Zagazig University Medical Journal
www.zumj.journals.ekb.eg
https://dx.doi.org/10.21608/zumj.2020.27331.1800 Volume 28, Issue 6, November 2022(124-131) Supplement Issue

Manuscript ID ZUMJ-2004-1800 (R1)
DOI **10.21608/zumj.2020.27331.1800**

ORIGINAL ARTICLE

Early Detection of Obstructive sleep apnea Using Adjusted Neck Circumference Score

***Doaa Mostafa Gad*[1]**

1 Chest diseases Department, Faculty of medicine Zagazig University, Egypt.

Corresponding author
Doaa Mostafa Gad
Assistant professor of chest diseases, Faculty of medicine Zagazig University, Egypt.
E.mail : dooagad@yahoo.com

Submit Date	2020-04-06
Revise Date	2020-04-20
Accept Date	2020-04-28

ABSTRACT

Background: Obstructive sleep apnea hypopnea syndrome (OSAHS) is a life threatening breathing disorder diagnosed by overnight polysomnography (PSG). As PSG is expensive and has limited availability, this study was done to establish the effectiveness of the Adjusted Neck Circumference Score (ANCS) as a diagnostic measure in early detection of OSAHS.

Methods: 427 patients were included in a retrospective study, they actually performed full-night PSG study, reviewing Epworth sleepiness scale (ESS) questionnaire, STOP-BANG score, BMI, Neck circumference (NC), Apnea Hypopnea Index(AHI) and ANCS which is composed of: NC, presence of snoring, evidence of nocturnal gasping or choking and presence of hypertension

Results: The current study included 427 patients, 396 (92.7%) were diagnosed as OSA (Group I) and 31 (7.2%) patients were non-OSA (Group II). NC of 40.5 cm can differentiate OSA cases from non OSA with sensitivity 72%, specificity 41.9%, accuracy 69.9%, PPV 94.1% and NPV 10.5% while ANCS could diagnose OSA cases with sensitivity 83.8% and exclude 54.5% of non OSA cases at cut off value of 42.5 , accuracy of 81.5%, PPV 95.9% and NPV 20.7%. Also, ANCS can predict severe OSA by 79.8 % at 44.5 cut off value, with specificity 54.9% and accuracy 70.2%.

Conclusion: ANCS is considered a simple clinical measurement for early detection of OSA and its severity at outpatient department. Also, ANCS has higher specificity, sensitivity and accuracy than NC in clinical diagnosis of OSA.

Keywords: Adjusted neck circumference score (ANCS), Apnoea hypopnoea index (AHI), Neck circumference(NC).

INTRODUCTION

Obstructive sleep apnea hypopnea syndrome OSAHS is considered a serious disorder represented by repeated nocturnal events of partial or complete cessation of breathing [1]. It is mainly represented with noisy breathing, nocturnal cessation of respiration, exhaustion, dry mouth, morning tiredness, with frequent diurnal somnolence [2]. This leads to deterioration in coping with life, activity achievement, more exposure to trauma and depression [3].

OSAS is the main hazardous factor for development of systemic hypertension, type II DM and subsequent retinopathy, arrhythmias, acute coronary syndrome, stroke and metabolic syndrome [4, 5, 6]. Therefore, its early management is mandatory. PSG is the most sensitive device to detect OSAHS [7]. As PSG is costly with restricted accessibility and difficult technological aids, therefore prognostic hazards leading to OSAHS should be realized. Accordingly, it is probable to detect who will proceed the other in performing PSG[8]. In order to detect the suitable patient for PSG performance. Berlin Questionnaire (BQ); although it is globally accepted in screening for OSA, it had a questionable wide range of sensitivity and specificity [9,10]. However, Epworth Sleepiness Scale (ESS) is commonly used as a tool for assessment of excessive daytime sleepiness, but still with low sensitivity and specificity[11].

The STOP-BANG Questionnaire was originally used for early detection of OSA in surgical patients at preoperative clinics, achieving sensitivity of

83.9%, 92.9% and 100%, respectively for detection of mild, moderate and severe OSA [12].

Although, a simpler and less expensive diagnostic tools were validated for OSA screening like: elderly patients, male sex, increased in blood pressure, obesity and increased neck size which is the most important risk factors, still some controversies accusing the validity of their impacts[8]. From these simple screening tool is Adjusted Neck Circumference Score (ANCS) which was assessed by many studies along the past years with conflicting results [13,14]. For that cause, this work aimed at establishing the effectiveness of the ANCS as a diagnostic measure in early detection of OSAHS.

PATIENTS AND METHODS

This study was conducted at Sleep Disordered Breathing unit (SDB) of Chest Department Faculty of Medicine, Zagazig University hospitals in the period from October 2015 till October 2017. Written informed consent was obtained from all participants. The study was done according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

PATIENTS: A Retrospective case-control observational study, from our SDB unit database, the medical records of our patients were reviewed from October 2015 till October 2017. The inclusion criteria were: patients underwent polysomnography at our SDB unit due to chief complaint of daytime and or nighttime symptoms of obstructive sleep apnea. The following conditions were not included: 1) Patients < 18 years old, 2) patients receiving CPAP, 3) congestive heart failure, neuromuscular disorders or severe lung diseases, 4)patients with mixed or central sleep apnea , or 5) Obesity hypoventilation syndrome

METHODS:

Patient's data were reviewed with recording previous history taking focusing on: Sleep disordered breathing symptoms that were assessed by both, Epworth sleepiness scale (ESS) questionnaire[15] and STOP-BANG [8], and the registered clinical findings including; Body Mass Index (BMI)[16], Neck circumference and ANCS that composed of : NC (cm=points), presence of snoring (3 points), and evidence of nocturnal gasping or choking (3 points) and presence of hypertension (4 points) [13,17].And data obtained from a full-night polysomnographic sleep study after it has been done using (SOMNO screen™ plus, Germany)[18].

STATISTICAL ANALYSIS: Quantitative Data were presented as mean ± SD for data and analyzed by one way analysis for variance (F test).

Qualitative data was presented by number and percentage and analyzed by Chi square test or Fisher Exact test when appropriate. Correlation coefficient (r) used to high lighten the association between quantitative variables. P-value <0.05 is considered significant.

RESULTS

This study included 427 patients, 396 (92.7) % were diagnosed as OSA (Group I) and 31 (7.2%) patients were non OSA(Group II). A statistical non-significant difference was observed between both studied groups as regard age (50.2 ± 11.4 yrs versus 49 ± 17.7 yrs) and gender (p value=0.71,0.09) respectively, but males(218) were more prevalent than females(178) in OSA group (55% versus 44%), while in non OSA group females were more than males(19 versus 12).

As for the severity of OSA assessed by Apnea hypopnea index, most of OSA patients were severe (249 cases:62.9%), while mild and moderate OSA were only represented in (73 cases:18.4 % and 74 cases: 18.7 %) OSA Group I.

Neck circumference was significantly higher in OSA group than non OSA group (mean±SD:43.3±4.85, versus 41.3±6.63) (p=0.02). Furthermore, Adjusted neck circumference score were higher in obstructive sleep apnea group than in non-obstructive sleep apnea group with statistically significant difference(mean ±SD: 47.2 ± 6.1,versus 43.9 ± 8.16)(p=0.005) .

In the current study, STOP-BANG score was significantly higher in group I than in group II (mean ±SD: 5.27 ± 1.5, versus 4.52 ± 1.7)(p-value= 0.02), while Epworth score was insignificantly different between both groups(mean ±SD:10.2 ± 5.15, versus 9.4 ± 5.69 (p=0.443) (Data not shown).

In obstructive sleep apnea group, Neck circumference was significantly higher in males than in females (mean ±SD: 44.1 ± 4.7,versus 42.6 ± 4.93) (p-value=0.002), however Adjusted neck circumference has a statistically non-significant difference between both sex(Mean ±SD: 47.7 ± 5.7,versus 46.7 ± 6.5) (p-value= 0.105)(Table 1)

Our results clarified that the ability of NC to differentiate OSA cases from non OSA cases was 72% at 40.5 cut off value, while it could exclude only 41.9% negative cases (non OSA) among truly negatives examined, however ANCS could diagnose 83.8% of OSA cases and exclude 54.5% of non OSA at cut off value 42.5. Besides, overall accuracy of ANCS was 81.5% as a predictor for

OSA screening while for NC accuracy was only 69.9% (Table 2).

There was a statistically highly significant positive correlation between both NC and ANCS with AHI, BMI, STOP-BANG score and Epworth score among OSA patients, however NC showed a non-significant correlation with snoring index, while ANCS has a remarkable positive relation with snoring index (p-value= 0.107,0.001) respectively(Table 3).

ANCS has a statistical highly significant values between mild, moderate and severe OSA patients regarding apnea hypopnea index (p <0.001) (Table 4).

Also,it was observed that, the ability of ANCS to predict severe OSA was 79.8 % at 44.5 cut off value, while it could exclude 54.9% negative cases (mild and moderate OSA) with overall accuracy 70.2%, PPV 73.8% and NPV 63.2%(Table 5).

Table 1. Relation between gender with NC and ANCS among studied OSA group.

	Male N=218	Female N=178	t-test\	P value
NC Mean ±SD	44.1 ± 4.7	42.6 ± 4.93	3.1	0.002 S
ANCS Mean ±SD	47.7 ± 5.7	46.7 ± 6.5	1.63	0.105 NS

NS: P-value>0.05 is not significant S: P-value<0.05 is significant

Table 2. Reliability data for clinical performance of NC and ANCS as predictors of OSA.

Variables	Cut off	AUC	P-value	PPV	NPV	sensitivity	specificity	accuracy
NC	40.5	0.610	0.04	94.1%	10.5%	72%	41.9%	69.9%
ANC	42.5	0.634	0.01	95.9%	20.7%	83.8%	54.5%	81.5%

AUC: area under curve PPV: positive predictive value NPV: negative predictive value

Table 3. Correlation between recorded diagnostic data among studied group with OSA.

	NC		ANCS	
	r	P	r	P
Snoring index	0.081	0.107 NS	0.275	<0.001 HS
AHI	0.284	<0.001 HS	0.283	<0.001 HS
BMI	0.283	<0.001 HS	0.321	<0.001 HS
STOP- BANG score	0.383	<0.001 HS	0.453	<0.001 HS
Epworth score	0.189	<0.001 HS	0.199	<0.001 HS

NS: P-value>0.05 is not significant HS: P-value<0.001 is high sig

Table 4. Statistical comparison between different severities of OSA group (AHI)regarding ANCS.

	OSA (N=396)				
	Mild N=73	Moderate N =74	Severe N=249	F test	P value
ANCS Mean ±SD	40.82±4.16	44.83 ± 6.5	48.6 ± 5.56	62.11	<0.001 HS

S: P-value<0.05 is significant

Table 5. Reliability data for clinical performance of ANCS in prediction of OSA severity.

Variables	Cut off	AUC	P-value	PPV	NPV	sensitivity	specificity	accuracy
ANCS	44.5	0.689	<0.001	73.8%	63.2%	79.8%	54.9%	70.2%

Figure 1. Receiver operating characteristic (ROC) curve for clinical prediction of OSA by NC and ANCS (original).

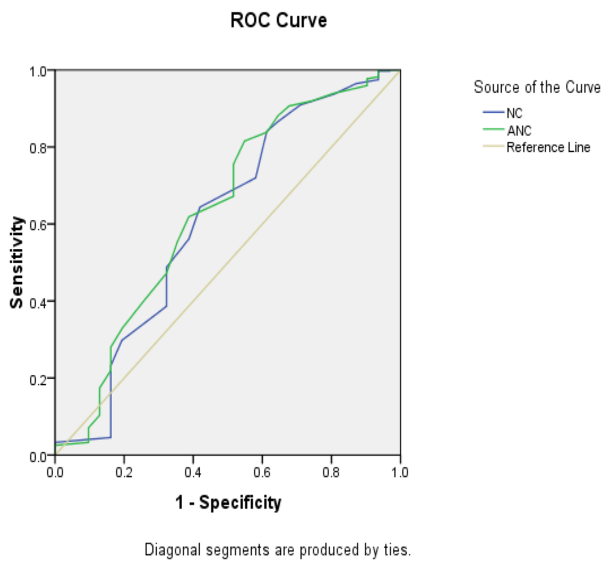
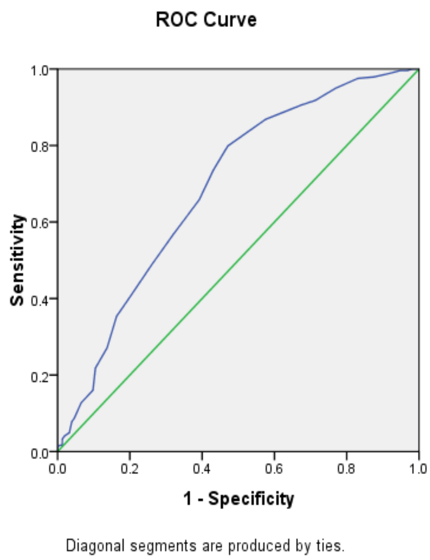


Figure 2. Receiver operating characteristic (ROC) curve for prediction of OSA severity with ANCS (original).



DISCUSSION

OSAHS is a prevalent disorder which occurs within 4% and 2% in males and females respectively [19]. PSG is mandatory for confirming presence of OSAHS, however it is costly and not easily accessible. Therefore, screening of these patients is essential for proper selection of which patient will be in need of performing PSG [20].

This study included Obstructive sleep apnea (Group I) and non Obstructive sleep apnea (Group II). Both groups were matched regarding advances of age. In concordance with our results, Kim et al. [21] who found that their patients mean age was 45.0 ±14.4 years, which is hazardous to develop OSAHS. While Martins et al. [22] confirmed the high association between age and OSA even after considering weight and NC that reasonably increased with age and attributed this to the decrease in the muscle tone with aging and consequent reduction in the dimensions of upper airway lumen. On contrary to the current result Cowan and Allardice [23] observed that elderly patients were less vulnerable to develop OSAHS than younger patients, as these patients had less BMI, furthermore they couldn't justify their day and night symptoms clearly.

As regard gender, the current results coincides with that of Cowan and Kim and their colleagues[20,21] who suggested that, OSA is more common in males than females, simply because of the anatomical varieties in their upper airways. Male pattern of fat distribution concentrates around upper airways and hence they have higher prevalence of OSA. On the other hand, effect of sex hormones in women, play a protective role against OSA, also they have higher prevalence of hypothyroidism and depression which may hide diagnosis of OSA among them [17].

It was observed that NC was significantly larger in OSA group than in non-OSA group. In concordance with these results Kim et al.[21] who found NC in OSA patients was 38.7±3.0 versus 35.6±3.3 in non OSA group, and concluded that large neck circumference with more deposition of fats was more linked to OSA than obesity in general [24].

Also in the current study, Adjusted neck circumference score was higher in OSA patients than in non-OSA group with significant difference. In agreement with these results, Wyckoff and O'Donnell [13] results of their studies who found that ANCS was remarkably increased when checking 251 OSA patients, (87.6%) were found to have OSA and (12.4%) have not.

Also, Nicholl et al. [25] found that ANCS was superior in detecting OSA even in chronic kidney disease or end stage renal disease populations. On the other hand, Ogna et al. [26] observed poor performance of ANCS screening tool in end stage renal disease, and proposed a mechanism of having chronic fluid overload with overnight fluid displacement especially around the neck in hemodialysis patients with OSA.

Regarding diagnostic scores, this study revealed low diagnostic role of Epworth score in OSA than STOP-BANG score in group I. Epworth score was described as a self-administered questionnaire for subjective assessment of sleepiness. However, hypersomnolence may not be a significant complaint in 40% of patients and ESS should not be confused for a pre-test probability score [27, 28].

Moreover, the low efficiency of ESS could be attributed to the designation of the score was primarily for determining hypersomnolence state rather than OSA screening [29].

In contrary, Ogna et al. [26] concluded from their study that STOP-BANG score and ANCS had poor performance in screening for OSA patients. As regard, they applied these scores on end stage renal disease patients and explained this result by the overlap between symptoms of renal failure and that of OSA.

Concerning about Neck circumference(Table 1), in agreement with the current results ,but with lower values, Adisen et al.[30] who found that NC was higher in males than females(40±1.7 cm versus 37±0.8 cm) as their study included small number of patients than this current study. While Liu et al. [29] noted that after matching waist size and BMI, male OSA had more obesity around chest and abdomen with more neck fat than female OSA patients.

However , ANCS wasn't different between both sex in OSA group. This may be attributed to ANCS is a summation of the value of neck circumference in centimeters associated with hypertension, snoring and night chocking, conditions added a numeric values to that of the neck circumference[31].

Regarding the ability of ANCS to diagnose OSA cases(Table 2). Similar results to the current study were suggested by Laldayal et al. [17] who found that cut off value of more than 42 for ANCS could screen 89.3% of OSA patients. Another study was carried out by Shetty et al. [32] who reported a higher cut-off level of ANCS for males(43.83)with sensitivity 84% and specificity 70%, and a lower cut-off level for females (40.32)yield sensitivity 74% and specificity 63%. This difference may be attributed to; 799 patients were included in their study which is nearly double the number of patients in this work. Furthermore, Castorena- Maldonado et al. [33] observed a lower sensitivity 63% to diagnose OSA with higher specificity 77% at a cut off level > 43, PPV(95%) and NPV(24%), when studying the validation of ANCS on 97 Mexican population with different upper airway morphometric analysis.

As for the ability of NC to differentiate OSA from non OSA(Table 2), it was concluded from the previous results that ANCS has higher specificity, sensitivity and accuracy than NC in clinical diagnosis of OSA.

Many studies in the literature had reported different cut-off values of NC in predicting OSA with different ethnic population and different anthropometric measures. From these studies, Onat et al. [34] who concluded a cut-off of value 39 cm NC in men an 35 cm in women for predicting OSAS in Turkish adults. Another study performed by Amra et al. [35] from Iran suggested cut-off values (34.5 cm versus 38.75 cm) for females and males. However, Zhou et al. [36] stated lowest NC (33cm versus 37 cm) for Chinese females and males.

In this study, there was a highly statistically significant positive correlation between ANCS and NC with AHI, BMI, STOP- BANG score and Epworth score among OSA patients (Table 3). Same results were observed by, kim et al. [21], Adisen et al. [30], Hannallah et al. [31] and Bhise et al. [37]. However, Bhimwal and his colleagues [38] noted an obvious higher prevalence in OSA with an increase in neck circumference but no significant increase in OSA severity was found in relation to increase in neck circumference. Pineda et al. [14] correlated NC with severity of OSA and concluded that NC could guide us to differentiate between grades of OSA severity but without statistical association with AHI. This controversy from the present study may be due to that the previous study was performed for screening of OSA at Diabetic clinic in a smaller group (50 patients) than the current study.

On the other hand, NC has a non-significant correlation with Snoring index, while ANCS has a highly statistically significant positive correlation with snoring index. This finding may be due to that 40 to 60% patients with OSA complained from snoring, as reported by American academy of sleep medicine, however virtually all patients with OSA snore, but not all snorers have sleep apnoea. This finding was documented by study of Somers VK et al. [39].

In the current study a statistical significant different ranges of ANCS was detected among mild, moderate and severe OSA according to (AHI) . Besides, the ability of ANC to predict severe OSA was 79.8 % at 44.5 cut off value, with specificity 54.9% and accuracy 70.2%(Table 4,5).Though there have been some conflicting results with Laldayal et al. [17]who concluded that neither difference in ANCS regarding OSA severity was statistically relevant nor ANCS and OSA severity correlate with each other .This difference can be explained by the small number of their studied OSA group(113)represented proportionately as mild (23%), moderate(30%), and severe(47%), while the current study included larger studied group(396) who were represented mostly with severe OSA(62.9%)regarding AHI.

In agreement with results of the present study, Wyckoff and O'Donnell [13] showed a significantly higher ANCS in patients with moderate-severe OSA. Furthermore, Castorena-Maldonado et al. [33] observed that ANCS was adequate for diagnosing OSAS and, value of > 48 can even identify severe cases of OSAS.

CONCLUSION

ANCS is considered a simple clinical measurement for outpatient department screening for OSA at cut off value 42.5 with (sensitivity 83.8%, specificity 54.5% and accuracy 81.5%). Furthermore it has the ability to predict severe OSA at cut off value 44.5, with sensitivity 79.8 % , specificity 54.9% and accuracy 70.2% .Also, ANCS has higher specificity, sensitivity and accuracy than NC in clinical diagnosis of OSA.

REFERENCES

1. Viswanath A, Ramamurthy J, Dinesh SP, Srinivas A. Obstructive sleep apnea: awakening the hidden truth. Niger J Clin Pract 2015;18: 1-7.

2. Pamidi S, Knutson KL, Ghods F, Mokhlesi B. Depressive symptoms and obesity as predictors of sleepiness and quality of life in patients with REM-related obstructive sleep apnea: cross sectional analysis of a large clinical population. Sleep Med 2011; 12: 827-831.

3. Teran-Santos J, Jimenez-Gomez A, Cordero-Guevara J, Cooperative Group Burgos-Santander N. The association between sleep apnea and the risk of traffic accidents. Engl J Med.1999; 340:847–51.

4. Lattimore JD, Celermajer DS, Wilcox I. Obstructive sleep apnea and cardiovascular disease. J Am Coll Cardiol 2003;41:1429–37.

5. Svatikova A, Wolk R, Gami AS, Pohanka M, Somers VK. Interactions between obstructive sleep apnea and the metabolic syndrome. Curr Diab Rep 2005;5:53–8.

6- Embarak S , Abbas A , Al-Nashar HY, Farag SE. The relationship between obstructive sleep apnea and diabetic retinopathy in type 2 diabetes patients, Zagazig University Hospitals, Egypt. Egypt J Chest DisTuberc 2019; 68:290-5.

7. Chung F, Yang Y, Liao P. Predictive performance of the STOP-Bang score for identifying obstructive sleep apnea in obese patients. Obes Surg 2013; 23:2050-2057.

8. Chung F, Yegneswaran B, Liao P,Chung SA,Vairavanathans S,Islam S, et al. STOP

questionnaire: a tool to screen patients for obstructive sleep apnea. Anesthesiology 2008; 108:812-821.
9. Ahmadi N, Chung SA, Gibbs A, Shapiro CM. The Berlin questionnaire for sleep apnea in a sleep clinic population: relationship to polysomnographic measurement of respiratory disturbance. SLEEP BREATH 2008;12: 39-45.
10. Saleh ABM, Ahmad MA, Awadalla N. Development of Arabic version of Berlin questionnaire to identify obstructive sleep apnea at risk patients. Ann Thorac Med 2011;6:212.
11. Ulasli SS, Gunay E, Koyuncu T, Akar O, Halici B, Ulu S, et al. Predictive value of Berlin Questionnaire and Epworth Sleepiness Scale for obstructive sleep
apnea in a sleep clinic population. Clin Respir J 2014; 8: 292-296.
12-Chung F, Yegneswaran B, Liao P, Chung SA, Vairavanathans S, Islam S, et al. Validation of the Berlin questionnaire and American Society of Anesthesiologists checklist as screening tools for obstructive sleep apnea in surgical patients. Anesthesiology 2008;108:822–30.
13-Wyckoff CC ,O'Donnell AE. Assessing the adjusted neck circumference sleep apnea screening score in patients clinically suspected to be at high risk of obstructive sleep apnea,Chest J 2007 Volume 132, Issue 4, Supplement, Page 649A.
14-Pineda E, Fitelson D, Rahill J, O'Donnell A, Kuru T, Waldhorn R, et al. Assessing the adjusted neck circumference sleep apnea screening score in patients undergoing polysomnography for suspected sleep apnea. Chest J 2011; 140
15 Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 1991;14:540–545.
16-Young T,Peppard PE, Taheri S. Excess weight and sleep-disordered breathing.
J APPL PHYSIOL 2005; 99(4): 1592-1599.
17- Laldayal D, Desai U , Joshi JM. Role of Adjusted Neck Circumference Score for Screening of Obstructive Sleep Apnea. Indian J Sleep Med 2016; 11.1: 30-35.
18-Redline S, Sanders MH, Lind BK, Quan SF, Iber C, Gottlieb DJ, et al. Methods for obtaining and analyzing unattended polysomnography data for a multicenter study. Sleep 1998; 21(7): 759-767.
19-Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl JMed 1993;328:1230–1235.
20- Cowan DC, Allardice G, MacFarlane D, Ramsay D, Ambler H, Banham S, et al. Predicting sleep disordered breathing in outpatients with suspected OSA. BMJ Open 2014; 4:e004519. doi:10.1136/bmjopen-2013-004519
21-Kim SE, Park BS , Park SH , Shin KJ ,Ha SY , Park JS, et al.
Predictors for Presence and Severity of Obstructive Sleep Apnea
in Snoring Patients: Significance of Neck Circumference. J Sleep Med 2015;12(2):34-38.
22- Martins AB, Tufik S, Moura SM. Physiopathology of obstructive sleep apnea-hypopnea syndrome. J Bras Pneumol 2007; 33:93-100.
23-Cowan DC , Allardice G. High risk for obstructive sleep apnea in patients with acute myocardial infarction. Rev Latino Am Enfermagem 2015 ;23(5):797-805.
24- Kawaguchi Y, Fukumoto S, Inaba M, Koyama H, Shoji T, Shoji S, et al. Different impacts of neck circumference and visceral obesity on the severity of obstructive sleep apnea syndrome. Obesity (Silver Spring) 2011;19: 276-28
25-Nicholl DDM, Ahmed SB, Loewen AHS, Hemmelgarn BR, Sola DY, Beecroft JM, et al. Diagnostic value of screening instruments for identifying obstructive sleep apnea in kidney failure. J Clin Sleep Med 2013;9(1):31-38.
26-Ogna VF, Ogna A, Pruijm M, Bassi I, Zuercher E, Halabi G, et al. Prevalence and Diagnostic Approach to Sleep Apnea in Hemodialysis Patients: A Population Study. Biomed Res Int 2015; Vol (2015).
27-Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 1991;14(6):540–5.
28- Johns MW. Daytime sleepiness, snoring, and obstructive sleep apnea: the Epworth sleepiness scale. Chest 1993 ;103(1):30–6.
29- Liu W-T, Wu H-t, Juang J-N, Wisniewski A, Lee H-C, Wu D, et al. Prediction of the severity of obstructive sleep apnea by anthropometric features via

support vector machine. PLoS ONE 2017 ;12(5): e0176991. https://doi.org/10.1371/journal.pone.0176991.

30- Adisen MZ, Misirlioglu M, Yorubulut S , Nalcaci R. Correlation of upper airway radiographic measurements with risk status for obstructive sleep apnea syndrome in young dental patients. Oral Surg Oral Med Oral Pathol Oral Radiol 2017;123:129-136.

31- Hannallah M, Exeter Y, Scher L, Habib G, Hwang G, Cai L.Comparison of “the STOP-Bang” and “the Modified Neck Circumference”obstructive sleep apnea screening questionnaires. Anaesth Pain &Intensive Care 2015;18(2):153-155.

32-Shetty MJ, Mohammad S, Sindhu P, Kremer A, McCarthy E ,Amoateng−Adjepong Y, et al. Adjusted Neck Circumference of 43.8 cm Predicts Positive PSG in Men. Am J Respir Crit Care Med 2009;179:A2140.

33- Castorena-Maldonado A, Espinosa-Morett L, Bosque FA, Carrillo-Alduenda JL, Torre-Bouscoulet L,Vazquez-Garcia1 JC, et al. Diagnostic Value of the Morphometric Model and Adjusted Neck Circumference in Adults with Obstructive Sleep Apnea Syndrome. Rev Inves Clin 2015;67:258-65.

34-Onat A, Hergenc G, Yuksel H, Can G, Ayhan E, Kaya Z, et al .Neck circumference as a measure of central obesity: Associations with metabolic syndrome and obstructive sleep apnea syndrome beyond waist circumference. Clinical Nutrition 2009 ; 28: 46–51.

35-Amra B , Pirpiran M , Soltaninejad F , Penzel T , Fietze I , Schoebel C .The prediction of obstructive sleep apnea severity based on anthropometric and Mallampati indices. J Res Med Sci 2019; 24: 66.

36-Zhou JY, Ge H, Zhu MF, Wang LJ, Chen L, Tan YZ, et al. Neck circumference as an independent predictive contributor to cardio-metabolic syndrome.Cardiovasc Diabetol 2013;12:76.

37- Bhise DH, Hegde RR, Phadtare JM and Ramraje NN. Study of obstructive sleep apnea in respiratory disorders. IJBR 2013; 04 (07):317-322.

38- Bhimwal RK, Makwana M, Jangid R and Bhati RL.To study the prevalence of obstructive sleep apnoea in type 2 diabetes patients in Western Rajasthan, India. Int J Adv Med 2017; 4(4): 894-902.

39-Somers VK, White DP, Amin R, Abraham WT, Costa F, Culebras A, et al. Sleep Apnea and Cardiovascular Disease: an American Heart Association/American College of Cardiology Foundation Scientific Statement from the American Heart Association Council for High Blood Pressure Research Professional Education Committee, Council on Clinical Cardiology, Stroke Council, and Council on Cardiovascular Nursing. J Am Coll Cardiol 2008;52(8):686–717.

How to cite
Gad, D. Early Detection of Obstructive sleep apnea Using Adjusted Neck Circumference Score. Zagazig University Medical Journal, 2022; (124-131): -. doi: 10.21608/zumj.2020.27331.1800