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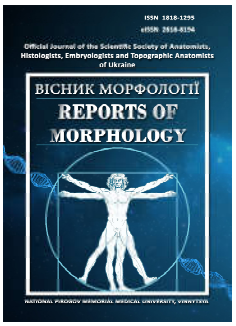

CT assessment of the height of the coronary arteries orifice location and the height of the aortic sinuses in women with structural changes in the coronary arteries

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The most common form of cardiovascular disease in Ukraine is coronary heart disease, which is characterized by damage to the coronary arteries. The height of the aortic sinuses and the height of the coronary arteries are assessed when planning interventional procedures and cardiac surgery. Computed tomography can verify structural changes in the coronary arteries and morphometrically evaluate the components of the aortic sac. The purpose of the study: to measure the height of the coronary arteries orifice; height of the aortic sinuses in women with structural changes of the coronary arteries using computed tomography and assess the interdependence of measurements with anthropometric indicators (age, height, weight, body mass index, body surface area). Computed tomography-angiography of the chest of females with coronary arteries were processed. Statistical analysis: Shapiro-Francia test (correctness of distribution), Student's t-test (comparison of the height of the coronary arteries and the height of the aortic sinuses); Pearson's linear correlation; Fisher's multifactorial regression analysis. The study found a direct correlation between height and measurability in women with coronary artery disease. The value of the growth rate was directly correlated with the height of the right aortic sinus (r=0.85, p=0.001), with the height of the lower edge of the right coronary artery orifice (r=0.74, p=0.01), the height of the upper edge of the left coronary artery orifice (r=0.67, p=0.03), the height of the upper edge of the right coronary artery orifice (r=0.67, p=0.03). It is proved that with increasing body surface area, the parameters of the right aortic sinus decrease: the inverse strong correlation r=-0.83, p=0.002. Significant direct relationships have been established between most of the measured components of the aortic root. Multifactor regression analysis showed a proven strong effect of anthropometric data and age on the height of the right aortic sinus: R=0.96, at p=0.009 (according to Fisher). This made it possible to build a model for predicting the height of the right aortic sinus depending on anthropometric and age parameters. Thus, in women with structural lesions of the coronary arteries, the increase in height correlates with an increase in the height of the right aortic sinus, the height of the coronary arteries orifice. An increase in body surface area correlates with a decrease in the height of the right aortic sinus in women with structural lesions of the coronary arteries.

Keywords: *coronary artery orifice, anatomy, computed tomography, aorta, measurements, aortic sinuses.*

Introduction

According to the World Health Organization, cardiovascular disease (CVD) is the leading cause of death worldwide [17]. The most common form of CVD in Ukraine is coronary heart disease among both men and women [15]. The quality of life of women in Ukraine due to CVD is much worse than in neighboring Europe and the United States [10].

Coronary heart disease (CHD) is characterized by damage to the coronary arteries. The main cause of coronary heart disease is atherosclerotic lesions of the

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coronary arteries, followed by calcium deposition. Computed tomography allows to determine the density of deposited calcium and verify structural changes in the coronary arteries [6]. The right and left coronary arteries originate from the corresponding aortic sinuses. The height of the aortic sinuses and the height of the coronary arteries are important clinically when planning endovascular interventions [1, 4, 5].

The purpose of the study: to measure the height of the right and left coronary arteries orifice; height of the right, left and posterior aortic sinuses in women with structural changes of the coronary arteries using computed tomography and to assess the interdependence of measurements with anthropometric indicators.

Materials and methods

The research was conducted in accordance with the Declaration of Helsinki and the **Bioethics Commission** of the Danylo Halytsky Lviv National Medical University (№10 of 2021). All patients or officials provided informed consent to participate in the study.

The material of the study was computed tomography-angiography (CT) of the thoracic organs of females with coronary artery disease. Inclusion criteria: women over 18 years of age; structural changes of coronary arteries (coronary artery calcification; density measurement according to Hounsfield units (HU)); no history of coronary artery bypass grafting and coronary artery stenting. Exclusion criteria: females with congenital malformations or anomalies of the cardiovascular system; persons with damage to heart valves or heart vessels; history of cardiac surgery or endovascular interventions; artifacts; incomplete clinical data. Of the 143 surveys analyzed, 11 people met these criteria, which were further divided into 2 groups: 1 group with a height of less than 1.60 m (n=5), 2 group - with a height of more than 1.61 m (n=6). Clinical data used: age, height, body weight, based on which the body mass index (BMI) and body surface area (BSA) were calculated (according to Mosteller's formula).

The study was performed on a LightSpeed 64 VCT XT, GE (General Electric, USA) CT scanner according to a standard protocol. Contrast - Ultravist 470 (Bayer Healthcare, Germany). Analysis of the image and measurement of the height of the coronary arteries, the height of the aortic sinuses (Valsalva sinuses) was performed according to the instructions [2] at the appropriate station with licensed software (General Electric, USA). Data are given in millimeters. The measurements were performed independently by two doctors.

Statistical analysis: software R version 4.0.5 (R Core Team, 2021) based on the Windows XP operating system [13]. Correctness of distribution: Shapiro-Francia test. Comparison of mean values: Student's t-test. Correlation analysis: Pearson's linear correlation (r). Multifactor regression analysis: Fisher. Data presented: arithmetic mean ± standard deviation (M±SD), absolute figures. Significance level: $p<0.05$.

Results

According to the results of the analysis of CT of the chest of women with coronary artery disease, it was found that the largest value was the height of the posterior aortic sinus - 19.10±1.65 mm. Indicators of the height of the aortic sinuses and the height of the coronary arteries in women with structural lesions of the coronary arteries are presented in table 1. Visualization of the components of the aortic bulb and coronary arteries with structural lesions of the coronary arteries is presented in Figure 1.

A study of the correlation between anthropometric parameters and measured parameters in women with structural lesions of the coronary arteries showed a direct relationship between height and most indicators, indicating their growth with increasing height. In particular, the value of the growth rate directly correlated with the height of the right aortic sinus (r=0.85, p=0.001), with the height of the lower edge of the right coronary artery orifice (r=0.74, p=0.01), the height of the upper edge of the left coronary artery orifice (r=0.67, p=0.03), the height of the upper edge of the right coronary artery orifice (r=0.67, p=0.03) (Table 2).

It is proved that with the increase of the anthropometric index of BSA, the parameters of the height of the right aortic sinus decrease: the strong inverse correlation r=-0.83, p=0.002. There are also significant direct relationships between most of the measured components of the aortic root. In particular, the height of the posterior aortic sinus increased with increasing height of the left aortic sinus (r=0.80, p=0.003), the height of the lower edge of the left coronary artery orifice (r=0.71, p=0.01), the height of the lower edge of the right coronary artery orifice (r=0.70, p=0.02), the height of the upper edge of the left coronary artery orifice (r=0.67, p=0.02), the height of the upper edge of the right coronary artery orifice (r=0.64, p=0.03). The value of the height of the left aortic sinus was directly related, except for the height of the posterior aortic sinus, with the height of the lower edge of the left coronary artery orifice (r=0.80, p=0.003), with the height of the lower edge of the right coronary artery orifice (r=0.62, p=0.04) and with the height of the upper edge of the left coronary artery orifice (r=0.78, p=0.005). There is also a direct strong correlation between the height of the right aortic sinus and the height of the lower edge of the right coronary artery (r=0.76, p=0.01) and the medium strength relationship with the height of the upper edge of the right coronary artery orifice (r=0.63, p=0.04).

Table 1. Indicators of the height of the aortic sinuses and the height of the coronary arteries orifice in women with structural lesions of the coronary arteries (m±SD, mm).

Parameters	n=11
Height of the posterior aortic sinus	19.10±1.65
Height of the left aortic sinus	17.98±1.71
Height of the right aortic sinus	17.00±1.34
Height of the left coronary artery orifice	11.69±2.04
Height of the right coronary artery orifice	12.07±2.17

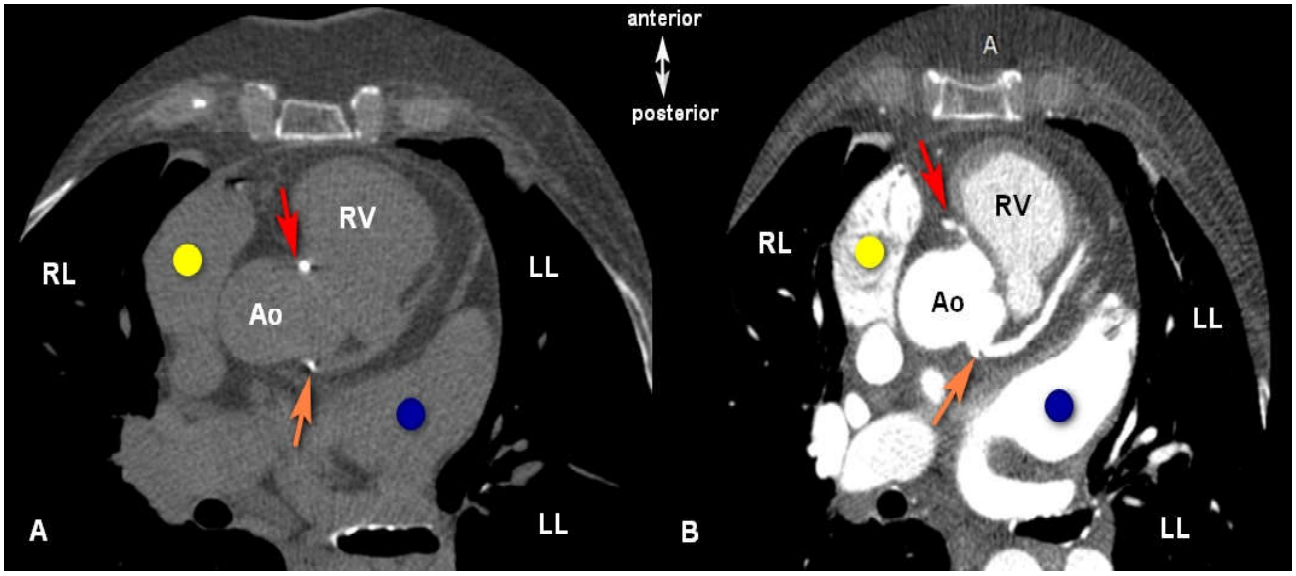

Fig. 1. Visualization of the components of the aortic bulb and coronary arteries in structural lesions of the coronary arteries. Image A, without and B, with the introduction of a contrast agent. Ascending aorta (*Ao*), right ventricle (*RV*), auricula atrii (*yellow circle*), left atrium (*blue circle*), right lung (*RL*), left lung (*LL*). A - calcium deposits in the projection of the right coronary artery (*red arrow*) and the left coronary artery (*orange arrow*). High calcium density is well visualized on examination without contrast. B - contrasting right coronary artery (*red arrow*) and left coronary artery (*orange arrow*). Chest computed tomography, axial section.

Table 2. Correlations (r) between coronary artery orifice height indicators and other studied parameters in women with coronary artery disease.

Indexes		Posterior AS	Left AS	Right AS	LCAI	RCAI	LCAu	RCAu
Age	r	-0.38	-0.19	-0.08	-0.37	-0.06	-0.40	-0.09
	p	*0.25*	*0.58*	*0.81*	*0.27*	*0.86*	*0.23*	*0.79*
Height	r	0.44	0.56	**0.85**	0.54	**0.74**	**0.67**	**0.67**
	p	*0.18*	*0.07*	***0.001***	*0.08*	***0.01***	***0.03***	***0.03***
Weight	r	0.03	-0.26	-0.58	0.01	-0.26	0.07	-0.01
	p	*0.94*	*0.44*	*0.06*	*0.98*	*0.43*	*0.84*	*0.97*
BMI	r	-0.16	-0.43	**-0.83**	-0.21	-0.53	-0.21	-0.30
	p	*0.64*	*0.18*	***0.002***	*0.54*	*0.09*	*0.54*	*0.38*
BSA	r	0.13	-0.14	-0.36	0.12	-0.07	0.24	0.17
	p	*0.70*	*0.68*	*0.28*	*0.72*	*0.84*	*0.49*	*0.62*
Left AS	r	**0.80**		0.53	**0.80**	**0.62**	**0.78**	0.57
	p	***0.003***		*0.10*	***0.003***	***0.04***	***0.005***	*0.07*
Posterior AS	r		**0.80**	0.36	**0.71**	**0.70**	**0.67**	**0.64**
	p		***0.003***	*0.28*	***0.01***	***0.02***	***0.02***	***0.03***
Right AS	r	0.36	0.53		0.42	**0.76**	0.45	**0.63**
	p	*0.28*	*0.10*		*0.20*	***0.01***	*0.16*	***0.04***
LCAI	r	**0.71**	**0.80**	0.42		0.49	**0.77**	0.47
	p	***0.01***	***0.003***	*0.20*		*0.13*	***0.01***	*0.14*
RCAI	r	**0.70**	**0.62**	**0.76**	0.49		0.45	**0.93**
	p	***0.02***	***0.04***	***0.01***	*0.13*		*0.17*	***0.001***
LCAu	r	**0.67**	**0.78**	0.45	**0.77**	0.45		0.47
	p	***0.02***	***0.005***	*0.16*	***0.01***	*0.17*		*0.15*

Continuation of table 2.

Indexes		Posterior AS	Left AS	Right AS	LCAl	RCAl	LCAu	RCAu
RCAu	r	**0.64**	0.57	**0.63**	0.47	**0.93**	0.47	
	p	***0.03***	*0.07*	***0.04***	*0.14*	***0.001***	*0.15*	

Notes: Posterior AS - posterior aortic sinus; Left AS - left aortic sinus; Right AS - right aortic sinus; LCAl - height of the lower edge of the left coronary artery orifice; LCAu - the height of the upper edge of the left coronary artery orifice; RCAl - the height of the lower edge of the right coronary artery orifice; RCAu - height of the upper edge of the right coronary artery orifice, BMI - body mass index; BSA - body surface area.

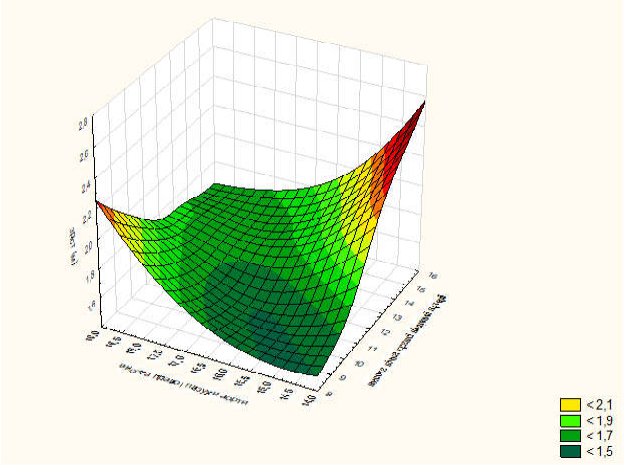

Fig. 2. Relationship between growth rates, right aortic sinus height and lower right margin coronary artery orifice height in women with coronary artery structural changes.

Table 3. The results of logistic regression calculations for predicting the size of the height of the right aortic sinus in women with structural changes of the coronary arteries.

Indicator	Symbol	Coefficient
Constant		-42.63
age	A1	-0.011
height	A2	11.05
weight	A3	-0.830
BMI	A4	0.616
BSA	A5	47.63

Notes: BMI - body mass index; BSA - body surface area.

The interdependence between the heights of the upper and lower edges of the coronary arteries is absolutely logical. In particular, the height of the lower edge of the left coronary artery orifice, in addition to the above connections, was also interdependent with the height of the upper edge of the left coronary artery orifice: strong direct connection (r=0.77, p=0.01), and the height of the lower edge of the right coronary artery with the height of the upper edge of the right coronary artery orifice: direct strong connection (r=0.93, p=0.001). A graphical representation of the relationship between height of person and height of the right aortic sinus and the height of the lower edge of the right coronary artery orifice is shown in Figure 2.

Multifactor regression analysis between independent predictors (anthropometric parameters and age) and dependent (aortic sinus height and coronary artery orifice height) in women with coronary artery structural changes showed a proven direct strong effect of anthropometric data and age on right aortic sinus height: R=0.96, at p=0.009 (according to Fisher) and a standard error of 0.53. The adjusted coefficient of multiple determination was R^2_{adj}=0.84, which indicates the proven effect of the complex of these independent predictors on the height of the right aortic sinus in 84% of cases. This made it possible to build a model for predicting the size of the right aortic sinus depending on anthropometric and age parameters. The necessary components are given in Table 3.

Taking into account the calculations, the linear equation of logistic regression relative to the predicted size of the height of the right aortic sinus in women with coronary artery disease will look like:

Height size = - 0.011 x A1 + 11.05 x A2 - 0.830 x A3 + 0.616 x A4 + 47.63 x A5 - 42.63

The average predicted value of the height of the right aortic sinus is 17.00±1.29 mm (minimum value 14.55 mm, maximum 18.98 mm), which coincides with the actual average value of 17.00±1.34 mm. The work of this logistic model was tested on the studied patients with different anthropometric and age parameters, which were selected from the general primary patient base. Below are two practical examples of the model.

Example №1. Patient №6 in the database: female, 63 years old, height 1.55 m, weight 110 kg, BMI 45.79 kg/m^2, BSA 2.18 m^2. According to the CT of the chest, the height of the right aortic sinus is 14.6 mm.

Substituting the patient's data, we obtain a linear equation:

Height size = -0.011 x 63 + 11.05 x 1.55 - 0.830 x 110 + 0.616 x 45.79 + 47.63 x 2.18 - 42.63 = 14.54 mm

Thus, the predicted value almost coincides with the actual value obtained by CT diagnosis.

Example №2. Patient №10 in the database: female, 70 years old, height 1.70 m, weight 85 kg, BMI 29.41 kg/m^2, BSA 2.00 m^2. According to the CT of the chest, the height of the right aortic sinus is 18.3 mm. Substituting the patient's data, we obtain a linear equation:

Height size = -0.011 x 70 + 11.05 x 1.70 - 0.830 x 85 + 0.616 x 29.41 + 47.63 x 2.00 - 42.63 = 18.20 mm

In this case, the predicted value is also very close to the actual value obtained by CT.

Thus, the use of this model may allow the rapid calculation of the size of the height of the right aortic sinus in women with structural changes in the coronary arteries when planning endovascular interventions or cardiac surgery. A

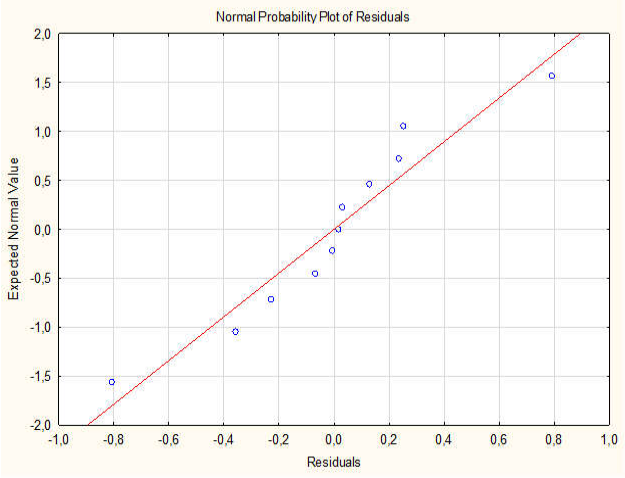

Fig. 3. Normal probability of influence of predictors on the predicted value of the height of the right aortic sinus in women with structural changes of the coronary arteries.

Table 4. Distribution of aortic sinus height and coronary artery orifice height (according to CT) in groups of women with structural changes of coronary arteries. Distribution by groups by height (M±SD, mm).

Indexes	1 group (women with height smaller than 1.60 m), n=5	2 group (women with height more than 1.61 m), n=6	p
Height of the posterior aortic sinus	18.06±1.85	19.97±0.87	0.06
Height of the left aortic sinus	16.68±1.49	19.07±0.97	0.013
Height of the right aortic sinus	15.78±0.78	18.02±0.63	0.001
The height of the lower edge of the left coronary artery orifice	10.55±2.39	12.65±1.15	0.11
The height of the lower edge of the right coronary artery orifice	10.07±1.21	13.73±0.96	0.0004
The height of the upper edge of the left coronary artery orifice	14.56±1.79	16.40±1.23	0.08
The height of the upper edge of the right coronary artery orifice	12.94±1.36	16.32±1.02	0.001

graphical representation of the normal probability of predictors influencing the predicted value of the right aortic sinus height is shown in Figure 3.

In comparing the dependence of other measured aortic parameters on anthropometric and age indicators by multifactorial regression analysis, no significant relationship was found between the studied data in women with structural changes of the coronary arteries: multiple correlation coefficient R = from 0.66 to 0.87, adjusted coefficient of multiple determination R^2_{adj} = from -0.13 to 0.51, at p>0.05 (according to Fisher).

A comparison of the height of the aortic sinuses and the height of the coronary arteries in women with structural changes in the coronary arteries by different growth groups showed that all studied parameters had a higher height in the second group (height over 1.61 m) compared to the first group (women's height less than 1.60 m). The height of the left aortic sinus was proved to be higher in the second group: 19.07±0.97 mm against 16.68±1.49 mm (p=0.013) in the first group; indicators of the height of the right aortic sinus: 18.02±0.63 mm against 15.78±0.78 mm (p=0.001); indicators of height of the lower edge of the right coronary artery orifice: 13.73±0.96 mm against 10.07±1.21 mm (p=0.0004), indicators of height of departure of the upper edge of the right coronary artery orifice: 16.32±1.02 mm against 12.94±1.36 mm (p=0.001) accordingly (Table 4). Other studied indicators were higher in the second group than in the first, but the difference was insignificant (p>0.05).

Discussion

In 2019, about 17.9 million people died from CVD. In low- and middle-income countries, including Ukraine, the proportion of CVD deaths is over 75% [17]. Analysis of the incidence rate from 1990 to 2019 shows a lack of positive dynamics [10]. Given the disappointing trend, steps are being taken to reduce the increase in morbidity and mortality due to CVD. According to the Resolution of the Ministry of Health and the National Academy of Medical Sciences of Ukraine, there is the State Program for Prevention, Treatment and Rehabilitation of Cardiovascular Diseases (2017-2021) (dated 15.07.2016 №711/61). In the Program of Medical Guarantees of the National Health Service of Ukraine, the treatment of acute myocardial infarction remains a priority.

Morphometric analysis of the components of the aortic bulb is taken into account when performing cardiac and cardiac surgical procedures. It is important to take into account anthropometric indicators. If the world data is sufficiently complete [3, 7, 8, 11], the relevant publications are just beginning to appear in Ukraine [9].

The study measured the height of the coronary arteries orifice and the height of the aortic sinuses in women with structural changes of the coronary arteries using computed tomography and evaluated the interdependence of measurements with anthropometric indicators. Using the correlation between anthropometric parameters (age, height, body weight, body mass index, body surface area) and measured parameters (height of the coronary arteries orifice and height of the right, left, posterior aortic sinuses) in women with structural lesions of the coronary arteries proved the presence of a direct relationship between growth and most of the studied indicators of the aortic bulb, which indicates their growth with increasing of height. In fact, higher height correlates with a lower risk of morbidity and mortality from cardiovascular disease [14, 18]. In contrast, an increase in body surface area correlates with a decrease in the height of the right aortic sinus (strong inverse correlation).

The use of multifactor regression analysis between independent predictors (anthropometric indicators and age) and dependent (aortic sinus height and coronary artery orifice height) in women with structural changes of coronary arteries showed a proven strong effect of anthropometric data and age on right aortic sinus height. Analysis of the

relationship between age and aortic bulb parameters varies between different study groups [3, 12, 16].

The proved influence of the complex of independent predictors on the height of the right aortic sinus made it possible to build a model for predicting the size of the right aortic sinus height depending on anthropometric and age parameters. This model can be used to quickly calculate the height of the right aortic sinus in women with structural changes in the coronary arteries when planning endovascular interventions or cardiac surgery.

Conclusion

In women with structural lesions of the coronary arteries, the increase in height correlates with an increase in the height of the right aortic sinus, the height of the upper edge of the left coronary artery orifice, the height of the upper and lower edges of the right coronary artery orifice. An increase in body surface area correlates with a decrease in the height of the right aortic sinus in women with structural lesions of the coronary arteries.

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КТ ОЦІНКА ВИСОТИ ВІДХОДЖЕННЯ ВІЧОК ВІНЦЕВИХ АРТЕРІЙ ТА ВИСОТИ ПАЗУХ АОРТИ В ЖІНОК ПРИ СТРУКТУРНИХ ЗМІНАХ ВІНЦЕВИХ АРТЕРІЙ

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Найпоширенішою формою серцево-судинних захворювань в Україні є ішемічна хвороба серця, котра характеризується ураженням вінцевих артерій. Висота пазух аорти та висота відходження вічок вінцевих артерій оцінюється при плануванні інтервенційних процедур та кардіохірургічних операцій. Комп'ютерна томографія дозволяє верифікувати структурні зміни

вінцевих артерій та морфометрично оцінити складові цибулини аорти. Мета дослідження: провести вимірювання висоти відходження вічок вінцевих артерій; висоти пазух аорти в жінок при структурних змінах вінцевих артерій за допомогою комп'ютерної томографії та оцінити взаємозалежність замірів з антропометричними показниками (вік, зріст, маса, індекс маси тіла, площі поверхні тіла). Були оброблені зображення комп'ютерної томографії-ангіографії органів грудної клітки осіб жіночої статі з ураженням вінцевих артерій. Статистичний аналіз: тест Шапіро-Франсіа (правильність розподілу), t-критерій Стьюдента (порівняння висоти відходження вінцевих артерій та висоти пазух аорти); лінійна кореляція Пірсона; мультифакторний регресійний аналіз за Фішером. За результатами дослідження доведений прямий кореляційний зв'язок між зростом та вимірюваними показниками у жінок зі структурним ураженням вінцевих артерій. Значення показника зросту прямо корелювало з висотою правої пазухи аорти (r=0,85, p=0,001), з висотою нижнього краю вічка правої вінцевої артерії (r=0,74, p=0,01), висотою верхнього краю вічка лівої вінцевої артерії (r=0,67, p=0,03), висотою верхнього краю вічка правої вінцевої артерії (r=0,67, p=0,03). Доведено, що зі збільшенням показника площі поверхні тіла, параметри висоти правої пазухи аорти зменшуються: зворотній сильний кореляційний зв'язок r=-0,83, p=0,002. Встановлено суттєві прямі взаємозв'язки між більшістю показників вимірюваних складових кореня аорти. Мультифакторний регресійний аналіз показав доведений прямий сильний вплив антропометричних даних та віку на висоту правої пазухи аорти: R=0,96, при p=0,009 (за Фішером). Це дало змогу побудувати модель прогнозування розмірів висоти правої пазухи аорти залежно від антропометричних та вікових параметрів. Таким чином, у жінок зі структурним ураженням вінцевих артерій збільшення зросту корелює зі збільшенням висоти правої пазухи аорти, висоти відходження вічок вінцевих артерій. Збільшення показника площі поверхні тіла корелює зі зменшенням висоти правої пазухи аорти у жінок зі структурним ураженням вінцевих артерій.

Ключові слова: *вічка вінцевих артерій, анатомія, комп'ютерна томографія, аорта, вимірювання, пазухи аорти.*