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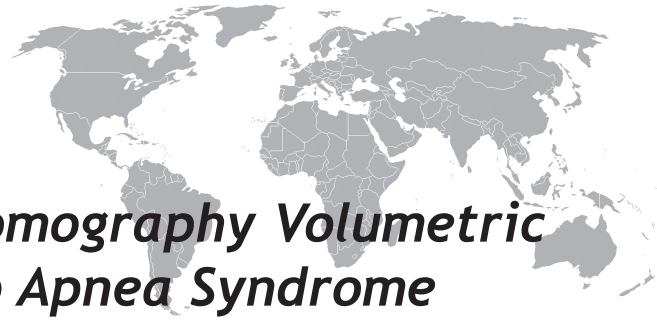

Paranasal Sinus Computed Tomography Volumetric Findings of Obstructive Sleep Apnea Syndrome

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ABSTRACT

Background: Obstructive sleep apnea syndrome (OSAS) is a disorder characterized by repetitive episodes of complete or partial airway obstruction due to pharyngeal collapse during sleep. The pathogenesis of OSAS is still not clear, although studies showing that OSAS is caused mainly by upper respiratory tract stenosis mainly at nasopharynx. The purpose of this study is to show the paranasal sinus (PNS) pathologies and nasal cavity volume, nasopharynx volume and adenoid diameters of OSAS patients, and correlate the multi detector computed tomography (MDCT) findings with severity of the disease.

Methods: A total of 48 (34 male and 14 female) OSAS patients were evaluated retrospectively between November 2011 and July 2012. Polysomnography and MDCT was performed to all patients.

Results: Mean age of the patients were 45.46±8.82 years. The body mass index grades were normal weight in 5 (10.4%), overweight in 13 (27.1%), obese in 30 (62.5%) patients. The OSAS were graded as mild (5 patients, 10.4%), moderate (16 patients, 33.3%) and severe (27 patients, 56.3%) according to their polysomnography findings. The correlation between OSAS grades and radiological measurements were low. There was no difference between gender regardless from the OSAS grades ($p \geq 0.05$).

Conclusion: OSAS patients have nasal septal spur formation and septal deviation which may aggravate their syndrome. PNS MDCT is important to demonstrate these disorders. Further studies comparing patients and controls may show 3D volumetric changes of the PNS region.

Key Words: Obstructive sleep apnea syndrome - paranasal sinus - computed tomography - nasopharynx - volumetry

INTRODUCTION

Obstructive sleep apnea syndrome (OSAS) is a disorder characterized by repetitive episodes of complete or partial airway obstruction for a minimum of 10 seconds duration due to pharyngeal collapse during sleep (1, 2). It is characterized with loud snoring, frequent awakenings, disrupted sleep, excessive daytime sleepiness, fatigue and decreased cognitive abilities. When the airway obstruction occurs inspiratory airflow can be completely absent (apnea) or reduced (hypopnea). In several studies, the prevalence of OSAS was reported approximately 4%, and 2% in male female patients, respectively.

The pathogenesis of OSAS is still not clear, although studies showing that OSAS is caused mainly by upper respiratory tract stenosis mainly at nasopharynx. Although, night polysomnography (PSG) recording has been regarded as the gold standard (2) for the diagnosis of OSAS, computed tomography (CT) was proven to demonstrate nasopharenx pathologies (1, 3-7).

To the best of our knowledge, there is no study in English literature searching paranasal pathologies and volumetric changes above level oropharynx of patients with OSAS on MDCT images.

Therefore the purpose of this study is to show the PNS pathologies and nasal cavity volume, nasopharynx volume and adenoid diameters of OSAS patients, and correlate the MDCT findings with severity of the disease.

MATERIALS AND METHODS

Institutional Review Board approval was obtained for this prospective study. PNS MDCTs of 48 OSAS patients were evaluated retrospectively between November 2011 and July 2012.

Polysomnography:

Full-night PSG recording was performed by Embla® N7000 (Medcare, Iceland) and the following parameters were recorded: electroencephalography, electrocardiography, electrooculography, submental and anterior tibialis muscle electromyography, nasal pressure, oronasal airflow by thermal sensor, snoring, oxygen saturation by finger oxymeter and respiratory effort by thoracic and abdominal inductance plethysmography. Sleep disordered breathing events were scored manually by the same investigator (NH) according to the American Academy of Sleep Medicine criteria (8). Obstructive apnea was defined as a drop in the peak oronasal thermal sensor excursion by ≥90% of baseline for at least 10 seconds. Hypopnea was defined as at least a 50% drop in airflow for at least 10 seconds despite respiratory efforts and at least a 3% drop in

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oxyhemoglobin saturation. Patients were diagnosed to have OSAS if the apnea-hypopnea index (AHI) was ≥5. The grading was made according to mild OSAS having an AHI between 5 and 15, moderate OSAS having an AHI between 15 and 30 and severe OSAS having an AHI ≥30 (9). The lowest O2 saturation value was measured throughout the night for each patient.

Computed Tomography and 3D Volumetry:

All the PNS MDCTs were scanned during awake period, using 64 slice MDCT device (Aquilion 64®, Toshiba Medical Systems, 2011, Zoetermeer, The Netherlands). Aquarius iNtuition Edition ver. 4.4.6 software was used for doing measurements.

The nasal cavity volume (NCV), nasopharynx volume (NPV) and the adenoid diameter (AD) were measured meticulously by two radiologists independently who were blinded to patients PSG results. The radiologists were named as observer 1(GO) and observer 2 (MD). The data of the observer 1 were named as NCV1, NPV1, AD1, and the data of the observer 2 were named as NCV2, NPV2 and AD2. All the measurements were recorded carefully by the two observers.

To measure the NCV and NPV, axial, coronal, sagittal and 3D volume rendered sagittal images were used. The monitor divided to four equal parts. The four aspects (axial, coronal, sagittal and 3D volume rendered sagittal) were placed to the four parts. Region growing tool was carried out to calculate the volumes on the coronal, sagittal and axial aspects and 3D volume rendered sagittal images were used to confirm the accuracy of measurements. To measure the AD, only the sagittal mid-line image of the nasopharynx was sufficient. The units of the volumes were 'cm3' and AD was 'mm'.

Statistical Analyzes:

Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 17.0 software package. Continuous vari¬ables were expressed as arithmetical mean ± standard deviation.

Kolmogorov-Smirnov test was used to determine the data was whether parametric or non-parametric. The data were parametric ($p>0.05$). Pearson correlation was used to correlate the grades of the OSAS and radiological measurements. The paired sample t test was used to determine the differences between the groups of NCV1 and NCV2, NPV1 and NPV2, AD1 and AD2. Student t test was performed to analyze the differences between gender, independently from the OSAS grades.

RESULTS

A total of 48 patients' PNS MDCT examinations were evaluated for the study. There were 34 male (70.8%) and 14 female (29.2%). Mean age of the patients were 45.46±8.82 years (between 25 and 63) and the mean body mass index (BMI) values were 31.67±5.21 (between 22.4 and 45.7). The BMI grades of the patients were normal weight in 5 (10.4%), overweight in 13 (27.1%), obese in 30 (62.5%) patients.

The OSAS were graded as mild (5 patients, 10.4%), moderate (16 patients, 33.3%) and severe (27 patients, 56.3%) according to their PSG findings. The minO2 saturation of the patients were 77.42±7.71 (range, 50-88). Although the correlation between OSAS grades and radiological measurements were low, the maximum correlation was in NCV with the correlation coefficient 0.123 for observer 1.

There was no significant difference between gender regardless from the OSAS grades ($p\geq0.05$ for NCV1, NCV2, NPV1, NPV2, AD1, and AD2)

Nasal septum deviation (NSD) was detected in 36/48 (75.0 %) of the patients. PNS MDCT findings showed nasal effusion, mucosal thickening, nasal septal spur formation (NSSF), septal spur contact, concha bullosa formation and ostimeatal complex obstruction and incidences are summarized in Table 1.

Table 1: *Paranasal sinus multi detector computed tomography results*

	Effusion	Mucosal thickening	Nasal septal spur formation	Septal spur contact	Concha bullosa	Ostiometal unit obstruction
No	30 (62.5%)	29 (60.4%)	21 (43.8%)	32 (66.7%)	36 (75%)	39 (81.3%)
Exist	18 (37.5%)	19 (39.6%)	27 (56.3%)	16 (33.3%)	12 (25%)	9 (18.8%)

Two independent observers' MDCT measurements were given in Table 2. AD measurements were significantly different between the two observers ($p<0.05$)

Table 2: *Measurements of the two observers*

	Observer 1	Observer 2	p
NCV	20.53±6.41(9.5-40.4)	20.92±5.05 (12.9-38.6)	0.399
NPV	6.61±2.17 (0.8-12.1)	6.84±2.53 (1.3-15.6)	0.307
AD	11.1±3.36 (5.0-20.5)	12.47±3.81 (4.5-21.0)	0.023

NCV, nasal cavity volume; NPV, nasopharynx volume; AD, adenoid diameter

Table 3: *Crosstab of body mass index (BMI) and Obstructive Sleep Apne Syndrome*

OSAS grade	BMI grade			
	normal	overweight	obese	total
Mild	2	3	0	5
Moderate	3	1	12	16
Severe	0	9	18	27
Total	5	13	30	48

DISCUSSION

The present study showed that 56.3 % of the OSAS patients have NSSF and 75.0 % have NSD by PNS MDCT. The high incidence of NSD and NSSF in OSAS patients may aggravate the apnea and asphyxia episodes of the patients. To the best our knowledge our study is the first study in the literature showing NSSF and NSD incidence in OSAS patients.

Haponik et al. showed CT scan measurements of cross-sectional areas of the nasopharynx, oropharynx, and hypopharynx in apneic patients were significantly reduced compared with those in the control subjects in awake patients with OSAS (10). We did not compare normal and OSAS patients, instead we compared different OSAS grades and our results showed no relation between the OSAS grades and PNS MDCT 3D volumetric measurements.

A dynamic CT study showed that in severe OSAS, patients had significant differences in the parameters including cross-sectional area at the level of uvula in expiration, mandibular

plane to hyoid distance, and maximum thickness of the soft palate and neck circumference (7). The authors concluded that the measurement of cross sectional area of oropharynx in expiration can be a helpful diagnostic measure to recognize severe OSAS. But, we could not find any relations between the severity of OSAS and NCV and NPV measurements. Because our study was a 3D volumetric study, the difference could be explained by using different techniques.

Shigeta et al. investigated the influence of tongue and mandible ratio on airway volume using 3D reconstructed models from CT data. There was a significant positive correlation between BMI and tongue volume, and a significant negative

correlation between BMI and airway volume. There was a negative correlation between airway volume and tongue and mandible ratio (11). Their study population was consisted only OSAS patients similar to our study. Our results demonstrate moderate and severe OSAS were seen in obese group in 62.5% of the OSAS patients.

Having no control PNS MDCTs of normal patients is the main limitation of our study. Comparison between normal and OSAS patients could better demonstrate anatomico-pathological changes of NPV and NCV. Our results showed no relations between the severity of OSAS grade and NCV or NPV. However, our PNS MDCT studies were obtained when the patients were awake. This may be the second limitation of our study. Further studies about measurements in dynamic MDCT scans of OSAS patients during sleep period could be helpful.

In conclusion, OSAS patients have NSSF and NSD which may aggravate their syndrome. PNS MDCT is important to demonstrate these pathologies. Further studies comparing patients and controls may show 3D volumetric changes of the PNS region.

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