

The relationship between clinical and laboratory findings and duration of sleep where oxygen saturation remains below 90–95% in obstructive sleep apnea

Suat Avcı¹, Aynur Yılmaz Avcı², Berna Devrim Yağbasan³, Hüseyin Günizi¹

¹Department of Otolaryngology, Faculty of Medicine, Başkent University, Ankara, Turkey

²Department of Neurology, Faculty of Medicine, Başkent University, Ankara, Turkey

³Department of Chest Diseases, Faculty of Medicine, Başkent University, Ankara, Turkey

Abstract

Objective: The aim of the present study was to determine correlations between CT₉₀ and CT₉₅ values and physical examination parameters, chronic metabolic diseases, smoking, mean platelet volume, cerebral magnetic resonance imaging (MRI), presence and number of hyperintense foci in obstructive sleep apnea (OSA).

Methods: A total of 1154 patients who underwent polysomnography in our sleep laboratory between 2011 and 2014 were screened retrospectively. Among them, 72 cases who underwent ear, nose and throat examinations, cerebral MR, CBC and biochemical tests were included in the study. All patients underwent a detailed anamnesis together with (1) measurements of BMI (body mass index) (2) circumferences of neck and abdomen, (3) examination of oropharynx, (4) Müller maneuver with the aid of fiberoptic endoscope, (5) estimation of Epworth sleep scale scores, (6) and polysomnographic (PSG) tests.

Results: According to the severity of OSA, the patients had simple snoring (22.2%), mild (19.4%) and severe OSA (38.9%). In multivariate regression analysis, body mass index (BMI) (p=0.026) and apnea/hypopnea index (AHI) (p=0.013) were seen as independent variables affecting CT₉₀ (R²=49%). Multivariate linear regression analysis demonstrated that independent variables of smoking (p=0.001), AHI (p= 0.003) and number of hyperintense foci (p=0.013) affected CT₉₅ (R²=%47.9), while relationships between diabetes, BMI and CT₉₅ were not statistically significant.

Conclusion: Since CT₉₅ values are affected by smoking without any statistically significant correlation with retropalatal and retroglossal Müller stages, we think that consideration of CT₉₀ value will be more appropriate in the evaluation of the severity of chronic intermittent hypoxia in patients with obstructive sleep apnea. However, the correlation between CT₉₀ value and AHI is closer to the value indicated in the literature, but not stronger.

Keywords: Obstructive sleep apnea, duration of sleep, clinical, laboratory.

Özet: Obstrüktif uyku apnesinde oksijen saturasyonunun %90-95 altında kaldığı durumlarda uyku süresi ile klinik ve laboratuvar bulguları arasındaki ilişki

Amaç: Bu çalışmanın amacı obstrüktif uyku apnesinde (OUA); CT₉₀ ve CT₉₅ değerleri ile fizik muayene parametreleri, kronik metabolik hastalıklar, sigara içimi, ortalama trombosit hacmi, beyin manyetik rezonans görüntülemesinde (MRG) hiperintens odak varlığı ve sayısı arasındaki ilişkileri saptamaktır.

Yöntem: Hastanemiz uyku laboratuvarında 2011–2014 tarihleri arasında polisomnografi uygulanan 1154 olgu retrospektif olarak tarandı. Bu hastalardan kulak burun boğaz muayenesi yapılmış, beyin MRG, CBC ve biyokimya tetkikleri bulunan 72 olgu çalışmaya dahil edildi. Tüm hastalarda ayrıntılı anamnez ile birlikte (1) Vücut kitle indeksi (VKİ), (2) boyun ve karın çevresi ölçümü, (3) orofarenks muayenesi, (4) fiberoptik endoskop ile Müller manevrası uygulaması, (5) Epworth uyku skalası ve (6) polisomnografi (PSG) tetkikleri yapıldı.

Bulgular: Olguların OUA şiddetine göre dağılımı: %22.2 basit horlama, %19.4 hafif, %19.4 orta ve %38.9 ağır OUA idi. Çoklu doğrusal regresyon analizi yapıldığında apne-hipopne indeksi (AHI) (p=0.026) ve vücut kitle indeksinin (VKİ) (p=0.013) CT₉₀'i etkileyen bağımsız değişkenler olduğu (R²=%49) görüldü. Çoklu doğrusal regresyon analizi yapıldığında sigara içimi (p=0.001), AHI (p=0.003) ve hiperintens odak sayısının (p=0.013) CT₉₅'i etkileyen bağımsız değişkenler olduğu (R²=%47.9), diyabet ve VKİ ile CT₉₅ ilişkisinin istatistiksel olarak anlamlı olmadığı görüldü.

Sonuç: CT₉₅ değerinin sigara içiminden etkileniyor olması, ancak retro-palatal ve retroglossal Müller evreleri ile istatistiksel anlamlı ilişkisi bulunmaması nedeniyle, obstrüktif uyku apnelilerde kronik entermitan hipoksi şiddetinin değerlendirilmesinde CT₉₀ değerinin dikkate alınmasının daha uygun olduğu düşünülmüştür. Bununla birlikte CT₉₀ değerinin AHI ile korelasyonu CT₉₀ için literatürde belirtilen değere yakın, ancak daha güçlüdür.

Anahtar sözcükler: Obstrüktif uyku apnesi, uyku süresi, klinik, laboratuvar.

Correspondence: Suat Avcı, MD. Department of Otolaryngology, Faculty of Medicine, Başkent University, Ankara, Turkey.
e-mail: suat_avci2002@yahoo.com

Received: November 6, 2015; **Accepted:** January 9, 2016

Online available at:
www.entupdates.org
doi:10.2399/jmu.2016001010
QR code:



Obstructive sleep apnea (OSA) is a prevalently seen syndrome characterized by recurrent collapses and intermittent hypoxia of upper respiratory tract. Impairment of gas exchange leads to oxygen desaturation, hypercapnia and fragmentation of sleep with resultant metabolic, neurocognitive and cardiovascular disorders.^[1] Apnea/hypopnea index (AHI) is used in the determination of the severity of OSA; however, AHI does not provide information about the duration of apnea and its morphology.^[2] Whereas, the longer the apneic episodes persist, the deeper is the hypoxia. Therefore, AHI does not fully reflect pathophysiologic characteristics of hypoxia.^[3] Cases with similar AHI values may have different clinical symptoms and sign.^[4,5] Chronic intermittent type is generally described as recurrent hypoxemic attacks followed by periodic reoxygenation.^[6] Nowadays, a globally accepted quantitative clinical test which can be used in the measurement of the severity of hypoxia does not exist.^[1]

In recent years, due to a direct correlation between ST_{90} value, severity and duration of hypoxia, OSA has attracted gradually increasing attention in investigations performed on OSA.^[7-9] Bostanci et al. investigated the relationship between various polysomnographic parameters and ST_{90} and reported age, body mass index (BMI), male gender, AHI, mean oxygen saturation as independent variables affecting ST_{90} .^[1] They indicated that AHI and ST_{90} values should be evaluated in combination as an appropriate approach to the determination of prognosis of the disease and selection of suitable treatment modality for the patient. In this study, the ratio between total of sleep durations where oxygen saturations stayed below 90, and 95% and total duration of sleep was determined as CT_{90} and CT_{95} values, respectively. Since these values represent the ratio between the time passed at the hypoxic state and total duration of sleep, they are considered to be a better indicator than ST_{90} values.

The aim of the present study was to determine correlations between physical examination parameters, chronic metabolic diseases, smoking, mean platelet volume, cerebral magnetic resonance imaging (MRI), presence and number of hyperintense foci.

Materials and Methods

A total of 1154 patients who underwent polysomnography in our sleep laboratory between 2011 and 2014 were screened retrospectively. Among them, those who underwent ear, nose and throat examinations, cerebral MR, CBC and biochemical tests were included in the study.

All patients underwent a detailed anamnesis together with (1) measurements of BMI, (2) circumferences of neck and abdomen, (3) examination of oropharynx, (4) Müller maneuver with the aid of fiberoptic endoscope, (5) estimation of Epworth sleep scale scores, (6) and polysomnographic (PSG) tests. Hypertension, other cardiovascular diseases, diabetes, and smoking habits were questioned. Tonsil size was graded. The patients were requested to open their mouths with their tongues remaining in their mouths. Oral cavity was inspected, and the position of the palate and root of the tongue was evaluated and modified Malampati score was determined. All patients were subjected to Müller maneuvers while seated and degree of obstruction at the level of the soft palate and tongue root was assessed. For the assessment of an upper respiratory tract of a patient seated erect, a fiberoptic endoscope was inserted through nasal route complying with the Frankfurt line parallel to the ground. Fibroscope was advanced till epiglottis was visible. During Müller maneuver (forced inspiration with the closed mouth and nose) retropalatal and retroglottal regions were observed. Müller maneuvers were repeated three or more times in case of need till we were certain that the patient made a forceful inspiration. The degree of retropalatal and retroglottal collapse was staged (Table 1).

Patients with chronic renal, heart or liver failure, abnormal pulmonary functions or sleep disorders other than OSA and patients who experienced previously any surgical intervention or those using any respiratory device for their treatment were not included in the study.

All patients underwent all-night polysomnographic examination in the Sleep Laboratory of Chest Diseases, Alanya Hospital of Başkent University using 44-channel Compumedics brand E series (Abbotsford, Australia) computerized system under the surveillance of an experienced technician. Polysomnographic examinations included (EEG), 2-channel electro-oculography (EOG), single-channel submental muscle electromyography (EMG), 2-channel EMG whose electrodes were placed on both anterior tibial muscles, 1-channel nasal cannula for the measurement of oronasal airflow, 1-channel oronasal thermal sensor, 2-channel inductive plethysmography to display respiratory efforts of thorax, and abdomen, “body position” sensor to determine position of the body, pulse oximetry device with a single-channel finger probe to measure arterial oxyhemoglobin (SpO_2) concentration and simultaneous video recordings. Apnea was defined as cessation of respiration for ≥ 10 seconds. At least 50% drop in respiratory effort together with 4% drop in SaO_2 was considered as hypopnea. AHI is the number of apneas and hypopneas per hour (Table 1).

Statistical analysis

Data were analyzed using the IBM Statistical Package for Social Sciences v21 (SPSS Inc., Chicago, IL, USA). A normal distribution of the quantitative data was checked using Shapiro-Wilk test. Parametric tests (independent-samples t-test and posthoc Tukey test) were applied to data of normal distribution and non-parametric tests (Mann-Whiney U test and Kruskal-Wallis test) were applied to data of

Table 1. Staging system of polysomnographic and physical examination findings used in patients evaluated for OSA.

Parameter	Stage	Description
Apnea hipopnea index (AHI)	1 (primary snoring)	AHI ≤ 5
	2 (mild)	5 < AHI ≤ 15
	3 (moderate)	15 < AHI ≤ 30
	4 (severe)	>30
Body mass index (BMI) (kg/m ²)	1	<25
	2	25 ≤ BMI ≤ 30
	3	30 < BMI ≤ 40
	4	>40
Size of the tonsils	0	Tonsillectomized
	1	Tonsils are in the tonsillar fossa, lateral to the plicas
	2	Occupies 25–50% of oropharynx
	3	Occupies 50–75% of oropharynx
Modified Mallampati	4	Occupies >75% of oropharynx; it nearly joins at midline
	1	Soft palate, plicas and tonsils can be seen
	2	Uvula, plicas and upper poles of tonsils can be seen
	3	Soft palate can be partially seen
Retropalatal Müller stage	4	Only hard palate is visible
	1	Less than 25 collapse of pharyngeal walls during Müller maneuver
	2	25–50%
	3	50–75%
Retroglossal Müller stage	4	>75%
	1	Vallecula and vocal cords are completely visible
	2	Vallecula and vocal cords are partially visible
	3	Root of the tongue touches epiglottis, and arythenoids are visible
	4	Root of the tongue pushes epiglottis and arythenoids cannot be seen.

questionably normal distribution. To calculate correlation coefficients, Spearman correlation was used. Data are expressed as mean±SD or median (interquartile range), as appropriate. Statistical significance was considered as p<0.05.

Results

General characteristics of the patients are seen in Table 2. The mean age of the patients was 47.6±12.2 (range: 23 to 75) years. The study population consisted of 64 (88.9%) male and 8 (11.1%) female patients. According to severity of OSA, the patients had simple snoring (22.2%), mild (19.4%) and severe OSA (38.9%).

Based on Spearman correlation analysis CT₉₀ was correlated with Epworth sleep score (r=0.29, p=0.013), AHI (r=0.713, p<0.001) and BMI (r=0.549, p<0.001). However, variables of diabetes mellitus (p=0.040), retropalatal Müller stage (p=0.018) and retroglossal Müller stage (p=0.034) affected CT₉₀ (Table 3). However, in multivariate regression analysis only BMI (p=0.026) and AHI (p=0.013) were

Table 2. General characteristics of the patients (n=72).

		mean±SD	min-max
CT ₉₀ , %		7.16±14.68	0–75.6
CT ₉₅ , %		44.6±31.57	0–100
Epworth sleep score		9.13±5.18	0–24
Hemoglobin (g/dL)		14.43±1.29	10.2–17.1
Mean platelet volume (fl)		7.86±1.51	5–15.3
Apnea hypopnea index		28.15±24.84	0–93
Body mass index (kg/m ²)		31.12±5.33	21.9–48
		n	%
Hyperintense foci	Absent	38	52.8
	Present	34	47.2
Number of hyperintense foci	Absent	34	47.2
	1–4	16	22.2
	≥5	22	30.6
Hypertension	Absent	40	55.6
	Present	32	44.4
Diabetes	Absent	58	80.6
	Present	14	19.4
Cardiovascular disease	Absent	59	81.9
	Present	13	18.1
Hyperlipidemia	Absent	54	75.0
	Present	18	25.0
Smoking	Absent	46	63.9
	Present	26	36.1

seen as independent variables affecting CT₉₀ (R²=49%) (Table 4). Spearman correlation analysis revealed correlation between CT₉₅ and AHI (r=0.604, p<0.001) and BMI (r=0.473, p<0.001). However, variables of diabetes (p=0.005), smoking (p=0.017) and number of hyperintense foci (p=0.011) affected CT₉₅ (Table 3). Multivariate linear regression analysis demonstrated that independent variables of only smoking (p=0.001), AHI (p=0.003) and number of hyperintense foci (p=0.013) affected CT₉₅ (R²=47.9%), while relationships between diabetes, BMI and CT₉₅ were not statistically significant (Table 4).

Discussion

The total duration of sleep where oxygen saturation remains below 90% and 95%, is an easily measurable

objective parameter. In this study a statistically significant correlation was not detected between retropalatal Müller stage, retroglossal Müller stage and CT₉₅ values, However, correlations between retropalatal Müller stage and retroglossal Müller stage CT₉₀ values were seen (p=0.018 and p=0.034, respectively).

Li and Jin reported a strong correlation between AHI and total duration of apnea (r=0.770 and 0.776, respectively).^[7] In our study, a strong correlation was found between CT₉₀ value and AHI; however, it was not so strong as ST₉₀ value indicated in the study by Li and Jin. (r=0.0713). A moderate degree of correlation was found between CT₉₅ and AHI (r=0.604). Besides, a correlation between Epworth sleep score and CT₉₀ (r=0.290) was found, whereas, a statistically significant correlation was not detected between CT₉₅ and EUS.

Table 3. Factors affecting CT₉₀ and CT₉₅.

		CT ₉₀		CT ₉₅	
		Median [min–max]	p value	Median [min–max]	p value
Hyperintense foci	Absent	0.40 [0–75.63]	0.364	31.7 [0.04–100]	0.146
	Present	1.11 [0–41.02]		48.6 [2.86–92.21]	
Hypertension	Absent	0.61 [0–48.66]	0.692	36.4 [0.04–96.61]	0.362
	Present	0.78 [0–75.63]		44.1 [1.63–100]	
Diabetes	Absent	0.40 [0–48.66]	0.040	30.0 [0.04–100]	0.005
	Present	4.46 [0–75.63]		74.3 [12.3–92.6]	
Cardiovascular	Absent	0.64 [0–75.63]	0.482	42.3 [0.04–100]	0.703
	Present	0.32 [0–41.02]		43.4 [1.63–86.3]	
Hyperlipidemia	Absent	0.61 [0–75.63]	0.696	41.4 [0.04–96.61]	0.830
	Present	1.04 [0–60.58]		51.5 [1.63–100]	
Smoking	Absent	0.31 [0–60.58]	0.088	28.0 [0.04–89.2]	0.017
	Present	2.21 [0.01–75.63]		63.9 [1.12–100]	
Gender	Male	0.71 [0–75.63]	0.405	44.9 [0.04–100]	0.333
	Female	0.27 [0–33.16]		22.2 [0.05–92.12]	
Number of hyperintense foci	WML absent	0.40 [0–75.63]	0.319	31.7 [0.04–100]	0.011
	WML 1–4	0.42 [0–33.16]		24.3 [0.13–91.85]	
	WML >5	1.72 [0.05–41.02]		62.4 [12.91–92.21]	
Mallampati stage	1	0.25 [0.01–33.16]	0.276	43.4 [0.05–92.12]	0.169
	2	0.46 [0–41.02]		29.5 [0.13–100]	
	3-4	0.85 [0–75.63]		65.0 [0.04–92.63]	
Tonsillar stage	1-2	0.30 [0–60.58]	0.128	30.9 [0.04–92.21]	0.213
	3	0.91 [0–75.63]		46.4 [1.63–100]	
	4	7.34 [0.09–19.14]		53.6 [26.9–86.3]	
Retropalatal Müller stage	1	0.17 [0–6.51]	0.018	20.3 [0.05–91.85]	0.063
	2	0.27 [0–33.16]		26.1 [0.13–96.61]	
	3	1.80 [0.04–60.58]		54.8 [6.93–92.21]	
	4	6.11 [0–75.63]		60.2 [0.04–100]	
Retroglossal Müller stage	1	0.62 [0–41.02]	0.034	35.6 [1.63–100]	0.072
	2	0.32 [0–36.29]		32.8 [0.04–96.61]	
	3-4	17.1 [0.05–75.63]		79.5 [9.96–92.63]	

Recent studies have demonstrated the close relationship between obesity and OSA, insulin resistance and metabolic syndrome.^[10,11] The studies performed more recently have detected that metabolic dysfunction developed in OSA which is not only correlated with obesity but also related closely to the severity of OSA irrespective of the presence of obesity.^[12,13] Punjabi et al. demonstrated that the insulin resistance developed in patients with OSA increases in parallel with the increase in the severity of the disease and pointed out to the severity of oxygen desaturation as one of the important factors which increase the insulin resistance.^[14,15] In our study, CT₉₀ and CT₉₅ values were found to be correlated with the presence of diabetes (p=0.040 and p=0.005, respectively).

In obstructive sleep apnea, hyperintense foci (= alterations in white matter) on cerebral periventricular and subcortical areas at T2-weighted and FLAIR (fluid attenuated inversion recovery) sequences of magnetic resonance imaging in obstructive sleep apnea were found to be correlated with, dementia and mortality.^[16-18] They are related to cognitive function and their preventable and treatable causes should be revealed.^[19,20] Even though heterogeneous pathological relations exist, the presence of gliosis related to focal myelinosis, axonal loss and hyalinosis suggests a role of chronic hypoperfusion in the development of hyperintense foci.^[21,22] Obstructive sleep apnea is related to the development of hypertension and hypertension was correlated with the development of hyperintense foci.^[16,23,24] Therefore, the presence of a cor-

relation between OSA and the presence of hyperintense foci is reasonable.^[25] In this study, a correlation between CT₉₀ value and the presence of hyperintense foci in the brain could not be found. However, a correlation was found between CT₉₅ value and number of hyperintense foci in the brain (p=0.011).

Increased activation of platelets plays an important role in the development of cardiovascular complications.^[26] Some authors have indicated an increase in platelet activation and aggregation.^[27-30] Mean platelet volume is an indicator of thrombocytic activation and plays a role in the pathophysiology of cardiovascular diseases as hypertension, diabetes, hypercholesterolemia and acute myocardial infarction.^[26,31] In this study, a statistically significant correlation was not detected between mean platelet volume, CT₉₀ and CT₉₅ values. Besides, statistically significant effect of smoking on CT₉₅ (p=0.017) was seen; however, it did not affect CT₉₀ values.

Polysomnographic, brain MR and blood values obtained at different time points because of retrospective design of the study and a scarce number of cases are major limitations of our study. Besides among cases who had undergone polysomnographic examinations, selection of only those who had cerebral MR and biochemical values might create a bias towards the cases who had health problems apart from OSA.

Based on the results of this study, correlations exist between CT₉₀ value, AHI, BMI, Epworth sleep score,

Table 4. Factors affecting CT₉₀ and CT₉₅ (multivariate linear regression analysis).

		Regression coefficient (95% confidence interval)	p value	R ²
CT ₉₀	Retroplatal Müller stage	0.419 (-2.58–3.419)	0.781	49%
	Retroglossal Müller stage	3.659 (-0.501–7.818)	0.084	
	Smoking	-0.049 (-5.719–5.621)	0.986	
	Diabetes	1.440 (-6.331–9.211)	0.712	
	Apnea hipopnea index	0.384 (-0.168–0.936)	0.169	
	Body mass index	0.173 (0.022–0.323)	0.026	
	Number of hyperintense foci	0.834 (0.180–1.488)	0.013	
CT ₉₅	Retroplatal Müller stage	1.546 (-5.041–8.133)	0.641	47.9%
	Retroglossal Müller stage	-5.783 (-14.873–3.307)	0.208	
	Smoking	21.198 (8.906–33.490)	0.001	
	Diabetes	6.337 (-10.440–23.114)	0.453	
	Apnea hipopnea index	0.504 (0.178–0.830)	0.003	
	Body mass index	1.052 (-0.334–2.439)	0.134	
	Number of hyperintense foci	8.615 (1.855–15.376)	0.013	

retropalatal, retroglossal stage and presence of diabetes. On the other hand, CT₉₅ value is correlated with AHI, BMI, diabetes, smoking and number of hyperintense foci detected on brain MR. In multivariate linear regression analysis, CT₉₀ value was correlated with only AHI and BMI and CT₉₅ value was correlated with AHI, smoking and a number of hyperintense foci in the brain. Since CT₉₅ values are affected by smoking without any statistically significant correlation with retropalatal and retroglossal Müller stages, we think that consideration of CT₉₀ value will be more appropriate in the evaluation of the severity of chronic intermittent hypoxia in patients with obstructive sleep apnea. However, the correlation between CT₉₀ value and AHI is closer to the value indicated in the literature, but not stronger.

Conflict of Interest: No conflicts declared.

References

- Bostanci A, Turhan M, Bozkurt S. Factors influencing sleep time with oxygen saturation below 90% in sleep-disordered breathing. *Laryngoscope* 2015;125:1008–12.
- Iber C, Ancoli-Israel S, Chesson A, Quan S. The AASM manual for the scoring of sleep and associated events: rules, terminology and technical specifications. Westchester, IL: American Academy of Sleep Medicine; 2007.
- Kulkas A, Tiihonen P, Julkunen P, Mervaala E, Töyräs J. Novel parameters indicate significant differences in severity of obstructive sleep apnea with patients having similar apnea-hypopnea index. *Med Biol Eng Comput* 2013;51:697–708.
- Mediano O, Barcelo A, de la Pena M, Gozal D, Agusti A, Barbe F. Daytime sleepiness and polysomnographic variables in sleep apnoea patients. *Eur Respir J* 2007;30:110–3.
- Asano K, Takata Y, Usui Y, et al. New index for analysis of polysomnography, "integrated area of desaturation", is associated with high cardiovascular risk in patients with mild to moderate obstructive sleep apnea. *Respiration* 2009;78:278–84.
- Neubauer J. Invited review: physiological and pathophysiological responses to intermittent hypoxia. *J Appl Physiol* 2001;90:1593–9.
- Li Q, Jin XJ. Correlations between the duration and frequency of sleep apnea episode and hypoxemia in patients with obstructive sleep apnea syndrome. [Article in Chinese] *Zhonghua Er Bi Yan Hou Jing Wai Ke Za Zhi* 2009;44:825–30.
- Zhang XB, Zen HQ, Lin QC, Chen GP, Chen LD, Chen H. TST, as a polysomnographic variable, is superior to the apnea hypopnea index for evaluating intermittent hypoxia in severe obstructive sleep apnea. *Eur Arch Otorhinolaryngol* 2014;271:2745–50.
- Zhang J, Li Y, Cao X, et al. The combination of anatomy and physiology in predicting the outcomes of velopharyngeal surgery. *Laryngoscope*. 2014;124:1718–23.
- Vgontzas AN, Papanicolaou DA, Bixler EO, et al. Sleep apnea and daytime sleepiness and fatigue: relation to visceral obesity, insulin resistance and hypercytokinemia. *J Clin Endocrinol Metab* 2000;85:1151–8.
- Alam I, Lewis K, Stephens JW, Baxter JN. Obesity, metabolic syndrome and sleep apnoea: all pro-inflammatory states. *Obes Rev* 2007;8:119–27.
- Punjabi NM, Sorkin JD, Katzell LI, Goldberg AP, Schwartz AR, Smith PL. Sleep-disordered breathing and insulin resistance in middle-aged and overweight men. *Am J Respir Crit Care Med* 2002;165:677–82.
- Theorell-Haglöw J, Berne C, Janson C, Lindberg E. Obstructive sleep apnoea is associated with decreased insulin sensitivity in females. *Eur Respir J* 2008;31:1054–60.
- Punjabi NM, Beamer BA. Alterations in glucose disposal in sleep-disordered breathing. *Am J Respir Crit Care Med* 2009;179:235–40.
- Punjabi NM, Shahar E, Redline S, Gottlieb DJ, Givelber R, Resnick HE. Sleep-disordered breathing, glucose intolerance and insulin resistance: the Sleep Heart Health Study. *Am J Epidemiol* 2004;160:521–30.
- Redline S, Yenokyan G, Gottlieb DJ, et al. Obstructive sleep apnea-hypopnea and incident stroke: the sleep heart health study. *Am J Respir Crit Care Med* 2010;182:269–77.
- Yaffe K, Laffan AM, Harrison SL, et al. Sleep-disordered breathing, hypoxia and risk of mild cognitive impairment and dementia in older women. *JAMA* 2011;306:613–9.
- Davies CW, Crosby JH, Mullins RL, et al. Case control study of cerebrovascular damage defined by magnetic resonance imaging in patients with OSA and normal matched control subjects. *Sleep* 2001;24:715–20.
- Bracco L, Piccini C, Moretti M, et al. Alzheimer's disease: role of size and location of white matter changes in determining cognitive deficits. *Dement Geriatr Cogn Disord* 2005;20:358–66.
- Xiong Y, Mok V, Wong A, et al. The age-related white matter changes scale correlates with cognitive impairment. *Eur J Neurol* 2010;17:1451–6.
- Fazekas F, Klemert R, Offenbacher H, et al. Pathologic correlates of incidental MRI white matter signal hyperintensities. *Neurology* 1993;43:1683–9.
- Schmidt R, Grazer A, Enzinger C, et al. MRI-detected white matter lesions: do they really matter? *J Neural Transm* 2011;118:673–81.
- Vermeer SE, Den Heijer T, Koudstaal PJ, Oudkerk M, Hofman A, Breteler MM. Incidence and risk factors of silent brain infarcts in the population-based Rotterdam Scan Study. *Stroke* 2003;34:392–6.
- Gottesman RF, Coresh J, Catellier DJ, et al. Blood pressure and white-matter disease progression in a biethnic cohort. Atherosclerosis Risk in Communities (ARIC) study. *Stroke* 2010;41:3–8.
- Kim H, Yun CH, Thomas RJ, et al. Obstructive sleep apnea as a risk factor for cerebral white matter change in a middle-aged and older general population. *Sleep* 2013;36:709–15B.
- Karakas MS, Altekin RE, Baktir AO, Küçük M, Cilli A, Yalçinkaya S. Association between mean platelet volume and severity of disease in patients with obstructive sleep apnea syndrome without risk

- factors for cardiovascular disease. Turk Kardiyol Dern Ars 2013; 41:14–20.
27. Geiser T, Buck F, Meyer BJ, Bassetti C, Haerberli A, Gugger M. In vivo platelet activation is increased during sleep in patients with obstructive sleep apnea syndrome. Respiration 2002;69: 229–34.
28. Hui DS, Ko FW, Fok JP, et al. The effects of nasal continuous positive airway pressure on platelet activation in obstructive sleep apnea syndrome. Chest 2004;125:1768–75.
29. Minoguchi K, Yokoe T, Tazaki T, et al. Silent brain infarction and platelet activation in obstructive sleep apnea. Am J Respir Crit Care Med 2007;175:612–7.
30. Varol E, Ozturk O, Gonca T, et al. Mean platelet volume is increased in patients with severe obstructive sleep apnea. Scand J Clin Lab Invest 2010;70:497–502.
31. Vizioli L, Muscari S, Muscari A. The relationship of mean platelet volume with the risk and prognosis of cardiovascular diseases. Int J Clin Pract 2009;63:1509–15.

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported (CC BY-NC-ND3.0) Licence (<http://creativecommons.org/licenses/by-nc-nd/3.0/>) which permits unrestricted noncommercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Please cite this article as: Avcı S, Yılmaz Avcı A, Yağbasan BD, Günizi H. The relationship between clinical and laboratory findings and duration of sleep where oxygen saturation remains below 90–95% in obstructive sleep apnea. ENT Updates 2016;6(1):16–22.