Original Article

Predicting high blood pressure among adults in Southeastern Nigeria using anthropometric variables

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Abstract

Background: Epidemiological studies on high blood pressure revealed that it has become a global public health concern. Efforts are being made to uncover other indicators of hypertension than the traditional and crude one popularly used, i.e. BMI. Obesity and overweight are common causes of most cardiovascular diseases. **Aim:** The study examined which anthropometric variable better predicts hypertension among adults in Enugu State of Nigeria. **Materials and Methods:** Sample of the present cross-sectional study included 540 (288 females and 258 males) adults aged 28-74 years old. Five anthropometric variables (weight, height, chest, waist, and hip circumferences) and blood pressure were measured. Data were collected by means of questionnaires from patients attending Korean Enugu State University Teaching Hospital. Subject is classified as being hypertensive if systolic blood pressure (SBP) >140 mmHg and/or diastolic blood pressure (DBP) >90 mmHg. **Results:** The overall prevalence rate of hypertension was found to be 26.30% while 24.4% and 28% were recorded for males and females respectively. The prevalence was not significantly associated with gender (χ^2 = 0.899, P = 0.343). Hypertension was found to be related to age, weight, chest, waist, and hip circumferences, and waist-hip ratio ($P < 0.05$) but not height ($P > 0.05$). Waist circumference with the largest area under the ROC curve was the best predictor of hypertension for all sample population, males and females respectively 0.67, 0.68 and 0.66. Logistic regression model revealed that CC, WC, HC and WHR are predictors of hypertension. **Conclusion:** Waist circumference appears to be a better predictor of hypertension than other anthropometrics in this sample population.

Key words: Anthropometry, blood pressure, Enugu, hypertension

INTRODUCTION

In Nigeria, a cross-sectional research has shown that hypertension is a potential cardiovascular risk factor

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Access this article online	
Quick Response Code:	Website: www.jecajournal.com

How to cite:
Okamkpa, C., Nwankwo, M., & Danborno, B. (2016). Predicting high blood pressure among adults in Southeastern Nigeria using anthropometric variables. J Exp Clin Anat, 15(2), 111-117.

irrespective of age group (Adediran *et al.,* 2013; Okpara and Adediran, 2013; Abiodun *et al.,* 2011; Ekwunife and Aguwa, 2011; Adedoyin *et al.,* 2008; Olatunbosun *et al.,* 2000; Rotimi *et al.,* 1999) and has now become a potential public health concern. Heart failure, stroke, and coronary artery disease are just a few of the various cardiovascular diseases associated with hypertension. Hypertension is the most common noncommunicable disease and the leading cause of cardiovascular disease in the world (Khakurel *et al.,* 2009; Kearney *et al.,* 2004). Many people with hypertension are unaware of their condition, and among those with hypertension, treatment is infrequent and inadequate. The global prevalence of hypertension has been on the increase. In 2000 alone, 972 million people are hypertensive with a prevalence rate of 26.4%. These are projected to increase to 1.54 billion affected individuals and a prevalence rate of 29.2% by 2025 (Kearney *et al.,* 2004).

Body mass index (BMI) has long been recognized as the most sensitive epidemiological measure of overweight and obesity. The usefulness of BMI is limited as it does not take account of body fat distribution as seen in different human populations (World Health Organization, 2002). This limitation of BMI necessitates the need for other anthropometric dimensions that take account of regional abdominal fat distribution (Dalton *et al*., 2003; Welborn *et al*., 2003; Ko *et al*., 1999). Previous studies have shown that regional abdominal fat distribution is related to hypertension (Kaufman *et al.,* 1996; Dustan, 1991; Itallie, 1985). For instance, chest circumference (CC), waist circumference (WC), hip circumference (HC), waist-height ratio (WHtR), and waist-hip ratio (WHR) are few anthropometrics that indicate obesity (Yusuf *et al.,* 2004). Overweight has being associated with two- to six-fold increase in the risk of developing hypertension (Deshmukh *et al.,* 2006). According to the World Health Organization (1996) report, 10 kg increase in weight among western population leads to 2–3 mmHg and 1–3 mmHg increase in systolic and diastolic blood pressure (SBP and DBP), respectively. Various studies in Nigerian population have reported the relationship between hypertension and various other factors. Much is not known about which anthropometric measurement better predicts hypertension among adults in Enugu State, Southeast Nigeria. Our aim therefore was to assess which anthropometric measurement better predicts hypertension in a sample of adults from Southeastern Nigeria.

MATERIALS AND METHODS

Study Population

The present cross-sectional study was conducted in Enugu State University Teaching Hospital in the southeastern region of Nigeria from January 2016 to April 2016. The population pattern of this region is homogenous mainly dominated by the Igbo ethnic group. Data were obtained through questionnaires administered to adult patients visiting the hospital, aged 28–74 years who are not hypertensive at baseline. Only patients who gave their informed consent to voluntarily participate in the study were included in the study. The study protocol was reviewed and approved by the Enugu State Ministry of Health. Questionnaires were administered before anthropometric or blood pressure measurements. The questionnaires have three sections. A demographic section concerned with self-reported individual and family characteristics; age, sex, ethnic group, region of residence (rural/urban). Family history of hypertension section concerning whether any family member has had hypertension previously, whether the subject smokes, takes alcohol, hard drugs, was diabetic, has been diagnosed to be hypertensive previously, and was on antihypertensive drugs.

Anthropometry

Measurements were taken from all the 540 subjects (282 females and 258 males) who constitute the analytic subjects. Simple random sampling technique was used to recruit subjects for the study. Five anthropometric variables were taken: Height, weight, CC, WC, and HC. Two indices were calculated: BMI = weight/height^2 in kg/m^2 and WHR. Height was measured in centimeters using a portable stadiometer with the subjects standing on level ground without shoes. Weight was also measured (to 0.1 kg) with shoes off using a portable scale (Tanita BF680W, Tanita Corp., Tokyo, Japan) placed on the level ground. CC, WC, and HC were measured with an inelastic tape. CC was measured by passing tape around the upper chest, midway between quiet expiration and inspiration. WC was measured with the subject in standing position, from mid-point of the lowest rib and top of the iliac crest at the end of expiration. HC was measured around the largest part of the buttock (Nwankwo *et al.,* 2015). Anthropometric measurements were collected following the World Health Organization (WHO) recommendations (WHO Expert Committee, 1995) based on Lohman *et al*.'s (1988) methodologies. All measurements were performed by trained research investigators.

Blood Pressure

Blood pressure was measured on the left arm by auscultatory method using mercury sphygmomanometer (Diamond Co., Industrial Electronics and Allied Products, Electronics Cooperative Estate, Pune, Maharashtra). The patient was first seated and made comfortable for at least five minutes in the chair before measurements were taken. Two readings were taken half an hour apart and the average of two was used taken. Hypertension was defined if SBP >140 mmHg and/or DBP >90 mmHg, following the US Seventh Joint National Committee on Detection, Evaluation and Treatment of Hypertension (JNC VII) recommendations (JNC VII, 2003).

Statistical Analyses

Statistical analyses were conducted using Statistical Package for Social Sciences version 22 (IBM SPSS Inc., Chicago, Illinois, USA) and statistical significance was accepted at two-tailed $P < 0.05$. We assessed the normality of all variables using the Kolmogorov–Smirnov test. Descriptive statistics were calculated as means (standard deviations) or geometric mean (95% confidence interval) if not normally distributed. Group differences were tested for significance using independent sample *t*-test or Mann–Whitney U-test if the variables failed normality test. Crosstabs (χ^2) were computed to calculate prevalence of hypertension with respect to their statistical significance based on gender. Odds ratios were computed to test the magnitude of the relationship between anthropometric variables and being hypertensive or normotensive. Receiver operating characteristic (ROC) curves were plotted to identify the cutoff point (Youden index) of anthropometric variables that delineate the risk of hypertensive and normotensive male and female subjects. Percent sensitivity and specificity were calculated and the value which corresponds to a point on the ROC curve nearest to the upper left corner of the ROC graph was used as the cutoff point for that indicator. Area under the curve and 95% confidence intervals were also calculated.

RESULTS

Anthropometric variables and blood pressure of 540 (282 females, 258 males) subjects were measured in 2016. Table 1 summarizes the descriptive statistics for age, anthropometric variables, and blood pressure. Male subjects are significantly ($P < 0.005$) heavier and taller but have proportionally smaller HC than female subjects. The mean age of the study subjects was 48.75 ± 11.46 years and 49.28 ± 10.78 years for females and males, respectively. The mean weight was 63.26 ± 9.68 kg in females and 70.09 ± 12.04 kg in males. The mean CC, WC, and HC were 91.29 ± 11.08 cm, 87.61 ± 11.76 cm, and 98.67 cm, respectively, for females and 90.05 ± 9.47 cm, 86.69 ± 10.96 cm, 96.41 ± 10.09 cm, respectively, for males. The mean SBP and DBP for females and males are, respectively, 128.15 ± 16.25, 91.87 ± 15.61 mmHg and 126.78 ± 15.26, 90.79 ± 14.62 mmHg. However, the mean values for BMI, CC, WC, HC, SBP, and DBP were higher among females when compared to males, but these differences were not statistically significant ($P > 0.05$).

Table 2 compares age, anthropometric variables between hypertensive and normotensive subjects for females,

Table 1: Descriptive statistics of subjects

	All population		Mean±SD		P
	Mean±SD	Minimum-maximum	Female	Male	
n	540		282	258	
Age (years)	49.00±11.14	28-74	48.75±11.46	49.28±10.78	0.586
Weight (kg)	66.53±11.38	43.00-110.00	63.26±9.68	70.09±12.04	<0.001
Height (cm)	164.44±9.18	106.00-196.00	160.29±7.43	168.99±8.75	<0.001
BMI (kg/m^2)	24.67±4.37	16.38-47.48	24.72±4.29	24.63±4.48	0.814
CC (cm)	90.70±10.35	66.00-136.00	91.29±11.08	90.05±9.47	0.166
WC (cm)	87.17±11.38	62.00-136.00	87.61±11.76	86.69±10.96	0.345
HC (cm)	97.42±10.70	72.00-140.00	98.67±9.84	96.41±10.09	0.004
WHR	0.91±0.39	0.75-1.14	0.89±0.08	0.90±0.06	0.184
SBP (mm Hg)	127.49±15.79	90.00-190.00	128.15±16.25	126.78±15.26	0.315
DBP (mm Hg)	91.36±15.14	53.00-152.00	91.87±15.61	90.79±14.62	0.411

BMI - Body mass index, CC - Chest circumference, WC - Waist circumference, HC - Hip circumference, WHR - Waist-hip ratio, SBP - Systolic blood pressure, DBP - Diastolic blood pressure, SD - Standard deviation

Table 2: Comparison of age, anthropometric variables between hypertensive and normotensive subjects

Variables	Mean±SD					
	All subjects		Females		Males	
	Hypertensive	Normotensive	Hypertensive	Normotensive	Hypertensive	Normotensive
n	79	203	63	195	142	255
Age (years)	54.16±9.76	46.65±11.41*	52.13±10.24	48.35±10.82*	53.26±9.99	46.58±11.02**
Weight (kg)	65.19±9.62	63.29±9.73*	71.16±13.26	67.75±11.63*	68.73±12.01	65.39±9.81*
Height (cm)	159.81±6.95	160.47±7.62	169.22±9.39	168.91±8.55	163.99±9.36	163.95±9.03
BMI (kg/m^2)	25.79±3.83	24.69±4.46*	25.87±4.38	24.55±4.51*	25.82±4.07	24.45±4.28*
CC (cm)	93.96±10.36	90.25±11.20*	93.16±11.33	89.05±8.57**	93.61±10.77	88.39±8.75**
WC (cm)	92.34±11.43	85.77±11.39**	91.71±12.71	85.06±9.83**	92.06±11.98	83.73±10.51**
HC (cm)	101.18±10.26	97.70±9.52**	100.08±11.56	94.76±11.11**	100.69±10.83	95.26±9.10**
WHR	0.91±0.06	0.88±0.09**	0.92±0.07	0.94±0.64	0.91±0.07	0.88±0.08**

*P<0.05, **P<0.01. BMI - Body mass index, CC - Chest circumference, WC - Waist circumference, HC - Hip circumference, WHR - Waist-hip ratio, SD - Standard deviation

males, and overall subjects. The mean difference in age is statistically significant between hypertensive and normotensive subjects for females, males, and overall subjects ($P < 0.05$). Again, the mean difference of CC, WC, HC, and WHR was statistically significant between the hypertensive and normotensive females, males, and overall subjects ($P < 0.05$). Hypertensive subjects showed higher mean age and anthropometric index than normotensive subjects. On the flip side, the difference in mean weight, height, and BMI between hypertensive and normotensive female, male, and overall subjects did not indicate significant difference ($P > 0.05$).

Table 3: Prevalence of hypertension

	Hypertensive, *n* (%)	Normotensive, *n* (%)	χ^2	*P*
Females	79 (28.00)	203 (72.00)	0.899	0.343
Males	63 (24.40)	195 (75.60)		
All population	142 (26.30)	398 (73.70)		

Table 4: Logistic regression of anthropometric variables related to the presence of hypertension

Explanatory variables	OR (95% CI)	*P*
Overall population		
BMI (kg/m^2)	0.990 (0.948-1.033)	0.634
CC (cm)	0.945 (0.923-0.967)	0.001
WC (cm)	0.931 (0.911-0.952)	0.001
HC (cm)	0.946 (0.925-0.967)	0.001
WHR	0.967 (0.895-0.904)	0.001
Females		
BMI (kg/m^2)	0.995 (0.937-1.056)	0.860
CC (cm)	0.952 (0.923-0.982)	0.002
WC (cm)	0.931 (0.903-0.959)	0.001
HC (cm)	0.954 (0.926-0.983)	0.002
WHR	0.890 (0.817-0.840)	0.001
Males		
BMI (kg/m^2)	0.985 (0.926-1.047)	0.624
CC (cm)	0.937 (0.905-0.971)	0.001
WC (cm)	0.932 (0.904-0.962)	0.001
HC (cm)	0.938 (0.907-0.969)	0.001
WHR	0.891 (0.820-0.875)	0.001

BMI - Body mass index, CC - Chest circumference, WC - Waist circumference, HC - Hip circumference, WHR - Waist-hip ratio, CI - Confidence interval, OR - Odds ratio

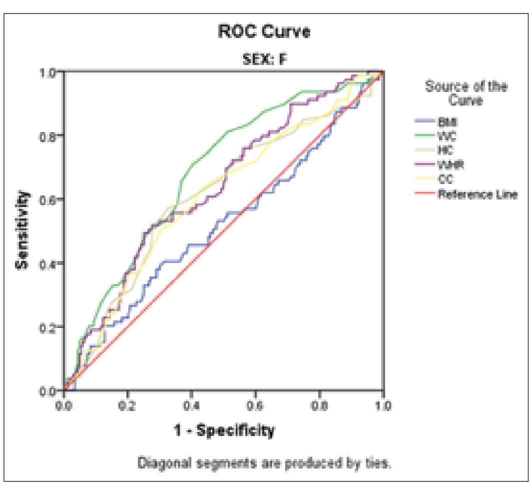
Table 3 summarizes the prevalence of hypertension among the sampled subjects. The prevalence of hypertension for the overall population is 26.30%. The prevalence of hypertension among females (28.0%) is relatively higher than that of males (24.40%).

Table 4 presents the logistic regression to test the influence of certain anthropometric variables on risk of having hypertension for females, males, and overall study participants. The odds ratios for all the anthropometric variables tested (CC, WC, HC, WHR) are significant ($P < 0.01$) for females, males, and overall study participants. There is no marked significant difference in the odds ratios for BMI when compared by each sex, for overall sample. Therefore, all other variables are better predictors of hypertension than BMI.

Table 5 shows the values for area under the ROC curve and the cutoff points for the anthropometric variables for predicting hypertension. The area of ROC for BMI and WHtR was not significantly different ($P > 0.05$) for females, males, and all the subjects. However, the area of the ROC for WC, HC, CC, and WHR was significantly different ($P < 0.001$) for females, males, and all the subjects. The optimal diagnostic points (Youden index) for predicting hypertension were also shown in Table 5. WHR has the least cutoff point for females, males, and all the subjects 0.95, 0.90, and 0.95, respectively. On the other hand, HC has highest cutoff point 99.50, 98.50, and 105.50 cm for females, males, and all subjects, respectively.

DISCUSSION

Hypertension (high arterial blood pressure) has continued to be one of the major causes of death among



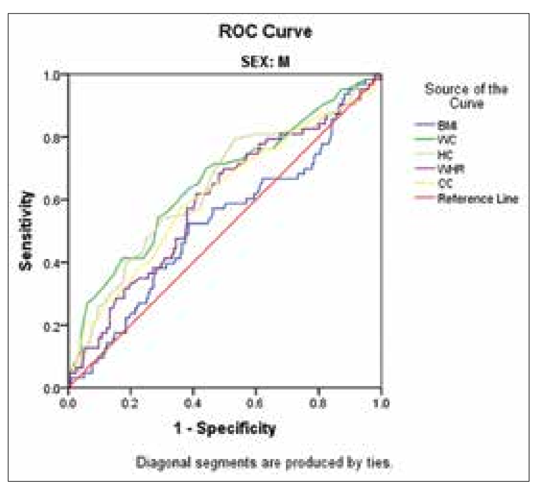


Table 5: Area under receiver operated characteristic curve, cutoff points, sensitivity, and specificity of different anthropometric variables

	AUC (95% CI)	SE	Youden index	Sensitivity (%)	Specificity (%)	*P*
Overall population (*n*=540)						
BMI (kg/m²)	0.52 (0.45-0.58)	0.029	24.54	59.17	61.74	0.402
WC (cm)	0.67 (0.61-0.72)	0.027	93.50	67.52	73.95	<0.001
HC (cm)	0.63 (0.57-0.68)	0.028	105.50	72.54	75.42	<0.001
WHR	0.62 (0.56-0.67)	0.027	0.95	73.28	75.3	<0.001
CC (cm)	0.61 (0.56-0.67)	0.028	98.50	72.82	76.02	<0.001
WHtR	0.48 (0.42-0.53)	0.028	0.55	68.45	66.02	0.028
Females (*n*=282)						
BMI (kg/m²)	0.52 (0.44-0.60)	0.040	24.79	60.38	63.5	0.656
WC (cm)	0.68 (0.61-0.75)	0.034	94.50	68.71	73.73	<0.001
HC (cm)	0.61 (0.54-0.69)	0.038	99.50	59.63	65.12	0.004
WHR	0.63 (0.56-0.71)	0.036	0.90	57.45	63.76	<0.001
CC (cm)	0.61 (0.53-0.68)	0.037	97.50	73.07	74.48	0.005
WHtR	0.49 (0.42-0.57)	0.039	0.54	68.08	67.64	0.860
Males (*n*=258)						
BMI (kg/m²)	0.53 (0.44-0.61)	0.043	24.57	60.43	62.38	0.549
WC (cm)	0.66 (0.58.0.74)	0.041	93.50	67.27	74.54	<0.001
HC (cm)	0.64 (0.56-0.72)	0.042	98.50	61.5	69.35	<0.001
WHR	0.60 (0.51-0.68)	0.042	0.90	55.88	60.26	0.022
CC (cm)	0.62 (0.53-0.70)	0.043	92.50	63.48	70.54	0.006
WHtR	0.46 (0.38-054)	0.040	0.51	48.93	44.72	0.371

AUC - Area under curve, WHtR - Waist-to-height ratio, BMI - Body mass index, CC - Chest circumference, WC - Waist circumference, HC - Hip circumference, WHR - Waist-hip ratio, CI - Confidence interval, SE - Standard error

cardiovascular disorders. It is at times described as a silent killer as its onset is often not detected early or because it is often idiopathic, hence the use of the term primary (essential) hypertension by many clinicians. Hypertension could also be secondary if its cause (such as renal arterial stenosis) is known. The impacts of hypertension being it to the general population or body are enormous. Many people have lost their loved ones from this condition silently as it is at times not diagnosed early or treated properly. Its deadly effects are either as a result of any or combination of the following; the high pressure will lead to excess workload on the heart which can lead to failure of the heart due to the high throughput. This often leads to death of the patient. If the arterial blood pressure increases, the blood vessels, including those in the brain could be damaged leading to death of the affected part. If the cerebrum, it leads to what is known as cerebral infarction. Finally, at the destination, hypertensive condition can lead to damage to organs of the body such as kidneys, and this could lead to kidney failure.

The present study investigates anthropometric variable best predicts hypertension among adults aged 28–74 years from Enugu in the southeastern part of Nigeria. The mean SBP for this group of adults was high (127.49 ± 15.79) mmHg compared to that reported by Abiodun *et al.* (2011), lower than that reported by Rotimi *et al.* (1999) but close to that reported by Adedoyin *et al.,* 2008 in Southwest Nigeria. The prevalence of hypertension in this cross-sectional study was found to be 26.30%. This is about twice the prevalence reported in earlier studies in Nigeria (Olatunbosun *et al.,* 2000; Kadiri *et al.,* 1999; National Expert Committee, 1997; Kaufman *et al.,* 1996; Ogunlesi *et al.,* 1991). In contrast, more recent findings revealed rather higher prevalence of hypertension and this is in keeping to our findings (Adeoye *et al.,* 2016; Adediran *et al.,* 2013). The prevalence of hypertension in this study was slightly higher among females than males. Evidence from previous studies points to the contrary (Ekwunife and Aguwa, 2011; Kearney *et al.,* 2005), Kearney *et al.* (2005) in the same work however projected that by 2025, women will record higher prevalence rate of hypertension than males by 0.5%. If this prediction turns out to be true, maybe, this is the beginning of it. Our results add credence to their projections. However, our sample size was not large enough either to support or to counter their projection. Relationship between hypertension, body mass index, age, and other anthropometric variables (especially BMI) is quite evident in many studies (Ejike *et al.,* 2008; Mufunda *et al.,* 2006; Cappucio *et al.,* 2004; Franklin *et al.,* 1997). Most hypertensive patients lead a sedentary lifestyle and are overweight (obese). Increased physical exercise has often been recommended as the first line of remedy in the treatment of hypertensive patients. The exercise will help in burning the excess fat, thereby leading to reduction in cardiac output due to mediation of physiological activities that play a role in hypertension.

More so, our results revealed that other than body mass index, other anthropometric variables that are indicators of body fat distribution are also risk factors for hypertension. CC, WC, and HC s are significantly higher among hypertensive subjects than their nonhypertensive counterparts, a finding supported by previous studies (Sola *et al.,* 2013; Janssen *et. al.*, 2002). How can we explain the influence of BMI, body circumferences and WHR (which are all body fat distribution indicators) on hypertension? Excess weight gain in itself does not lead to hypertension rather it leads to additional workload against the excess fat tissue, consequently leading to vascular damage especially in the kidneys leading to kidney failure. The impact of age on hypertension may be due to peripheral resistance (Abiodun *et al.,* 2011). Owing to the significant impact of anthropometric adiposity on hypertension, we recommend increased physical activities and weight loss as the first intervention guideline to patients with hypertension.

The average rate of change for CC, WC, HC, and WHR is greater than that for BMI and WHtR, which is suggestive that these variables are more effective for predicting hypertensive condition. However, some portion of the curve for BMI slightly falls below the diagonal line, indicating a weak predictor ($P > 0.05$) of hypertensive condition; hence, the area is close to 0.5. WC is the best significant ($P < 0.001$) predictor of hypertension from the present study since it has the largest area for overall, female, and male subjects, respectively, at 0.67, 0.68, and 0.66. The very small amount of overlap of confidence intervals between CC, HC, and WHtR suggests that WC is a significantly better diagnostic test even though the *P* values are identical. Our result is in agreement with previous studies (Li *et al.,* 2013; Czernichow *et al.,* 2011; Park *et al.,* 2009; Klein *et al.,* 2007; Hadaegh *et al.,* 2005).

CONCLUSION

We found that higher WC is the best predictor of hypertension, while CC, HC, and WHR are moderate predictors, and BMI is the least predictor of hypertension among adult males and females in Enugu Metropolis, Southeastern Nigeria. This therefore highlights the need for adults to closely monitor their WC. We also recommend the use of WC as a useful diagnostic tool for predicting hypertension. This is because WC is easy to measure with no any form of technicalities involved.

Acknowledgments
We gratefully appreciate the patience and cooperation of all participants in this study. We also thank the following individuals for assisting us with data collection Uzoigwe Soky, Nneji Ifeanyi, Emeka Kingsley, Chibuoke Ifeoma, and Sopulu.

Financial Support and Sponsorship
Nil.

Conflicts of Interest
There are no conflicts of interest.

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