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The influence of upper airways diameter on the intensity of obstructive sleep apnea

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Abstract

Introduction and Objective. Obstructive sleep apnea (OSA) is characterized by at least 5 ten-second-long episodes of apnea or hypopnea, per hour of sleep. This disease may lead to severe, life-threatening complications. Therefore, risk analysis and its influence on disease intensity is crucial for proper implementation of preventive treatments.

Objective. To determine the relation between the intensity of OSA expressed in Apnea-Hypopnea Index (AHI), and the anterior-posterior diameter of upper airways at the levels of soft palate and tongue base.

Material and Method. Medical records of 41 patients with sleep apnea (AHI>4) diagnosed through polysomnographic examination obstructive were used for the study. The data consisted of: age and gender, polysomnographic examination results (AHI), lateral cephalogram with cephalomertic analysis, together with measurements of the upper and lower pharyngeal depth according to McNamara. Statistical analysis was carried out in accordance with Pearson's r correlation coefficient test (Statistica 8.0 software package).

Results. Analysis of the influence of upper airways diameter on the intensity of OSA showed that the value of upper airways diameter at the tongue base level had no statistically significant impact on the value of AHI (p=0.795). However, a statistically significant impact of the value of upper airways diameter on the AHI value (p=0.008) at the soft palate level was observed. Patients with OSA have narrowed upper airways diameter. The value of AHI increases with the decrease of upper diameter and is not dependent on a lower diameter value. Patients with a decreased upper airways diameter should be informed about potential breathing disorders during sleep.

Keywords

Obstructive sleep apnea, AHI, upper airways diameter

INTRODUCTION

Obstructive sleep apnea (OSA) is characterized by at least five 10-second episodes of apnea or hypopnea per hour of sleep, accompanied by arterial blood oxygen saturation decrease by 2-4%, with retained, or even intensified, respiratory muscle movements. The hypopnea is a decrease in the airflow in the upper airways by over 50% (in comparison to 2-minute stable breathing rhythm period) lasting over 10 seconds, or leading to a decrease in blood saturation by more than 4% [1].

The severity of OSA is measured by the Apnea-Hypopnea Index (AHI), which indicates the average number of apneas and hypopneas per hour of sleep. The lack of airflow is connected with muscle tension lowering in deeper sleep phases – 3rd and 4th NREM phase (non-rapid eye movement) and REM phase (rapid eye movement). This is due to the anatomical structure of the upper airways. Nose, larynx, trachea, and bronchi are surrounded by bone and cartilage structures supporting the patency, regardless of muscle tension, whereas the patency of the pharynx is maintained mainly by the genioglossal muscle and the tensor veli palatini, stimulated through hypoglossal nerve [2].

As sleep is a significant part of human life, all abnormalities occurring during that time exert a great influence on human health and may consequently lead to severe complications. Obstructive sleep apnea results in a considerable decrease in the length and quality of a patient's life as a result of the development of pulmonary and arterial hypertension, cardiac rhythm disorders, metabolic syndrome and type 2 diabetes [3, 4, 5, 6]. Patients with OSA are more exposed to traffic accidents due to increased sleepiness [7, 8]. The above-mentioned instances place the patients with OSA in a group at risk of premature death.

Among the risk factors leading to obstructive sleep apnea are: obesity [9], anatomic and post-inflammatory upper airways abnormalities [10], anatomic craniofacial abnormalities [11, 12, 13] improper sleep hygiene, and abuse of sleep-inducing medications and alcohol.

Thorough analysis of the obstructive sleep apnea risk factors and determination of the circumstances leading to its intensification are necessary. This will enable taking effective preventive actions and proper education of patients. In the longer perspective, it should also make it possible to replace present symptomatic treatment methods with more effective causal treatment.

OBJECTIVE

The aim of the presented study was to determine the relationship between the intensity of OSA expressed in AHI, and the value of anterior-posterior diameter of upper airways at the levels of soft palate and tongue base.

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MATERIALS AND METHOD

Medical records of 41 patients with obstructive sleep apnea (AHI>4) diagnosed through polysomnographic examination were used in the study. They were referred to the Chair and Department of Jaw Orthopedics at the Medical University of Lublin in the years 2003-2012 for orthodontic OSA treatment. Patients' data consisted of:
- data concerning age and gender;
- results of polysomnographic examination (AHI);
- lateral cephalogram with cephalomertic analysis, together with the marked measurements of upper and lower pharyngeal depth.

In order to confirm obstructive sleep apnea, all patients were subjected to polysomnographic examination. The examination was performed overnight, during sleep with the help of a SleepDoc Porti 8 device which recoded thoracoabdominal movements, oronasal airflow, saturation, body position movements, snoring, pulse, and EEG. The intensity of each patient's OSA was expressed in AHI.

Lateral cephalomertic radiographs were obtained from each patient. The roentgenograms were taken with the lamps (cone of the radiograph unit) positioned 1.52 m from the patient's head and the cassette (radiograph film holder). The PROSCAN (PLANMECA) unit operating at 70 kV and with exposure time of 0.65 s was used. The sagittal plane was parallel to the film. The images were projected in the right lateral position with the head placed in a natural position. The patients were asked to swallow before the exposure. If a patient was to swallow during the imaging, the shape of the palate would resemble an inverted letter 'V', and such a picture would lose its diagnostic value [14]. The cephalometric analysis using Segner and Hasund method [15] was conducted based on a tracing prepared by one researcher with a 0.3 mm pen. The upper airways diameter was measured at the soft palate level and at the tongue base level in accordance with McNamara analysis [14]. The upper anterior-posterior dimension determined the shortest distance between a point in the upper half of the soft palate outline and the posterior pharyngeal wall (Fig. 1a), whereas the lower dimension was measured from the cross-section point of the mandible and tongue outline to the nearest point at the posterior pharyngeal wall (Fig. 1b). According to McNamara, the standard value for theupper measurement is 20 mm in men and 17 mm in women; for the lower measurement – 13 mm in men and 12 mm in women.

Statistical analysis. The examined characteristics were quantitative data. The following descriptive parameters were calculated: mean value, standard deviation (SD), minimum and maximum value and median (Me). The studied relations between variables were tested with Pearson's r correlation coefficient used for measuring the strength of association between two variables. A 5% error risk was taken into account. This means that the studied hypothesis was rejected in cases where p>0.05 and p<0.05 – the difference between groups was significant. The measurements were conducted using Statistica 8.0 software package.

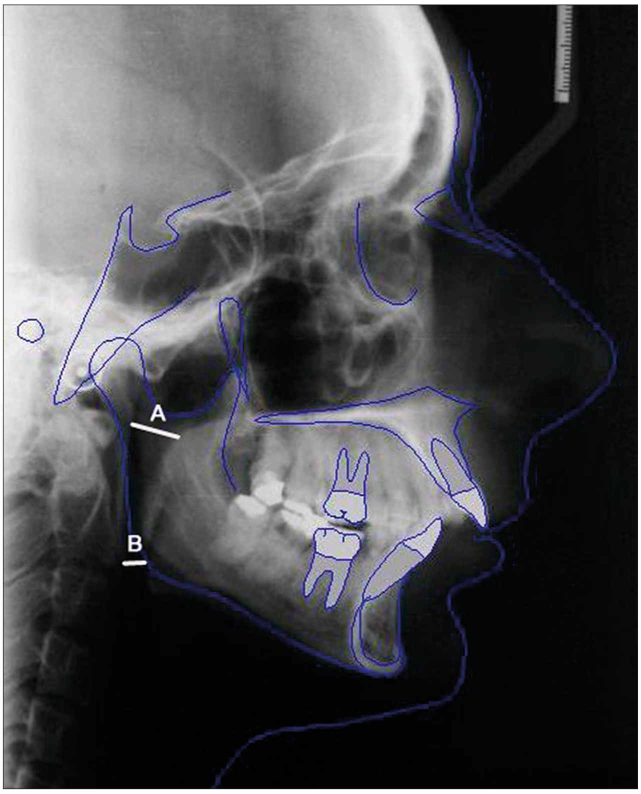

Figure 1. Method of measurement of upper airways diameter at the level of soft palate and tongue base. Section a – upper airways diameter at the level of soft palate – Ø↑; section b – upper airways diameter at the level of tongue base – Ø↓

RESULTS

The examined group of patients consisted of 7 women (17%) and 34 men (83%). The patients' ages ranged from 38-74 years, averaging 57.6 years of age. The largest group was the patients between 50-65 years of age, which constituted 75% of all the examined (Fig. 2).

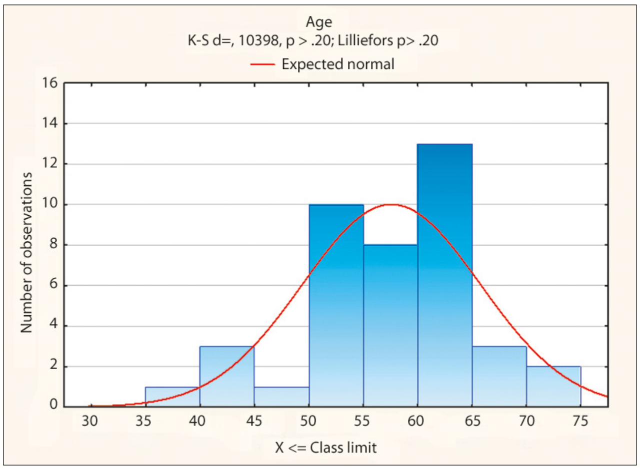

Figure 2. Patient distribution among different age groups

AHI value was between 9.1 and 80.6; averaging 30.8 episodes of apnea or hypopnea per hour of sleep. Seven patients qualified for the group with a mild form of obstructive sleep apnea, which constituted 17% of all the patients, 16 patients (39%) had a moderate form, and 18 patients (44%) had a severe form of the disease.

Analysis of the upper airways diameter determined that the average value of upper measurement was between 6-17 mm (mean 10.4 mm). Among almost all patients (40 subjects – 97.6%) this measurement was below the norm outlined by McNamara. In only one case the value of the measurement was in accordance with the norm. The value of the lower upper airways diameter averaged 10.4 mm and oscillated between 5-19.5 mm. Likewise, in most patients this value was below the norm (31 subjects – 75.6%), in 2 patients it was within the norm, and in 8 patients it was above the adopted norm (see: Tab. 1 for the result comparison of the descriptive parameters).

Table 1. Result comparison of descriptive parameters. AHI – apnea/hypopnea index; Ø↑ – upper diameter of upper airways; Ø↓ – lower diameter of upper airways

Examined variables	Descriptive parameters					
	N	Average	Me	Min	Max	SD
AHI	41	30.79268	27.90000	9.10000	80.60000	17.92905
Ø↑	41	10.42683	11.00000	6.00000	17.00000	2.63287
Ø↓	41	10.35366	10.00000	5.00000	19.50000	3.15880
Age	41	57.58537	59.00000	38.00000	74.00000	8.17305

Analysis of the influence of upper airways diameter on the intensity of obstructive sleep apnea showed that the value of upper airways diameter at the tongue base level had no statistically significant impact on the value of AHI (p=0.795). However, a statistically significant impact of the value of upper airways diameter on the value of AHI at the soft palate level was observed (p=0.008). It was a negative correlation – with the decrease of pharyngeal diameter at this level, the number of apneas and hypopneas among patients increased.

DISCUSSION

Obstructive sleep apnea has a multi-causative etiology. In most cases, it develops after the appearance of several factors leading to upper airways collapse. Only in isolated cases, the OSA may develop when only one risk factor is observable; however, usually such a factor is substantially intensified (e.g. significant anatomical abnormalities). It is essential to thoroughly monitor further risk factors and determine their correlation with the disease's intensification. This would make it possible to create treatment protocols, eliminating the causes and replacing the present symptomatic treatment.

A considerable reduction of the tension in the muscles taking part in supporting the upper airways patency occurs during sleep. The size of the nasopharynx, to a large extent, depend on the construction of pharyngeal tissues, the positioning of craniofacial bones and the upper airways diameter size. Factors contributing to the decrease in diameter size, in consequence, lead to the development of obstructive sleep apnea. This is supported by the cases of apnea in patients with upper airways tumours [16], tonsils hyperotrophy [10], or macroglossia [17, 18]. The upper airways diameter size is also connected with the craniofacial structure, as proved by earlier studies on narrowing of the pharyngeal diameter in patients with micrognathia [19].

The decrease in the upper airways diameter value is characteristic for patients with obstructive sleep apnea. In comparison to the standards (set by McNamara), the presented study shows that 97.6% of patients with obstructive sleep apnea have a decreased upper airways diameter value at the soft palate level, and 75.6% at the tongue base level. Many researchers have reported the decreased upper airways diameter values in their studies [20, 21, 22, 23, 24].

The results of the presented study show that the severity of obstructive sleep apnea expressed in AHI is statistically influenced by the upper airways diameter size at the level of the soft palate. Such a correlation was not observed at the level of tongue base. This means that with the decrease in the upper airways diameter, the number of apnea or hypopnea episodes increases. It ought to be acknowledged that the anterior-posterior upper airways diameter, which in the examined patients was considerably decreased, was measured on the basis of the cephalograms of the patients sitting in an upright position. Presumably, the measured values would decrease even more if the patients were examined in a laying position. The available literature confirms a decrease in the diameter of the pharynx, or other measurements, such as surface area or height of the pharynx, among patients in a lying position [25, 26, 27, 28]. It should also be noted that the cephalometric examination was performed while the patients were awake, whereas the apnea episodes appear during sleep, when muscle tension in the pharynx decreases. This difference in muscle tension in the examined patients is said to be the reason for discrepancies in the examination results [29, 30]. The research of Martin et al. proved a significant decrease in the upper airways diameter in men after switching to a lying position, in comparison to women. This is said to be due to a better muscle tension in the nasopharynx in women, as it allows women to oppose the pressure of the adipose tissue weight more effectively [27].

CONCLUSIONS

The study results clearly show that the analysis of upper airways diameter ought to be carried out routinely during a cephalometric analysis of all orthodontic patients. Information about unfavourable narrowing of nasopharyngeal diameter will allow preventive treatment and risk factor control, such as proper body weight maintenance, to be undertaken by both the physician and the patient. This may prevent the development of obstructive sleep apnea. Simultaneously, in order to replace the present symptomatic treatment with the causative treatment, further analysis of OSA risk factors and their influence on the intensity of the disease is advised.

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