory resistive loads do not provoke an adequate muscular response in pharyngeal zones, where greater collapsibility is found. These results suggest that there may be an altered regulation of these structures (14). Other studies on the upper airway resistance (UAR) of patients with OSA, using transducers placed in different pharyngeal zones, have shown that the UAR is higher in these patients than in normal subjects (15,16). These data suggest that the causes of OSA may be primarily anatomic, and that some muscular regulation factor may be altered, leading to an increase in upper airway resistance even in the awake state. During sleep these alterations may be much more pronounced causing periodic occlusions of the pharynx (17,18).

The flow-volume curve, mainly the inspiratory phase, has been the parameter most frequently used to look for a simple way to pinpoint patients with OSA, since the PSG is a difficult and expensive exam. The saw-tooth signal and an $FEF_{50\%}/FIF_{50\%}$ ratio >1.0 have been the most used variables, but there are controversies about their reliability (4,5). Haponik et al. (10) studied the $FEF_{50\%}/FIF_{50\%}$ and the PIF in two groups of patients, 27 with OSA and 25 without OSA, and observed that the group with OSA had $FEF_{50\%}/FIF_{50\%}$ >1.0 and lower PIF. The authors concluded that the flow-volume curve was useful for the diagnosis of OSA. Tammelin et al. (8) studied the flow-volume curve and performed fiberoptic nasopharyngoscopy in 22 patients with OSA. They observed that, in the presence of endoscopic alterations of the upper airway, the flow-volume curve was often abnormal (saw-tooth, $FEF_{50\%}/FIF_{50\%}$ >1.0 or both). The authors concluded that patients with OSA and an abnormal flow-volume curve are likely to present anatomical alterations of the upper airway.

Hoffstein et al. (5) analyzed 405 patients referred to the sleep laboratory with the major complaint of snoring. According to the PSG, the patients were divided into 207 with OSA and 198 without OSA. The authors showed that the $FEF_{50\%}/FIF_{50\%}$ ratio did not differ between groups. Rauscher et al. (6) showed that the $FEF_{50\%}/FIF_{50\%}$ ratio and saw-tooth sign are of limited value for predicting OSA and Katz et al. (7) reported similar results.

We examined 50 male patients with complaints of snoring and daytime sleepiness and compared them to a control group. The $FEF_{50\%}/FIF_{50\%}$ ratio was not significantly dif-

Table 2 - Expiratory and inspiratory flows for the patients studied.

Values are reported as means ± SEM. OSA: Obstructive sleep-apnea; AHI: apnea/hypopnea index; PEF: peak expiratory flow; $FEF_{50\%}$: forced expiratory flow at 50% of forced vital capacity (FVC); $FEF_{75\%}$: forced expiratory flow at 75% of FVC; $FIF_{50\%}$: forced inspiratory flow at 50% of FVC; PIF: peak inspiratory flow; $FEF_{50\%}/FIF_{50\%}$: ratio of $FEF_{50\%}$ to $FIF_{50\%}$. *P<0.05 *vs* control; +P<0.05 *vs* snorers (ANOVA).

	Control	Snorers	OSA (AHI<20/h)	OSA (AHI>20/h)
PEF	8.93 ± 1.08	8.39 ± 1.11	7.94 ± 1.34	7.65 ± 2.11
$FEF_{50\%}$	4.46 ± 0.78	4.52 ± 1.26	4.20 ± 1.52	3.79 ± 1.52
$FEF_{75\%}$	1.61 ± 0.45	1.54 ± 0.56	1.53 ± 0.75	1.28 ± 0.68
PIF	5.68 ± 1.21	4.55 ± 1.28	3.96 ± 1.55*	3.72 ± 1.35*
$FIF_{50\%}$	5.48 ± 1.23	4.30 ± 1.38*	3.69 ± 1.50*	3.17 ± 1.38*+
$FEF_{50\%}/FIF_{50\%}$	0.89 ± 0.39	1.11 ± 0.35	1.42 ± 0.75	1.64 ± 0.88

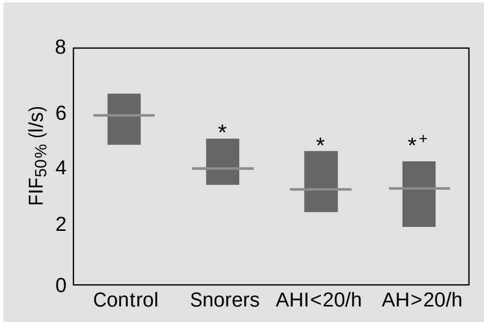

Figure 1 - Forced inspiratory flow at 50% of vital capacity ($FIF_{50\%}$) in the 4 groups studied. The group of snorers and both groups of snorers with obstructive sleep apnea (OSA) had a lower $FIF_{50\%}$ than the control group. The group of patients with severe OSA (AHI>20/h) had a lower $FIF_{50\%}$ than the snorers without OSA. Data are reported as median (horizontal bars) and 25-75 percentiles. *P<0.05 *vs* control; +P<0.05 *vs* snorers (ANOVA).

ferent in the four groups studied. In other words, the $FEF_{50\%}/FIF_{50\%}$ ratio is not helpful to diagnose OSA among snoring patients. Regarding the inspiratory flows, snorers with and without OSA have a significantly lower $FIF_{50\%}$ than normal subjects, and snoring patients with OSA have a significantly lower PIF than the control group.

It is interesting to note that snorers with mild OSA (AHI<20/h) and snorers without OSA have a similar $FIF_{50\%}$, but snorers with severe OSA (AHI>20) have significantly lower $FIF_{50\%}$ than snorers without OSA. Figure 1 shows the $FIF_{50\%}$ for the four groups: the higher $FIF_{50\%}$ was observed in the control group and the lowest in snorers with severe OSA (AHI>20/h).

The data referring to $FIF_{50\%}$ suggest that snoring patients with or without OSA have in common partial obstruction of the upper airway. When we compare the control group to the group of snoring patients, with or without OSA, we find a significantly lower $FIF_{50\%}$; when we compare the $FIF_{50\%}$ of snoring patients with severe OSA (AHI>2/h) to that of snoring patients without OSA, the differences remain statistically significant. In contrast, when we compare snorers without OSA to snorers with mild to moderate OSA (AHI<20/h) the difference is no longer significant. Thus, the flow-volume curve is not useful to identify among snoring patients those having mild to moderate OSA, but the flow-volume curve is useful to identify those having severe OSA. In other words, though the flow-volume curve is not useful for predicting OSA, it is useful to easily demonstrate that the increase of UAR is a factor playing an important role in the severity of OSA.

In conclusion, the present data suggest that a) the $FEF_{50\%}/FIF_{50\%}$ ratio is not useful for predicting patients with OSA and b) the $FIF_{50\%}$ is decreased in snoring patients and patients with OSA, suggesting that these patients have increased upper airway resistance.

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