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Research paper

Association between neck circumference and the severity of obstructive sleep apnea

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Abstract

Introduction: **Neck circumference (NC) is one of the parameters to be as**sociated with obstructive sleep apnea (OSA). However, there is lack of research data reflecting our local population with regard to the size of NC in relation to the severity of OSA.

Aim: The primary goal of this study was to investigate the association of NC with OSA and to compare NC with other parameters as a predictor of the severity of OSA, among local population. This future reliable parameter can be used in front line clinics as to guide the referral to the tertiary center.

Material and methods: This was a prospective study conducted upon 120 OSA patients, aged within 18–55 years, who underwent overnight polysomnography with apnea/hypopnea index more than 5 and met all the inclusion criteria. All patients completed the Epworth sleepiness scale questionnaire while all the parameter measurement including height, weight, body mass index and NC were documented.

Results and discussion: A Pearson correlation analysis showed NC was significantly associated with OSA ($r = 0.495$, $P < 0.001$) while multiple linear regression model displayed an association between NC and lowest SpO_2 desaturation during sleep (LSAT) as predictors of OSA severity ($P < 0.001$). Mean value of NC also significantly higher among severe OSA compared to mild OSA (42.7 ± 0.9 cm vs. 39.0 ± 1.3 cm; $P < 0.001$).

Conclusions: NC was significantly associated with OSA and both NC and LSAT were significantly correlated as predictors of OSA severity.

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1. INTRODUCTON

Obstructive sleep apnea (OSA) is the most common type of sleep-disordered breathing which is characterized by recurrent episodes of upper airway collapse during sleep.[1] The overall prevalence of self-reported OSA was 13.8% in men and 6.4% in women.[2] Most of the patients were obese.[3] Snoring and daytime somnolence are the main symptoms.[4]

OSA can be evaluated via several methods. The more subjective, questionnaire-based test, Epworth sleepiness scale (ESS) measures the tendency of a subject to doze off during eight different situations.[5] It has higher specificity as a screening tool in OSA.[6] An objective evaluation of nocturnal polysomnography (PSG) or sleep study is considered as the gold standard in diagnosing OSA, which consists of simultaneous recording of multiple physiologic parameters which are related to sleep and wakefulness.[7–9] American Academy of Sleep Medicine has graded OSA by using apnea/hypopnea index (AHI), into mild (AHI 5–15), moderate (AHI 15–30) and severe (AHI >30).[10]

Abnormalities in the upper soft tissues anatomy in the neck contributes to the pathogenesis of OSA.[11] An increased in neck circumference (NC) has been suggested for a better sign of OSA than other clinical indices.[12] Independent of visceral obesity, NC is reliably associated with its severity.[13] The greater the NC the more severe the OSA will be, as evidenced by significantly higher in mean NC among the apneic subjects compared to non-apneic subjects.[14] Obese people in general have thicker neck as compared to that of non-obese people. The size of NC of 40 cm or more is more specific and sensitive to predict the severity of OSA when compared to other parameter such as body mass index (BMI),[15,16] while 29% of female subjects with NC of more than 37.1 cm and male subjects with NC of more than 42.9 cm suffered from sleep-disordered breathing.[17] The deposition of fat in the peripharyngeal region which increases the thickness of the neck is associated with increase tendency of collapse of the pharyngeal wall,[18] while narrowing of the lateral pharyngeal wall had the highest association with OSA compared to other structural abnormalities particulaly enlargement of tonsils, uvula and tongue.[19] Gender-associated fat distribution also play a role in determining the severity of OSA whereby total parapharyngeal soft tissue volume are greater in apneic male patients while in women, they tend to be deposited in lower body.[20]

In comparison between the parameters of OSA to predict the severity, it was demonstrated that AHI correlate more with NC when compared to BMI as a predictor for OSA,[11] however, height-corrected NC or NC divided by height (NC/Ht) is shown to be associated more significantly with high AHI when compared to the measurement of NC per se.[13]

None of the literature reviews shown the correlation between the NC and the severity of the OSA amongst Malaysian patients. Furthermore, it is practically a robust method to predict the severity of OSA. It can serve as a screening parameter for OSA in less facilitated center.

2. AIM

This study aims to determine the association between NC and the severity of OSA, and to compare NC with other known parameters as predictor of the severity of OSA, which is BMI, NC/Ht, lowest oxygen saturation (LSAT) and ESS.

3. MATERIAL AND METHODS

This cross sectional study was conducted at Hospital Universiti Sains Malaysia (HUSM) in a 12-month period from December 2015 to November 2016. All patients from Otorhinolaryngology Clinic HUSM, aged 18–55 years, who had been diagnosed with OSA by sleep study of which AHI of more than 5 per 1 h, were recruited. Patients with history of surgery related to OSA (uvulectomy, adenotonsillectomy, cautery-assisted palatal stiffening operation, uvulopalatopharyngoplasty and nasal reconstruction including septoplasty or turbinectomy) or who had neck abnormalities including any kind of neck mass causing obliteration of normal neck size (thyroid enlargement, lipoma, cyst or massive lymphadenopathy) or who had intranasal or nasopharyngeal abnormalities (severe turbinate hypertrophy causing nasal obstruction, nasal polyposis or enlarged adenoid) and those with severe tonsillar enlargement (grade 2 or larger) were excluded. Total of 120 patients that met the inclusion criteria were finally enrolled in this study. The sample size was calculated using the Pearson's correlation coefficient test for the first objective and linear multiple regression test by using G*Power software for the second objective. The calculated sample size including 20% dropouts was 116.

The Human Ethical Committee of the School of Medical Sciences, Universiti Sains Malaysia, approved this study protocol. All the subjects were briefed regarding the study and the informed consent taken. The patient's medical and surgical information were documented.

Physical examinations were performed, in which specific parameters, including height, weight, BMI, ESS and NC were recorded. Height was measured to the nearest centimeters while weight was measured to the nearest 0.1 kg,[24] using the SECA 769 (GmbH & Co. KG, Germany) stand-on scale. NC was measured in centimeter, while the patient sat on a chair in upright position, the flexible measuring tape was placed around the patient's neck at the level of cricothyroid membrane,[12,15,21] with the head aligned to the Frankfort horizontal position. It is the head position when the upper margin of the external auditory meatus and the lower margin of the orbit of the eye are horizontal.[22,23] The Malay version of ESS questionnaire was used to assess the tendency to doze off while the AHI and LSAT were recorded from the patient's PSG report. For the purpose of this study, all the patients were only seen once in the clinic without subsequent follow-up. All the devices used in this study were calibrated periodically and similar devices were used on all of the patients to maintain the standard of measurement and result.

Analysis of the collected data was performed using IBM SPSS Statistics v. 22 software. The Pearson correlation coefficient and Spearman's rank test were used to see the correlation between NC with OSA based on AHI. Five different clinical variables (NC, BMI, NC/Ht, LSAT and ESS) were compared to predict the severity of OSA using multiple linear regression (MLR) tests. The difference of mean of NC between groups of OSA patients was analyzed using one-way ANOVA with post-hoc multiple comparison test. A P value of less than 0.05 indicates statistically significant.

4. RESULTS

This study involved 120 patients with OSA who met the inclusion criteria. There were 78 males and 42 females. Racial distribution showed 85% (N = 102) were Malay, 10% (N = 12) Chinese and 5% (N = 6) Indian. The mean age was 42.46 ± 1.84 years.

PSG result showed mean AHI of 36.7 (95% CI: 32.2, 41.2, range 5–105.7). From all 120 patients, 29 (24.2%) patients had mild OSA, 31 (25.8%) had moderate OSA and another 60 (50%) had severe OSA (Table 1). The mean NC measurement was 41.3 ± 0.7 cm overall, gender-based mean of NC were 42.5 ± 0.8 cm (male) and 39.2 ± 1.0 cm (female), mean of BMI was 36.4 ± 1.5 (95% CI: 34.9–37.9, range 23.9–64.9 kg/m^2), mean of LSAT was 73.2 ± 2.2%, mean of ESS was 12.1 ± 0.9, while the mean of NC/Ht was 109.6 ± 2.4 (95% CI: 107.3, 112.0, range 14–139.5) (Table 2).

Table 1. Numbers of patients according the severity of OSA.

AHI category	N(%)
Mild	29(24.2)
Moderate	31(25.8)
Severe	60(50)

The Pearson correlation coefficient is used to see correlation between NC with OSA based on AHI (Table 3). At least one of the variable (NC) showed normal distribution. The result showed significant, positive and fair correlation between these two variables (r = 0.50, P < 0.01). Spearman's rank test showed almost similar result (r = 0.47, P < 0.01).

Five different clinical variables (NC, BMI, NC/Ht, LSAT and ESS) were compared to predict the severity of OSA. Single linear regression (SLR) test of each variables were initially analyzed, in which the result showed four variables were significantly correlated with AHI (NC: r = 0.495, P < 0.025; NC/Ht: r = 0.284, P = 0.025; ESS: r = 0.423, P < 0.025; LSAT: r = –0.497, P < 0.025; significant P < 0.025 for SLR) (Table 4). These four variables were

Table 2. Mean value of all parameters.

Parameters	Mean (SD)			Mean difference (95% CI)
	Overall	Male	Female	
NC, cm	41.3(3.70)	42.5(3.50)	39.2(3.12)	3.24
BMI, kg/m^2	36.4(8.39)	34.9(7.16)	39.22(3.12)	4.23
ESS	12.1(4.85)	12.4(4.69)	11.6(5.15)	0.82
LSAT, %	73.2(12.21)	72.2(11.71)	75.1(13.03)	–2.85
NC/Ht, %	109.6(13.04)	109.6(14.36)	109.7(10.31)	–0.02

Table 3. Pearson Correlation Between NC with OSA.

		NC, cm	AHI
NC, cm	Pearson correlation	1	0.495*
	Sig. (2-tailed)		<0.01
	N	120	120
AHI	Pearson correlation	0.495*	1
	Sig. (2-tailed)	<0.01	
	N	120	120

Comments: * Correlation is significant at the 0.01 level (2-tailed).

Table 4. Single linear regression (each parameter vs. AHI).

Parameters	r	P value*
NC	0.495	<0.25
BMI	0.200	0.28
ESS	0.423	<0.25
LSAT	–0.497	<0.25
NC/Ht	0.284	<0.25

Comments: Dependent variable – AHI. *Significant P < 0.25 (SLR).

Table 5. Multiple linear regression (all parameters vs. AHI).

Parameters	β (AHI)	95% CI	*P* value*
NC	3.32	2.25–4.38	<0.05
BMI	0.59	0.06–1.12	0.86
ESS	2.24	1.40–3.08	0.06
LSAT	–1.01	–(1.33–0.09)	<0.05
NC/Ht	0.54	0.21–0.88	0.37

Comments: Dependent variable – AHI. *Significant $P < 0.05$ (MLR).

Table 6. Comparison between mean NC between mild, moderate and severe OSA.

Comparison	Mean difference (95% CI)	*P* value[a]
Mild vs. moderate	–1.91 (–4.09, 0.26)	0.097
Mild vs. severe	–3.75 (–5.65, –1.84)	<0.001
Moderate vs. severe	–1.83 (–3.70, 0.03)	0.055

Comments: [a] one-way ANOVA was applied followed by post-hoc multiple comparison test with Scheffe method.

then analyzed with multiple linear regression (MLR) and the result showed only NC (β = 3.3; 95% CI: 2.54, 4.38; $P < 0.001$) and LSAT (β = –1.01; 95% CI: –1.31, –0.69; $P < 0.001$) was significant as predictors of severity of OSA (significant $P < 0.05$ for MLR) (Table 5).

There were also significant difference of mean NC between mild and severe groups of OSA patients ($P < 0.001$) revealed by one-way ANOVA with post-hoc multiple comparison tests (Table 6).

5. DISCUSSION

Demographic data from this study showed that from 120 subjects, 65% ($N = 72$) were male and 35% ($N = 48$) were female with the mean age of 42.46 years. The gender distribution were identical with the literatures representing western population with OSA whereby men are about twice more common than women,[17, 24] and study among Asian by Aibek et al. (2013).[25] Malays were mostly involved (85%), followed by Chinese (10%) and Indian (5%). As this study was conducted in one center (HUSM), the pattern of race distribution is expected as this locality is largely resided by Malay population. Cho et al. (2016) demonstrated that no significant ethnic difference amongst OSA patients.[26]

Our study revealed strong positive correlation between NC and severity of OSA ($r = 0.495$) (Table 3). Postulation that the increase in the mass loading in the upper airway causing obstruction by reduction in the airway caliber as demonstrated in animal model is expected to occur in OSA patients.[12] It causes enlargement of soft tissue around the upper airway by deposition of fat subcutaneously and periluminally. This will lead to narrowing of the patency of the airway, in addition to the impairment of its compliance that increase the tendency of airway collapse during sleep.[27]

The mean value of NC also differs between genders. It is greater among men (42.5 ± 0.8 cm) compared to women (39.2 ± 1.0 cm). The reported figures of mean NC (men 43.2 cm vs. women 40.6 cm) by Ho et al. (2011).[16] Similar findings were observed by Ahbab et al. (2013), that mean value of NC among men were significantly greater compared to women ($P < 0.001$).[14] Apart from NC per se, we found that when corrected for height (NC/Ht) as a predictor for severity of OSA, MLR analysis result was not significant ($P = 0.367$) (Table 5). On the contrary, Kawaguchi et al. (2010) demonstrated that NC/Ht were significantly associated with higher AHI (>50 per 1 h) but not with lower AHI value.[13]

The difference between NC of mild and severe OSA subjects was also significant ($P < 0.001$). Increase in NC is strongly associated with obesity, one of the most important risk factor of OSA. Another anthropometric variable related to obesity is BMI, which is thought to be associated with severity of OSA. The mean value of BMI was reported to be higher in those with severe OSA with significant difference from the non-severe OSA ($P = 0.02$).[14,28] From our study however, the result showed otherwise ($r^2 = 0.04$, $P = 0.28$) (Table 4). Kasey et al. (2000) showed that while higher BMI were reportedly associated with severity of OSA, the severity of OSA however persists despite after this factor was eliminated.[30] It is possibly thought to be due to the accumulation of fat around the neck in OSA patient may not necessarily occur in generally obese patient.[27] Cho et al. (2016) reported that there was no difference in BMI between OSA patients and control groups,[26] while Young et al. (2002) showed that 60% of OSA patients were non obese.[29] Nevertheless, the NC as predictor of severity may not be applicable for the elder population as the association decreases with age.[28]

The LSAT result showed significant correlation as predictor of OSA severity ($r^2 = 0.25$, $P < 0.001$) (Table 5). It showed a decrease in 1% of SpO_2 with every 1.01 AHI increment. The mean value of LSAT differs between genders and severity of OSA (Table 2). Li et al. (2000) study between Caucasian and Asian subjects demonstrated a mean of 78%

of lowest desaturation among OSA patients, with no significant difference between the ethnics.[30] Sharma et al. (2004) demonstrated that maximum desaturation of 33% among OSA patients with more than 15 AHI.[31]

There were few notable limitations from this study despite the positively demonstrable association of NC and severity of OSA. Firstly, because of this is a cross-sectional study within a limited time frame, the actual effect of NC towards the disease progression and treatment outcome cannot be determined, by which it can be achieved by cohort study in the future. Secondly, as a one-hospital-based data collection, the result of this study does not actually reflect the general population in Malaysia, however, a larger scale of similar study involving other centers in other states can provide better information that can be applied to our local population as a whole. As demonstrated by linear regression model for predicting the AHI, only 25% variation were explained by NC.

6. CONCLUSIONS

This study demonstrated that NC, along with LSAT is significantly associated with OSA as well as predictor of its severity. As measuring the NC is practically very easy, it can be used as the screening tool for potential OSA patients. It can be used in peripheral clinics or district hospitals at the initial phase, where the PSG is not readily available before the patient referred to well-equipped centers. The urgency of referral can be supported by the screening findings.

Conflict of interest

None declared.

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