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Morphometric Assessment of the Length of the Pulmonary Trunk amongst Nigerians Using Ultrasound Technique

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ABSTRACT

The pulmonary trunk which is also referred to as the main pulmonary artery is an arterial output originating from the right ventricle, carrying deoxygenated blood to the lungs for oxygenation. The aim of this study was to use echocardiogram to assess the length of the pulmonary trunk amongst Nigerian normotensive and hypertensive subjects, males and females ≥18years of age. Fifty seven (57) volunteers partook in this research (32 males, 56%; 25 females, 44%). Data were collected primarily and analysed using SPSS version 25.0. ANOVA, t-test and correlation were used to analyse the data, $p<0.05$ at 95% confidence interval. Results showed that males with systemic hypertension had a mean pulmonary length trunk of 5.11cm which is higher compared to male normotensives, overweight males also had a mean pulmonary trunk length of 5.19cm which is also greater compared to males with normal weight. There was no significant difference in length of pulmonary trunk in females with systemic hypertension compared with normotensive females. Also no significant difference was found with respect to BMI and length of pulmonary trunk amongst females. This research recommends that Physicians (Cardiologists) should carry out regular assessment on the length of the pulmonary trunk of their patients especially males with systemic hypertension, also overweight males should have the length of their pulmonary trunk assessed. In conclusion, this study provided reference values for the length of the pulmonary trunk in normotensives and hypertensives in our population.

Keywords: Echocardiography, Length of pulmonary trunk, normotensive, hypertensive, BMI.

INTRODUCTION

Background to the Study

The pulmonary trunk which is also referred to as the main pulmonary artery is an arterial output which originates from the right ventricle, carrying blood devoid of oxygen to the lungs. Approximately, the length of the pulmonary trunk is 50mm (5.0cm). [1, 2]

It divides into the main branches; namely the right and left main pulmonary artery. [2] The right and left main pulmonary arteries give out other branches, corresponding to the lobes of the lungs, referred to as lobar arteries. The lobar arteries give rise to segmental arteries which in turn give off the subsegmental pulmonary arteries. [4] These finally produce the intralobular arteries. [5]

The pulmonary artery is the originator of the pulmonary circulation. It carries deoxygenated blood away from the right ventricle of the heart to the lungs for oxygenation and then returns oxygen rich blood to the left atrium and left ventricle. [6] The World Health Organization (WHO) in her annual report in 2010 said pulmonary vascular disease (e.g., pulmonary hypertension, pulmonary embolism) affect more than two million people in the world. [7]

In an article published in 2019, Pulmonary hypertension was defined as a mean pulmonary artery pressure (mPAP) of > 20mmHg, a decrease from previous definition of mPAP ≥ 25mmHg, based on certain reasons by the authors. [8] Early identification of individuals with grave occult illnesses is very imperative, hence helping the clinician to develop management strategy. Identification of illnesses by using non-invasive methods provides safety of the patient, abnormal pulmonary trunk length can be easily assessed using ultrasound techniques, and may be due to pulmonary hypertension or embolism. [9] Previous studies showed that the right ventricle is the main factor in the functional state and prognosis in pulmonary hypertension. [10] Therefore long standing systemic hypertension with right ventricular failure may result in abnormal pulmonary trunk length. Also in another study, it was discovered that obesity causes mechanical compression of the diaphragm, lungs and chest cavity, leading to restrictive pulmonary damage, decrease respiratory compliance, increase pulmonary resistance. [11] This may result in abnormal pulmonary trunk length. There is paucity of data with respect to this research amongst Nigerians.

This study was therefore designed to provide scientific data for the length of the pulmonary trunk amongst subjects in our Nigerian Population.

MATERIALS AND METHODS

Fifty seven (57) volunteers, Nigerians 18 years and above residing in Bayelsa State were recruited for this research (32 males, 56%; 25 females,44%). Data were collected primarily by taking medical history, checking blood pressure, height, weight, echocardiogram performed on the individual subjects. Exclusion criteria are; diabetes mellitus, pregnancy, stroke, chronic obstructive pulmonary disease such as pulmonary tuberculosis. Blood Pressure was done by using an electronic (SilverCarePlus) Blood pressure measuring device tied round the arm between the cubital fossa and the shoulder joint and readings were recorded in millimetres mercury (mmHg), including the heart rates of the subjects recorded in beats per minute (bpm). Height and weight readings were obtained with individual participants standing on bare foot on a RGZ-160 Height and weight measuring scale, readings were recorded in meter and kilogramme respectively.

BMI (Body Mass Index) – Derived using the formula weight (kg) divided by the square of the height (m^2), the unit is kg/m^2. A transthoracic echocardiogram using the M-mode and 2-D was done on the individual subjects while lying down on a couch in left lateral position, an ultrasonic transducer (probe) was place on the anterior chest wall and the length of the pulmonary trunk was measured at the level of the pulmonary valves to the point of its bifurcation during diastole. Transthoracic echocardiography is non invasive and the most widely accepted method in cardiology. [12]

Data were analysed using SPSS version 25.0. ANOVA, t-test and correlation were used to analyse the data, $p<0.05$ at 95% (confidence interval).

Ethical clearance was gotten from the ethical review committee for human experimentation of the School of Graduate Studies, University of Port Harcourt. Furthermore a knowledgeable permission was also obtained from each subject and confidentiality of subject's identity was maintained.

Film 1 shows Echocardiographic dimension of the Length of the pulmonary trunk

STATISTICAL METHOD

Data was analyzed by means of statistical package for the social science (SPSS version 25.0) and Microsoft Excel 2019 enterprise edition. Results were presented in Figures 1 – 4 and Tables 1 – 8. Continuous variables were presented as Mean±SD, while categorical variables were presented as pie and bar charts. Sex differences in measured length of pulmonary trunk, differences according to blood pressure (bp) were determined using t-test, while analysis of variance (ANOVA) was used to determine differences in length of pulmonary trunk across different body mass index (BMI). Correlation analysis also done to determine if any relationship exists between Body Mass Index, Blood Pressure and Heart rate against the length of pulmonary trunk. The confidence interval was set at 95% and $p < 0.05$ was considered significant.

RESULTS

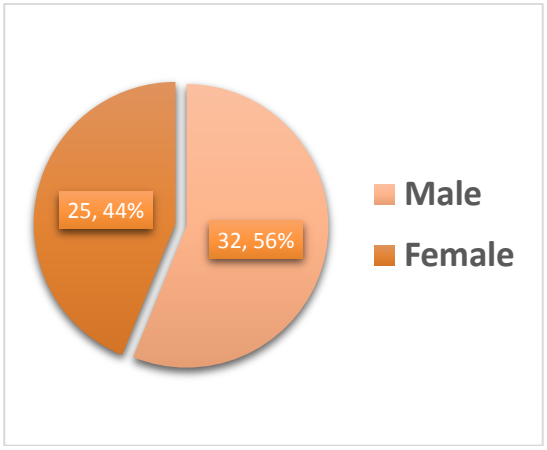

Figure 1: Distribution of the sample population by sex

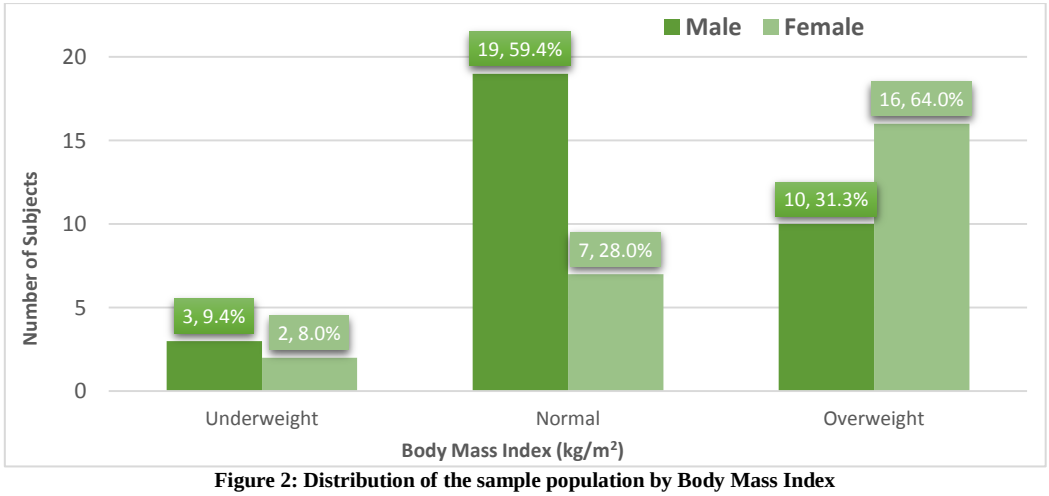

Figure 2: Distribution of the sample population by Body Mass Index

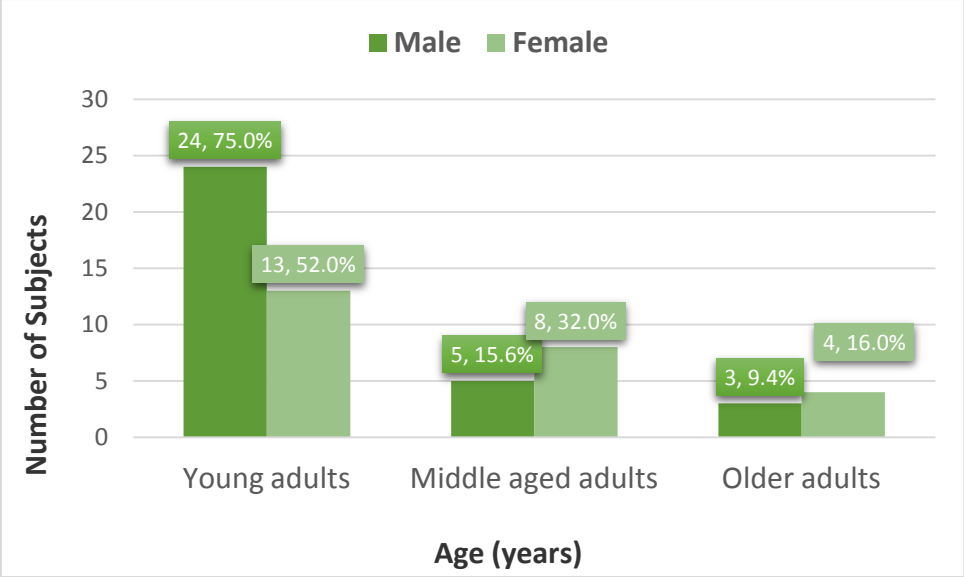

Figure 3: Distribution of the sample population by Age

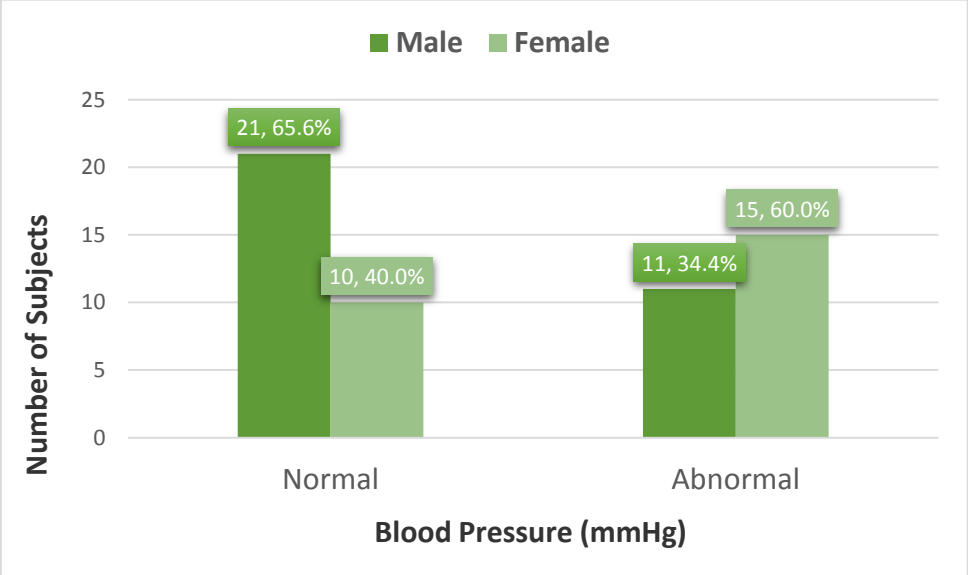

Figure 4: Distribution of the sample population by Blood Pressure

Table 1: Descriptive characteristics of the subjects

Parameters	Sex	N	Mini	Maxi	Mean±SD	T-test		
						df	t-value	p-value
Age (years)	Male	32	18.00	85.00	30.94±15.33	55.00	-1.83	0.07
	Female	25	18.00	70.00	38.60±16.08			
	Total	57	18.00	85.00	34.30±15.99			
Weight (kg)	Male	32	48.00	110.00	68.58±12.93	38.30	-1.08	0.28
	Female	25	46.00	124.00	73.68±20.55			
	Total	57	46.00	124.00	70.82±16.73			
Height (m)	Male	32	1.50	1.97	1.70±0.09	55.00	4.82	0.00*
	Female	25	1.50	1.80	1.60±0.07			
	Total	57	1.50	1.97	1.65±0.09			
BMI (kg/m^2)	Male	32	16.70	39.30	23.87±5.26	40.51	-2.78	0.01*
	Female	25	17.00	46.20	28.87±7.70			
	Total	57	16.70	46.20	26.06±6.85			
Systolic BP (mmHg)	Male	32	73.00	165.00	119.03±21.08	55.00	-2.19	0.03*
	Female	25	90.00	182.00	133.32±28.13			
	Total	57	73.00	182.00	125.30±25.22			

Diastolic BP (mmHg)	Male	32	57.00	100.00	81.19±11.24	55.00	-1.75	0.09
	Female	25	48.00	130.00	87.96±17.92			
	Total	57	48.00	130.00	84.16±14.80			
Heart rate (bpm)	Male	32	55.00	167.00	82.56±24.05	55.00	-0.14	0.89
	Female	25	65.00	117.00	83.28±12.20			
	Total	57	55.00	167.00	82.88±19.60			
Length of pulmonary trunk (cm)	Male	32	3.90	6.60	4.80±0.55	55.00	1.02	0.31
	Female	25	3.40	7.50	4.62±0.81			
	Total	57	3.40	7.50	4.72±0.68			

** = Significant, N = Number of Subjects, Mini = Minimum, Maxi = Maximum, SD = Standard Deviation, BMI = Body Mass Index, BP = Blood Pressure*

Table 2: Length of pulmonary trunk compared in normotensive and hypertensive subjects

Parameters	**BP (mmHg)**	**N**	**Descriptive Statistics**				**T-test**		
			Mini	**Maxi**	**Mean**	**SD**	**df**	**t-value**	**p-value**
Male subjects									
Length of pulmonary trunk (cm)	Normotensives	21	4.10	5.40	4.64	0.34	30.00	-2.47	0.02*
	Hypertensives	11	3.90	6.60	5.11	0.75			
	Total	32	3.90	6.60	4.80	0.55			
Female subjects									
Length of pulmonary trunk (cm)	Normotensives	10	3.40	5.20	4.29	0.56	23.00	-1.70	0.10
	Hypertensives	15	3.70	7.50	4.83	0.89			
	Total	25	3.40	7.50	4.62	0.81			

** = Significant, N = Number of Subjects, Mini = Minimum, Maxi = Maximum, SD = Standard Deviation, BP = Blood Pressure*

Table 3: Length of pulmonary trunk compared by Body Mass Index (BMI)

Parameters	**BMI (kg/m^2)**	**N**	**Descriptive Statistics**				**ANOVA**		
			Mini	**Maxi**	**Mean**	**SD**	**df**	**F-value**	**p-value**
Male Subjects									
Length of pulmonary trunk (cm)	Underweight	3	4.40	4.70	4.50	0.17	2	4.55	0.02*
	Normal	19	3.90	5.40	4.64	0.38			
	Overweight	10	4.40	6.60	5.19	0.71			
	Total	32	3.90	6.60	4.80	0.55			
Female Subjects									
Length of pulmonary trunk (cm)	Underweight	2	4.40	4.60	4.50	0.14	2	2.23	0.13
	Normal	7	3.40	5.40	4.11	0.67			
	Overweight	16	4.00	7.50	4.85	0.83			
	Total	25	3.40	7.50	4.62	0.81			

** = Significant, N = Number of Subjects, Mini = Minimum, Maxi = Maximum, SD = Standard Deviation, BMI = Body Mass Index*

Table 4: Tukey's Post Hoc test comparing the length of pulmonary trunk in male subjects by Body Mass Index

Parameters	BMI; I (kg/m2)	BMI; J (kg/m2)	MD (I-J)	SEM	p-value
Length of pulmonary trunk (cm)	Underweight	Normal	-0.14	0.31	0.89
		Overweight	-0.69	0.33	0.11
	Normal	Overweight	-.54789*	0.19	0.02*

** = Significant, BMI = Body Mass Index, MD = Mean Difference, SEM = Standard Error of Mean Difference*

Table 5: Correlation between Body Mass Index, Blood Pressure and Heart rate against the length of pulmonary trunk

Variables	Correlation	Length of Pulmonary Trunk (cm)	
		Male [N = 32]	Female [N = 25]
Weight (kg)	r	0.594**	0.400*
	p-value	0.000	0.048
Height (m)	r	-0.182	-0.010
	p-value	0.318	0.960
BMI (kg/m2)	r	0.568**	0.402*
	p-value	0.001	0.047
Systolic BP (mmHg)	r	0.280	0.531**
	p-value	0.121	0.006
Diastolic BP (mmHg)	r	0.236	0.267
	p-value	0.194	0.197
Heart rate (bpm)	r	-0.012	0.329
	p-value	0.947	0.109

** = Correlation is significant at the 0.05 level (2-tailed), ** = Correlation is significant at the 0.01 level (2-tailed), r = Pearson correlation, N = Number of Subjects*

Reference range values for the length of pulmonary trunk
Using the formulae;

$$LOWER\ LIMI = m - t_{0.975,\infty} \times \sqrt{\frac{n+1}{n}} \times S.D$$

$$UPPER\ LIMIT = m + t_{0.975,\infty} \times \sqrt{\frac{n+1}{n}} \times S.D$$

⇨ $t_{0.975,\infty} = 1.96$

Using the above formulae, the reference values for the measured echocardiographic parameter (length of pulmonary trunk) are represented hereunder

Table 6: Reference values for the length of pulmonary trunk

Parameter	Male	Female
Length of pulmonary trunk (cm)	3.71-5.89	3.00-6.24

Table 7: Reference values for the length of pulmonary trunk in Normotensive and Hypertensive Subjects

Parameter	Male		Female	
	Normotensive	Hypertensive	Normotensive	Hypertensive
Length of pulmonary trunk (cm)	3.96-5.32	3.57-6.65	3.14-5.44	3.03-6.63

Table 8: Reference values for the length of pulmonary trunk in Underweight, Normal and Overweight Subjects

Parameter	Body Mass Index		
	Underweight	Normal	Overweight
Male			
Length of pulmonary trunk (cm)	4.12-4.88	3.88-5.40	3.73-6.65
Female			
Length of pulmonary trunk (cm)	4.16-4.84	2.71-5.51	3.17-6.53

Data Analysis

Data was presented in figures (1 – 4) and tables (1 – 8).

Figure 1 shows the sample population by sex (male and female) subjects, 56% (32) and 44% (25) respectively.

Figure 2 shows sample population by BMI, 9.4% males were underweight, 8.0% females were underweight. Normal males and females were 59.4% and 28.0% respectively. Also overweight (males and females) were 31.3% and 64.0% respectively.

Figure 3 shows sample population by age. This study showed that 75.0% males and 52.0% (14) females were young adults, 15.0% males and 32.0% females were middle aged adults. Also 9.4% males and 16.0% females were older adults.

Figure 4 shows the sample distribution by Blood Pressure. This study showed that 65.6% males and 40% females had normal pressures whereas 34.4% males and 60% females had abnormal blood pressures.

Table 1 shows the descriptive characteristics of the subjects demographics, the mean age (years) for males and females are 30.94±15.33 and 38.60±16.08, (the females have the higher mean value), weight (kg) for males 68.58±12.93 and females 73.68±20.55, (females have a higher mean), height (m) for males 1.70± 0.09, females 1.60±0.07, (males have a higher mean), BMI (kg/m^2) 23.87±5.26 for males, females 28.87±7.70 (females have a higher mean), systolic BP (mmHg) for males 119.03±21.08, females 133.32±28.13 (females have a higher mean), diastolic BP (mmHg) for males 81.19±11.24, females 87.96±17.92 (females have a higher mean) heart rate for males 82.56±24.05, females 83.28±12.20 (females have a higher mean value) and length of pulmonary trunk (cm) for males 4.80±0.55, females 4.62±0.81 (males have a higher mean value).

Table 2 shows Length of pulmonary trunk compared in male normotensive and male hypertensive subjects, male normotensive had a mean value of 4.64, while male hypertensive had a mean value of 5.11. Hence there is a significant difference ($p<0.05$) in the length of the pulmonary trunk between male normotensive and hypertensive subjects. The male hypertensives had longer length. Female normotensives had a mean value of 4.29, whereas the hypertensives had a mean value of 4.83. There was no significant differences ($p>0.05$).

Table 3: Length of pulmonary trunk compared by Body Mass Index (BMI). There is a significant difference ($p<0.05$) in BMI with respect to length of pulmonary trunk for males. This significant difference was obtained using ANOVA, however further analysis using Tukey's Post Hoc test in table 4 revealed that the difference actually lies between normal and overweight male subjects. There was no significant difference in BMI with respect to the length of the pulmonary trunk in normal, underweight and overweight females.

Table 5: Correlation between Body Mass Index, Blood Pressure and Heart rate against the length of pulmonary trunk. A moderate correlation was observed between the length of pulmonary trunk and weight of male subjects (r=0.594), while a weak correlation existed between length of pulmonary trunk and weight of female subjects (r=0.400). No correlation between height and length of pulmonary trunk in both sexes. Moderate correlation was observed between length of pulmonary trunk and BMI in male subjects (r=0.568), whereas a weak correlation was noticed between length of pulmonary trunk and BMI in female subjects (r=0.402). No correlation between systolic blood pressure and length of pulmonary trunk in male subjects (r=0.280), but there is in female subjects (r=0.531). No correlation between diastolic blood pressure and length of pulmonary trunk in males (r=0.236) and female subjects (r=0.267).

Also no correlation between heart rate and length of pulmonary trunk in males (r=-0.012) and female participants (r=0.329).

Table 6 shows Reference values for the length of pulmonary trunk (cm), males ranges from 3.71-5.89, females 3.00-6.24.

Table 7 shows Reference values for the length of pulmonary trunk in Normotensive and Hypertensive Subjects. Male (normotensive 3.96-5.32, hypertensive 3.57-6.65). Female (normotensive 3.14-5.44, hypertensive 3.03-6.63).

Table 8: shows Reference values for the length of pulmonary trunk in Underweight, Normal and Overweight Subjects. Length of pulmonary trunk (cm) in Males underweight 4.12-4.88, normal 3.88-5.40, overweight 3.73-6.65.

Length of pulmonary trunk (cm) in females underweight 4.16-4.84, normal 2.71-5.51, overweight 3.17-6.53.

DISCUSSION

Blood Pressure

This study discovered that male with systemic hypertension had longer pulmonary length trunk.

This could possibly be due to the effect of male sex hormone called testosterone. However previous studies suggested that oestradiol enhances cardioprotection whereas testosterone enhances cardiac hypertrophy which consequently may result in right ventricular failure. [13]

And hypertrophy of the right ventricle is the main issue in pulmonary hypertension. [10]

Therefore the longer pulmonary length trunk observed in males with systemic hypertension (compared to females) in this study, is in tandem with scientific evidence as stated above. No significant difference was observed between females hypertensives and normotensives. This also could be due to the cardioprotective role of estradiol as reported in previous studies. [13]

BMI (Body Mass Index)

This study revealed that BMI affects the length of the pulmonary trunk. It was observed that overweight males had longer pulmonary length trunk compared to men with normal weight. This result is in agreement with previous study which reported that obesity results in mechanical compression of the diaphragm, lungs and chest cavity, leading to restrictive pulmonary damage, decrease respiratory compliance, increase pulmonary resistance.

[11]. This may result in abnormal pulmonary trunk length.

There was no significant difference in BMI with respect to the length of the pulmonary trunk in females, this may be due to the effect of estradiol as earlier noted.

CONCLUSION

This study therefore made a point that male hypertensives and overweight males have longer pulmonary length trunk, and also provided references values for the length of pulmonary trunk for Nigerian normotensive and hypertensive males and females.

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