Can Bioelectrical Impedance Technique Predict the Risk of Obstructive Sleep Apnea Syndrome Occurrence?

MARC MONICA[1], CRISTIAN OANCEA[1], ELENA BERNAD[2]*, STELA IURCIUC[3]*, FLORINA BULEU[3]*, ALEXANDRU CARABA[4], CRISTINA FLORESCU[5], ANDREEA-IULIA DOBRESCU[6], IULIUS JUGANARU[6], MIRCEA IURCIUC[3]

[1] Victor Babes University of Medicine and Pharmacy, Department of Pulmonology, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

[2] Victor Babes University of Medicine and Pharmacy, Department of Obstetrics and Gynecology, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

[3] Victor Babes University of Medicine and Pharmacy, Department of Cardiology, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

[4] University of Medicine and Pharmacy Victor Babes, Department of Internal Medicine, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

[5] University of Medicine and Pharmacy, Department of Cardiology, 2 Petru Rares Str., 200349, Craiova, Romania

[5] Victor Babes University of Medicine and Pharmacy, Department of Genetics, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

[6] Victor Babes University of Medicine and Pharmacy, Department of Pediatrics, I[st] Pediatric Clinic, Louis Turcanu Emergency Hospital for Children, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

Obstructive sleep apnea syndrome (OSAS) is a life-threatening condition, with several risk factors and predictors. Some of them are easy to evaluate and had a great sensitivity to indicate the risk of OSAS occurrence.The aim of the study was to evaluate the correlation between specific body composition items obtained with and OSAS compared with body mass index (BMI). We performed a cross-sectional study including 76 patients, 51 with OSAS and 25 without OSAS used as control group. Anthropometric measurements, bioelectrical impedance analysis and polysomnography were performed in all included patients. All patients were overweight. Statistically significant differences were identified between groups for visceral fat accumulation (VFA) (201.10 cm^2 vs bioelectrical impedance technique 155.10 cm^2, p<0.0001) and body fat mass (BFM) (44.44 vs 33.50, p<0.0001). Also, waist-to-hip ratio was statistically significant greater in OAS group (p=0.0011).It was a strong statistical significant correlation between apnea-hypopnea index (AHI) vs VFA(r=0.533, p<0.05). VFA indicates the occurrence of OSAS with high sensibility(76.5%), but medium specificity (88%).Bioelectrical impedance analysis offers the possibility to calculate important body composition items, highly correlated with OSAS, in an economic, easy and non-invasive way. It can also be used in sleep apnea syndrome prescreening.

Keywords: Sleep disorders, obstructive apnea syndrome, bioelectrical impedance analysis, obesity, body composition, polysomnography

Sleep disorders are an actual and important topic for sudden death occurrence in adults. Several risk factors were mentioned, without clear conclusion- obesity, nose or throat problems, and genetic patterns [1,2]. Sleep apnea syndrome (SAS) is defined as at least 10 apnea episodes per hour of sleep or cessation of airflow through the nose and mouth during sleep, lasting more than 10 seconds [3].Obstructive sleep apnea syndrome (OSAS), a life-threatening condition, is characterized by repeated respiratory pauses, lasting more than 10 seconds, due to partial or total airway collapse. The clinical features appear when at least 100 apnea episodes occur during total sleep period or more than 10 episodes in one hour of sleep.OSAS was associated with high incidence of hypertension, stroke, cardio-vascular diseases [4] and in pregnant women with increases body mass index (BMI) and presence of other comorbidities [5].

The impact of stress, tiredness, and disorders of the circadian rhythm and sleep abnormalities on health is highly evaluated. Literature indicates the presence of OSAS in 1-5% of adults, futhermorelongitudinal studies of OSAS indicate an increased prevalence even across gestation [6].The condition became a public health problem because of its day by day implications [7,8].

Apnea-hypopnea index (AHI) that describes the ratio between apnea and hypopnea episodes during sleep, had a prevalence of 5/hour, and varies between 11-24% for general population, 9% of women and 24 % of men. The prevalence is increased with age and occurrence of snoring.Mortality rate is increased in adults under 50 years old and AHI greater than 20[9].90% of SAS cases are males and obese. More than 70% of SAS cases associate excessive daytime sleepiness [10].

Clinical evaluation of SAS and OSAS brings important and significant information but it is not enough to have a final positive diagnosis. The gold standard diagnosis test is polysomnography [11-13].

Several prospective and cross-sectional studies highlighted strong metabolic effect of visceral fat accumulation (VFA). Patients develop hepatic and peripheral insulin resistance, obesity, and type 2 diabetes mellitus and associated comorbidities [14-16]. The gold standard to evaluate VFA is nuclear magnetic resonance (MRI) and computed tomography (CT) [17].

Bioelectrical impedance analysis or bioimpedance is a cheaper, easy to use and to interpret, noninvasive and mobile modality to evaluate body composition. It benefits are controversial because the results could be biased by several factors like age, gender, fatness and ethnic backgrounds. However, its applicability and predictive value are recognized and accepted as far as international protocol criteria are followed [18].

The aim of this study was to evaluate the correlation between specific body composition items obtained with bioelectrical impedance technique and OSAS compared with BMI.

Materials and methods

This prospective observational study enrolled 76 patients, 51 with OSAS and 25 without OSAS used as control group. The study was approved by "Victor Babeş" University of Medicine and Pharmacy Ethics Committee and complied with Declaration of Helsinki; all patients signed informed consent before any evaluation.

Exclusion criteria for experimental group were represented by age under 18 years old, patient disagreement, absence of OSAS, normal weight and any acute or chronic disease that needed immediate treatment.

Anthropometry

The same investigator performed all anthropometric measurements to avoid any potential bias. The evaluation included weight, height, and neck and abdominal circumference (at cricothyroid membraneand at the middle between the costal rim and iliac crest at the end of normal expirationrespectively). BMI was calculated as ratio of weight (kg) and height squared (m^2). All measurements fulfilled quality control criteria. Abdominal obesity was defined as abdominal circumference greater or equal than 80 cm in women and 94cm in men.

Body composition

Body composition was assessed with InBody720- Body Composition Analysis (Biospace Co., Ltd) device, an easy, efficient and non-invasive method. It provides easy to read and understand evaluation, for both physician and patient, including graphs and recommended ranges of several parameters. In presented study was used area of visceral fat, waist-to-hip ratio, intra and extracellular water and mass of adipose tissue.As indicator of excessive visceral fat tissue was considered a value greater or equal with 100 cm^2 of visceral fat area, according to indications.

Sleep evaluation

Pollysomnography was assessed with Respironics, Phillips Alice device. It evaluates muscular, cerebral and ocular activity during sleep, respiratory flow and snoring. Sleep apnea severity was established followed the validated international criteria. It is a combination between daytime sleepiness and apnea-hypopnea index (AHI) value.Daytime sleepiness severity was appreciate with Epworth Sleepiness Scale (ESS), with a range of 0-24 points; values greater than 10 are pathological [13].

AHI is classified as follow:

-5-15 events per hour: mild OSAS

-15-30 events per hour: moderate OSAS

-more than 30 events per hour: severe OSAS

Data analysis

Statistical analysis was performed with "GraphPad Prism v.5" and "R v.2.9.2" programs. To describe the cohort, data were presented as mean± standard deviation (for normal distributed data), respectively medianand interquartile interval (IQR).Results were compared using unpaired T test within the group and paired T test between groups; a two-tailed p-value <0.05 was considered significant.Differences body composition items, including neck and abdominal circumference, were compared with ROC curves.

Results and discussions

76 patients were evaluated and included in the study, 51 in OAS group (37.25% women) and 25 in control group (40% women).

Mean age in OAS group was 52.78±1.51 years and 48.76±1.57 in controls, without statistical significant differences. Table 1 summarizes the clinical evaluation of patients, including body composition items.

Table 1
COHORT DESCRIPTION

	OAS group (n=51)	Control group (n=25)	p**
Age (mean± SD, years)	52.78±1.51	48.76±1.57	p>0.05
BMI (kg/m^2)	36.44±0.88	34.11±0.85	p>0.05
Neck circumference (mean± SD, cm)	45.00±0.72	40.88±0.50	p=0.0003
Abdominal circumference(mean± SD, cm)	120.40±3.03	111.3±2.53	p>0.05
ICW	28.68±0.95	28.40±1.35	p>0.05
ECW	17.97±0.58	17.45±0.80	p>0.05
BFM	44.44±1.57	33.50±1.49	p<0.0001
Waist-to-hip ratio	1.02±0.01	0.97±0.01	p=0.0011
Adipose tissue percentage	40.71±1.13	37.88±1.78	p>0.05
VFA	201.10±5.12	155.10±4.56	p<0.0001

BMI= body mass index, SD= standard deviation, cm= centimeters, ICW= intracellular water, ECW= extracellular water, BFM= body fat mass, VFA= visceral fat accumulation.**unpaired t test

All patients were overweighed. Statistically significant differences were identified between groups for VFA (201.10 cm2 vs 155.10 cm^2, p<0.0001) and BFM (44.44 vs 33.50, p<0.0001). Also, waist-to-hip ratio was statistically significant greater in OAS group (p=0.0011).

The correlations between AHI, anthropometric measurements and body composition items are described in table 2.

Table 2
CORRELATION BETWEEN AHI AND SPECIFIC CLINICAL ITEMS

Spearman's rho correlation	Correlation coefficient (p- value)
AHI vs neck circumference	0,5062(p<0,0001)
AHI vs abdominal circumference	0,4431 (p<0,0001)
AHI vs BMI	0.06 (p>0.05)
AHI vs ECW	0,477 (p<0,001)
AHI vs ICW	0.14 (p>0.05)
AHI vs VFA	0.533 (p<0.05)

Correlation plots between AHI and body composition items are represented in figure 1.

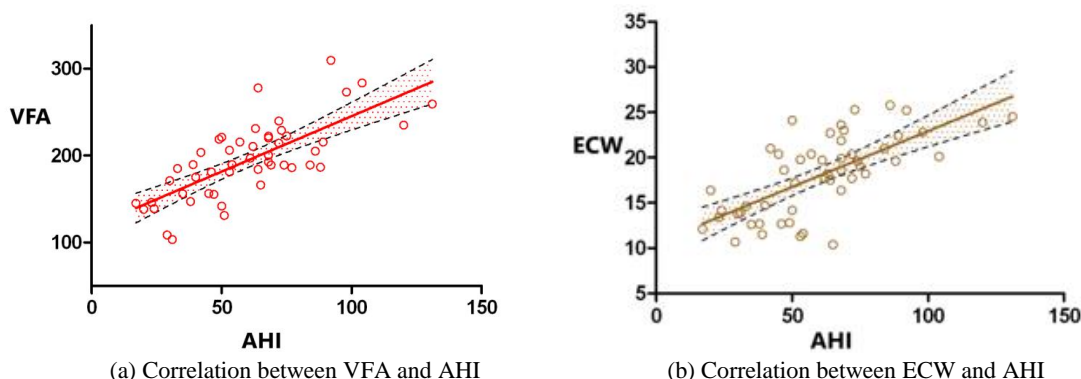(a) Correlation between VFA and AHI   (b) Correlation between ECW and AHI

Fig. 1. Correlation between AHI and body composition

In table 3 is reported the ability of neck circumference and bioimpedance results to predict OSAS.

Table 3
THE ABILITY OF NECK CIRCUMFERENCE AND BIOIMPEDANCE RESULTS TO PREDICT OSAS

	AUC (95%CI)	Sensibility	Specificity	OR
Neck circumference	0.76 (0.66-0.87)	54.9%	92%	14
VFA	0.87 (0.79-0.94)	76.5%	88%	23.83

	Waist-to-hip ratio	0.72 (0.61-0.84)	56.9%	88%	9.66
	BFA	0.79 (0.69-0.89)	50.9%	92%	11.96

BFA= body fat mass, VFA= visceral fat accumulation, AUROC= area under the curve, OR= odds ratio

VFA indicates the occurrence of OSAS with a higher sensibility compared with BFA (76.5% vs 50.9%), but a smaller specificity (88% vs 92%) (figure 2).

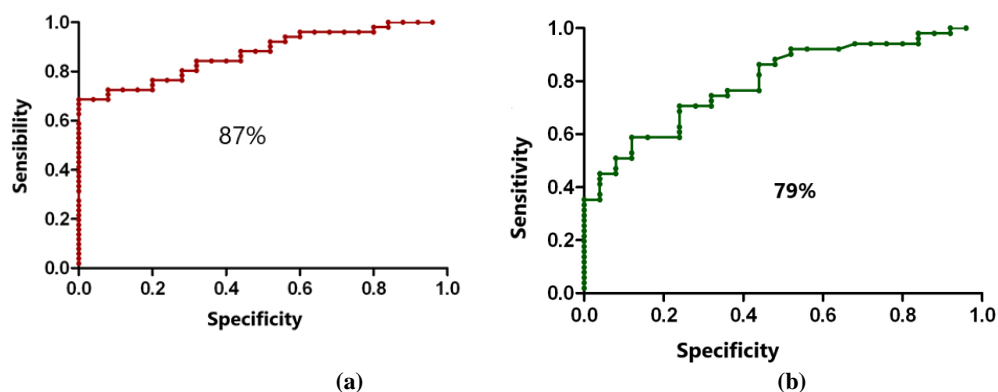(a)   (b)

Fig. 2. ROC curve of VFA (a) and BFA (b) predictive value for OSAS

The study approach is new and controversial. We evaluated two groups, including overweighed adults, with and without OSAS. There were statistical significant differences between groups according to neck circumference (p- value< 0.001), VFA (p-value<0.0001) and waist-to-hip ratio (p-value<0.01), an indicator that abdominal obesity could predict the occurrence of OSAS bather than general obesity.It was identified a strong correlation between AHI and VFA (r=0.533, p<0.05), and no correlation with BMI (r=0.06, p-value>0.05). From anthropometric measurements, AHI showed a strong correlation with neck circumference (r=0,506, p<0,0001). A study conducted by Ho et al., showed that neck circumference can be included as a simple screening for OSAS [19].Dixon et al. reported that neck circumference is an important predictor for OSAS occurrence [20].

ECW was moderately correlated with AHI (r=0,477, p<0,001), and it has a clinical value indicating subclinical edema in those patients.In a study conducted on peritoneal dialysis population it was observed that ECW was more prevalence in OSAS sample compared with Non-OSAS sample [21].

In this study body composition items resulted from bioelectrical impedance analysis had the greatest predictive value. These results are in line with similar published finding [22, 23].VFA had the greatest predictive value for OSAS occurrence.Anthropometric measurements were not identified as good predictors. However, taking in consideration the accessibility, neck circumference could be used to indicate OSAS, with a sensitivity of 54.9% and specificity 92%.Increased neck circumference was identified as a predictor of OSAS also in short-sleeping obese men and women [24].

Literature suggests a strong correlation between sleep breathing abnormalities and several parameters of obesity. Hoffstein and Mateika demonstrated that patients with OSAShad a significant greater BMI and neck circumference compared with patients without OSAS[25]. Ögretmenoglu et al., evaluated 51 patients using Bioelectrical impedance analysis technique. They reported a strong correlation between BMI and BFA, and also betweenadipose tissue percentage and AHI[23]. Shinoharaet al obtained same results as presented study, showing a strong correlation between AHI and VFA in adult patients [26].

Studies from literature also sustained that a comprehensive rehabilitation programs, based on dietary and physical activity improved conditions associated with OSAS in different risk patients [27-29].

Conclusions

Although BMI is the most popular indicator of obesity, it has a small predictive value for OSAS. Being a life-threatening condition, diagnosis of OSAS is very important. Our outcomes indicate a strong statistical significant correlation between AHI and VFA, highlighting the importance of body composition evaluation in overweigh patients.

Bioelectrical impedance analysis offers the possibility to calculate important body composition items, highly correlated with OSAS, in an economic, easy and non-invasive way. It can also be used in SAS prescreening.

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Manuscript received: 09.12.2019