

Ultrasonographic evaluation of abdominal wall fat index, carotid intima-media thickness and plaque score in obstructive sleep apnea syndrome

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Abstract

Aims: Obstructive sleep apnea syndrome (OSAS) is strongly related with increased risk of cardiovascular diseases and visceral obesity. Abdominal wall fat index (AFI) is an indicator of visceral fat accumulation determined by ultrasonography (US). Carotid intima-media thickness (C-IMT) and carotid plaque score (C-PS) are the indicators of cardiovascular risk. The aim of this study was to investigate the relation between OSAS and AFI, C-IMT or C-PS. **Materials and methods:** One-hundred and four subjects (31 females, 73 males) between 23-73-year-old, candidate for polysomnography (PSG) with suspect of OSAS and without other atherosclerotic risk factor, were evaluated by US. AFI, C-IMT_{mean} and C-PS values were determined and the subjects were grouped according to their apnea-hypopnea index (AHI) values as follows: no OSAS (<5), mild OSAS (5-15), moderate OSAS (15-30) and severe OSAS (>30). **Results:** There was a statistically significant correlation between AFI and AHI (p=0.019). The C-IMT_{mean} values of subjects with OSAS (AHI >5) were significantly higher than those without OSAS (AHI <5) (p=0.035). C-PS was not correlated with AHI (p=0.345) and also there was not a statistically significant difference between OSAS groups in terms of C-PS (p=0.775). **Conclusions:** This study revealed that AFI correlates with AHI and C-IMT increases in OSAS. The two parameters could be used as indicators of risk of metabolic disorders and atherosclerotic diseases in subjects with sleep apnea in the future.

Keywords: ultrasonography; obstructive sleep apnea syndrome; abdominal wall fat index; carotid intima-media thickness; carotid plaque score

Introduction

Obstructive sleep apnea syndrome (OSAS) is a disease characterized by repetitive episodes of total or partial obstruction of upper airway and related hypopnea and

apnea attacks during sleep [1,2]. Common complaints are fragmentation of sleep, snore, daytime somnolence and mouth dryness after awakening [1-3]. The prevalence of OSAS is 2-5% and 3-7% in middle-aged women and men, respectively [4-7]. Obesity is the prominent risk factor of OSAS [8,9]. The positive diagnosis of OSAS rely on the presence five or more obstructive apneas and/or hypopneas per hour of the sleep (apnea-hypopnea index) along polysomnography in a subject with symptoms of OSAS [10].

OSAS was related with metabolic disorders such as dyslipidemia and diabetes mellitus [11-14] and recently a relation between visceral fat deposition and severity of OSAS was reported [13,15]. Increased visceral fat seems

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to be a key factor for metabolic syndrome and OSAS. At this point, a need for a new indicator to demonstrate visceral fat deposition in OSAS patients arises. Abdominal wall fat index (AFI), established by Suzuki et al [16] is an indicator of visceral fat deposition and it was thought to reflect metabolic disorders [16]. It can be assessed by ultrasonography (US) in an easy, quick, safe, cheap and reproducible way.

OSAS was also related with increased risk for atherosclerotic diseases [17–20]. Intima-media thickness of common carotid arteries (C-IMT) is a known indicator of cardiovascular risk [21–23] and carotid plaque score (C-PS) was also reported as an indicator of cardiovascular risk in a few studies [24,25].

In this study we aimed to reveal whether there is a relation between AFI and presence and/or severity of OSAS. Also, we tried to find whether there is a relation of OSAS with C-IMT and C-PS.

Material and methods

Participants

All participants enrolled were selected among the subjects candidate for polysomnography with complaints suggesting OSAS (snoring, daytime somnolence, etc.) from the department of Pulmonary Diseases. The study was reviewed by the Ethical Committee of our institution (decision number: 30/05) before the study. In order to avoid the effects of atherosclerotic and metabolic risk factors other than OSAS the exclusion criteria were smoking, diabetes mellitus, hyperlipidemia and hypertension. Written and signed informed consents were taken from all participants. Age, sex, body mass index (BMI) and waist circumference (WC) of each participant were recorded before US examination. From August 2016 to February 2017, 104 subjects (31 females and 73 males, between 23-73 years old) were enrolled.

Ultrasonography

All US examinations were done by the same radiologist (with 12 years of US experience) within the day before polysomnography, so the radiologist was blind to the AHI values. All examinations were done with the same ultrasound system (Aplio 500 Toshiba Ultrasound Systems, Tokyo, Japan) and with the same linear-array transducers.

Abdominal wall fat index

Maximum thickness of preperitoneal fat (P_{max}) and minimum thickness of subcutaneous fat (S_{min}) were measured using 10 MHz linear probe and AFI was calculated ($AFI = P_{max}/S_{min}$) [16] (fig 1). The examination was performed in the supine position, and paramedian scanning was done beginning from the xiphoid to the

umbilical level, the transducer was kept perpendicularly and touched slightly to avoid compressing fat layers. The subject was asked to hold their breath in order to keep the anterior surface of the left hepatic lobe parallel to the skin [16].

Carotid intima-media thickness

Examination of bilateral carotid arteries was performed using a 7.5 MHz linear-array transducer. In the supine position, bilateral common and internal carotid arteries were examined for the presence of atherosclerotic plaques, using gray scale and color Doppler modes. C-IMT was defined as the thickness of the hypoechoic layer between the vessel lumen and hyperechoic adventitia [26]. A plaque was defined as a localized increase in the thickness of intima-media more than 1.2 mm [26,27]. C-IMT measurements were done at approximately 1 cm proximal of the bulb from areas without plaque [26,27] and the average of four values (right near wall, right far wall, left near wall, left far wall) was recorded as $C-IMT_{mean}$ (fig 2).

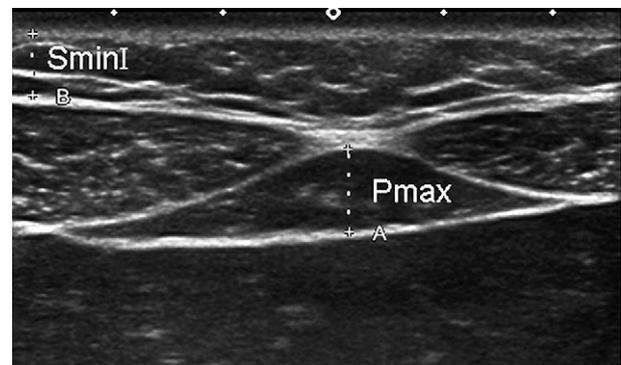


Fig 1. An example to the measurement of maximum thickness of preperitoneal fat (P_{max}) and minimum thickness of subcutaneous fat (S_{min}) in a 28-year-old male subject.

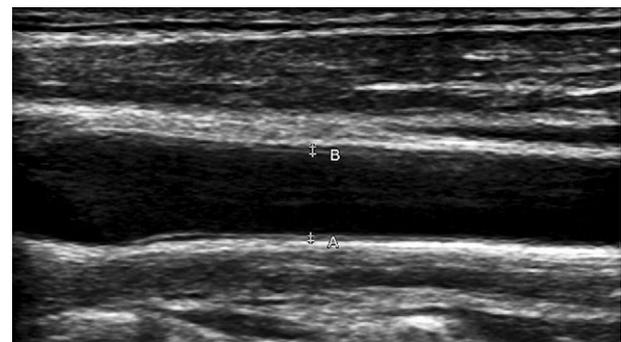


Fig 2. An example to the measurement of carotid intima-media thickness (C-IMT) of a 28-year-old male subject. C-IMT measurements were done at approximately 1 cm proximal of the bulb from areas without plaque in the far (A) and near (B) walls of each common carotid artery.

Carotid plaque score

For each common carotid artery, the plaque degree was defined as follows: 0, no plaque; 1, one plaque thinner than 30% of the vessel diameter; 2, one plaque with thickness between 30-50% of the vessel diameter or multiple plaques thinner than 30% of the vessel diameter; and 3, one plaque thicker than 50% of the vessel diameter or multiple plaques with at least one plaque with thickness between 30-50% of the vessel diameter [26]. C-PS was recorded as the maximum plaque degree observed on both common carotid arteries.

Polysomnography

Subjects were grouped according to their AHI values as follows: no OSAS, less than 5; mild OSAS, between 5-15; moderate OSAS, between 15-30; and severe OSAS; more than 30, as previously described [10,13,27].

Statistical analysis

Statistical analysis of findings was performed by the programme 'SPSS Statistics Base 22.0' (IBM, United States). First, normal distribution of all values was checked using Kolmogorov-Smirnov test, evaluation of skewness and kurtosis and histogram analysis. Secondly, the assessment of the relationship between different parameters was done. Pearson correlation analysis was used to assess the relation of age with AHI, AFI and C-IMT_{mean}; AHI with BMI, WC, P_{max}, S_{min}, AFI and C-IMT_{mean} and AFI with C-IMT_{mean}; one way-ANOVA test (analysis of variance) was used to assess the relation of OSAS groups with BMI, WC, AFI and C-IMT_{mean}; C-PS with age and AHI; independent group *t* test was used to assess relation of OSAS groups with AFI and C-IMT_{mean}; sex with AHI and AFI; Chi Square test to assess the relation between OSAS groups and C-PS. *P* values below 0.05 were accepted to be statistically significant.

Results

The mean AHI values in male and female subjects were 27.82 and 18.29, respectively and AHI values of

Table I. Relation between the age, ultrasound and polysomnography findings of the study population assessed using Pearson correlation analysis.

	p value	r value
Age - AHI	0.207	-0.125
Age - AFI	0.640	0.046
Age - C-IMT _{mean}	<0.001	0.514
AHI - BMI	<0.001	0.382
AHI - WC	<0.001	0.402
AHI - P _{max}	<0.001	0.369
AHI - S _{min}	1	0
AHI - AFI	0.019	0.23
AHI - C-IMT _{mean}	0.158	0.139
AFI - C-IMT _{mean}	0.062	0.183

AHI – apnea-hypopnea index; AFI – abdominal wall fat index; C-IMT_{mean} – mean carotid intima-media thickness; BMI – body mass index; WC – waist circumference; P_{max} – maximum thickness of preperitoneal fat; S_{min} – minimum thickness of subcutaneous fat

male subjects were significantly higher than female subjects ($p=0.046$). There was no significant correlation between age and AHI ($p=0.207$). The mean AFI values in male and female subjects were 1.94 and 0.89, respectively and AFI values of male subjects were also significantly higher than female subjects ($p<0.001$).

The relations between the age, US and polysomnography findings of the study population assessed using Pearson correlation analysis are shown in Table I and the relations of OSAS groups with AFI, C-IMT_{mean} and C-PS in Table II. Although there was no significant difference between OSAS groups in terms of C-IMT_{mean}, C-IMT_{mean} values of subjects with OSAS (AHI>5) were significantly higher than the subjects without OSAS (AHI<5) ($p=0.035$).

There were 76 subjects with C-PS of 0, 23 subjects with C-PS of 1, 5 subjects with C-PS of 2 and no subject with C-PS of 3. C-PS was significantly correlated with age ($p<0.001$) but not with AHI ($p=0.345$). The relation between AHI and C-PS is shown in Table III.

Table II. The relation of OSAS groups with AFI, C-IMT_{mean} and C-PS

OSAS	Mean AFI	C-IMT _{mean}	C-PS (number of subjects)		
			Score 0	Score 1	Score 2
No (n=18)	1.35±0.51	0.5 ±0.12	14	3	1
Mild (n=34)	1.64±1.02	0.59±0.11	26	7	1
Moderate (n=22)	1.45±0.83	0.57±0.12	13	7	2
Severe (n=30)	1.92±1.13	0.62±0.12	23	6	1
Total (n=104)	1.63±0.96	0.59±0.12	76	23	5
p value	0.179	0.099		0.775	

Unless otherwise indicated, data are mean±standard deviations. OSAS – obstructive sleep apnea syndrome; AFI – abdominal wall fat index; C-IMT_{mean} – mean carotid intima-media thickness; C-PS – carotid plaque score

Table III. Relation between apnea-hypopnea index and carotid plaque score

C-PS	Mean AHI	p value
0 (n=76)	25.59±27.03	0.345
1 (n=23)	23.06±18.78	
2 (n=5)	24.58±28.05	
Total (n=104)	24.98±25.28	

Unless otherwise indicated, data are mean±standard deviations. AHI – apnea-hypopnea index; C-PS – carotid plaque score

Discussions

Previous studies revealed that the severity of OSAS was associated with visceral fat rather than BMI and that visceral fat could be the link between OSAS and metabolic syndrome (MetS) [13,28-30]. Also, it has been reported that visceral obesity contributes to worsening the MetS and OSAS [29,30]. Therefore, early determination of increased visceral fat may lead to early detection of increased risk of worsening of OSAS and the metabolic disorders associated with OSAS. According to our knowledge, this study is the first study dealing with the relation between OSAS and AFI and it revealed that AFI is correlated with AHI. This finding was compatible with the studies that analysed the relation between OSAS and visceral fat [13,15]. Besides this, this preliminary result also gives hope about the efficiency of AFI as an indicator of the increased risk of worsening of OSAS and metabolic disorders associated with OSAS.

In most of the studies concerning the relation between OSAS and central obesity, the waist circumference, waist-to-hip ratio or V/S ratio (the ratio of visceral fat area to the subcutaneous fat area at umbilical level) have been used to determine visceral obesity [12–14]. Tokunaga et al [31] have determined the V/S ratio by computed tomography, in order to appreciate the visceral fat distribution. The determination of AFI using US is easier and practical than the V/S ratio. AFI can be measured by any US device, does not need a special computer programme and a long time for calculation like the V/S ratio. Also, the patients are not exposed to ionizing radiation.

Our study revealed a significant correlation between AHI and AFI but could not demonstrate a statistically significant difference between OSAS groups in terms of AFI. This fact was considered to be due to low numbers of participants in each group. It is obvious that further studies with wider sample sizes are needed to assess the exact relation between severity of OSAS and AFI.

This study revealed that C-IMT_{mean} values of subjects with OSAS (AHI>5) were significantly higher than the subjects without OSAS (AHI<5). This finding was also

compatible with other studies about the OSAS and C-IMT relationship [26,32]. Altin et al [26] revealed that the severity of atherosclerotic plaques of the patients with severe OSAS was higher than the patients with mild OSAS and the subjects without OSAS. Contrary to this study, we could not find any relation between C-PS and OSAS. This could be due to the fact that the subjects with OSAS in our study population were recently diagnosed and do not have any other atherosclerotic risk factor.

There are limitations to this study. The numbers of subjects were low in each group, especially in the group without OSAS (AHI<5) and there was a striking difference between numbers of subjects in the group without OSAS (AHI<5) and the groups with OSAS (AHI>5). This situation was due to the inclusion of only the symptomatic subjects in order to obtain AHI values from all participants; also, we have no control group consisting of asymptomatic subjects for avoiding the unnecessary polysomnographies. Also, all of the subjects with OSAS were diagnosed at the same time as the initiation of the study and they did not have any other atherosclerotic risk factor other than OSAS. This situation encouraged us to investigate the relation between OSAS and C-IMT directly, but at the same time most of the participants had a low-risk for cardiovascular disease. So, it was not surprising that there was no subject with C-PS of 3. Other significant limitations were the lack of agreement analysis and the calculation of the sample sizes. Also, in this preliminary study, the subjects were not classified or selected according to their BMI, WC, menopause status or sex. It will be possible to eliminate most of these limitations by the help of wide-range studies with control groups including follow-up of the patients.

In **conclusion**, this study demonstrated that AFI increases with the increase of AHI and C-IMT increases in OSAS patients. With its various advantages, AFI may be a new indicator of increased visceral fat and therefore an increased risk of metabolic disorders and worsening of the disease in OSAS patients in the future. To support these findings, wide-range studies including long-term follow-up of OSAS patients are required.

Conflict of interest: none

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