MORPHOLOGICAL CHARACTERISTICS OF THE ARTERIES OF THE SMALL CIRCULATION OF THE CIRCULATION ON THE BACKGROUND OF EXPERIMENTAL DIABETES

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Resume: *Diabetes is a global problem throughout the world. According to WHO, today about 422 million people suffer from diabetes, which is 6.028% of the total population of the planet. The incidence of diabetes is increasing every year. If the situation continues to develop at the same pace, then by 2025 the number of patients with diabetes will increase by 2 times. By 2030, diabetes will be the 7th cause of death worldwide. Vascular diseases occupy an important place in the structure of the incidence of diabetes mellitus and are manifested by organ infarction and vascular insufficiency. The severity of angiopathy depends on the degree and duration of hyperglycemia. Timely and properly selected insulin therapy, maintaining blood glucose levels close to normal values slows down and stops the development of vascular complications.*

Key words: *artery, glycoprotein, hyperplasia, diabetes mellitus, membrane, dystrophy, elastic fibers.*

Резюме: *Сахарный диабет – это глобальная проблема всего мира. По данным ВОЗ, на сегодняшний день диабетом страдает около 422 млн человек, что составляет 6,028% от всего населения планеты. Статистика заболеваемости диабетом ежегодно растёт. Если ситуация будет развиваться теми же темпами, то к 2025 году количество пациентов с диабетом увеличится в 2 раза. К 2030 году сахарный диабет станет 7-й причиной смерти во всём мире. Сосудистые заболевания занимают важное место в структуре заболеваемости сахарным диабетом и проявляются инфарктом органов и сосудистой недостаточностью. Тяжесть ангиопатии зависит от степени и продолжительности гипергликемии. Своевременная и правильно подобранная инсулинотерапия, поддержание уровня глюкозы в крови близким к нормальным значениям замедляет и останавливает развитие осложнений со стороны сосудов.*

Ключевые слова: *артерия, гликопротеин, гиперплазия, сахарный диабет, мембрана, дистрофия, эластические волокна.*

Arteries of the 1st and 3rd levels belong to the muscular-elastic type, arteries of the 4th-6th level - to the arteries of the muscular type. For a more thorough study, the arteries were divided into three groups: arteries of small, medium and large caliber. The results of our studies show that a spiral smooth muscle layer develops on the arteries of the 3rd and

4th degrees. This layer in cross sections looks like a separate pillow-shaped thickening. It is located close to the outer elastic membrane on the side of the adventitia.

Objectives. The study of morphological changes in the pulmonary arteries on the background of diabetes mellitus.

Material and methods of research. The study is fundamental and was conducted at the Department of Anatomy, Clinical Anatomy of the Tashkent Medical Academy, the Vivarium of the Tashkent Medical Academy and the Urgench branch. 163 white laboratory Vistar rats at different stages of postnatal ontogenesis were used as the object of the study.

To achieve the set goals and objectives, scientific work is mainly based on experimental and morphological methods and research materials. Experimental studies were carried out on 163 Vistar white rats. For the morphological study, the lungs were selected and the arteries of the pulmonary circulation were examined. The rats were divided into 2 groups. The first group is the experimental group. In the experimental group, newborn white laboratory rats from the 3rd day of life were intraperitoneally injected with streptozotocin in the amount of 4 mg per 100 g of body weight from the 3rd day of life to create experimental diabetes mellitus and periodically measured the blood sugar level by taking blood from the tail vein. The 2nd group was the control group, in which 0.9% saline was injected into the abdominal cavity of rats. Rats were sacrificed by decapitation at different stages of development: 21 days, 3 months, 12 months and 24 months.

Given that the 21-day period of postnatal ontogenesis corresponds to the period of feeding, 120 days to the period of puberty, 12 months to the period of maturity, and 24 months to old age, postnatal ontogenesis was studied precisely in these periods. To study the morphological structure of the arteries of the pulmonary circulation, both lungs were taken along with the organs of the mediastinum. The resulting lungs were fixed in 12% formalin solution. After fixation, histological preparations were prepared. Prepared histological preparations were stained with hematoxylin-eosin, Van Gieson and PAS methods. In stained finished histological preparations, the following parameters were determined: the length of the inner and outer elastic membranes in the wall of the arteries of the pulmonary circulation; the cross-sectional area of the cavity bounded by the internal elastic membrane of the blood vessel; cross-sectional area of the middle layer between the inner and outer elastic membranes. The ratio between the layers of the arterial wall was studied using the Pearson coefficient. A strong correlation relationship was considered in the presence of ratios from +0.7 or -0.7 to 1.

When assessing the conductivity of the arteries, the Kernogan index was used. Transmission electron microscopy was used to study the ultrastructural structure of lung tissue. The data obtained during the study were subjected to statistical processing using the Microsoft Office Excel-2012 software package on a Pentium-IV personal computer using the built-in statistical processing functions.

When comparing the wall thickness of the right and left pulmonary arteries, the thickness of the middle layer and the internal diameter, it was noted that the size of the right pulmonary artery was 24-28% larger relative to the left pulmonary artery, and the

cross-sectional area exceeded 58.7%. When comparing the cross section of the cavity of the arteries in the pulmonary trunk, this indicator was 26.8% more than the sum of the cross sections of the right and left pulmonary arteries, and the inner diameter was 25.4% less than the sum of the inner diameters of both arteries. When comparing the wall thickness of the main arteries of the pulmonary circulation in all cases, the thickness of the middle layer of the artery exceeded the thickness of the adventitious layer. According to the results of our research, the ratio of the middle and outer layers of the pulmonary trunk was 1:0.6. This ratio showed that in the right pulmonary artery it is equal to 1:0.62, and in the left pulmonary artery it is more, that is, it is 1:0.85.

The intraorgan artery of the lung is a vessel of the muscular-elastic and muscular type. According to a number of scientists, the intraorgan arteries of the lungs can be divided into the following groups: the arteries of the 1st and 3rd degrees belong to the muscular-elastic type, and the arteries of the 4-6th degree belong to the arteries of the muscular type. They, in turn, are divided into 3 groups: arteries of large, medium and small caliber. By structure, the intrapulmonary lobar arteries belong to the vessels of the muscular-elastic type. In the middle and inner layers of these arteries, fully formed elastic membranes are revealed, and in the outer layer - delicate elastic membranes. Therefore, these arteries belong to the arteries of the muscular-elastic type. The inner layer of these arteries is represented by an endothelial layer consisting of round endothelial cells. Beneath it is the subendothelial layer. The middle layer consists of smooth muscle fibers with an oblique longitudinal direction. In this layer, 3 elastic membranes can be seen. On Van Gieson staining, a small amount of collagen fibers can be seen in the middle layer of these arteries. The outer and inner elastic membranes of the arteries of the muscular-elastic type are equally well developed, the boundaries are clearly separated. As the diameter of the artery decreases, the elastic membrane in the middle layer of the artery becomes smaller, thinner, and merges with the outer elastic layer. It was revealed that the adventitial layer consists of connective tissue fibers, mainly collagen and elastic fibers. In the outer adventitial layer of muscular arteries, a muscular layer is additionally developed, which spirally surrounds the vascular wall. As a result, the middle muscle layer of such arteries becomes thicker, relative to the middle layer of arteries of a different caliber.

Special patterns were observed in the development of the vessels of the pulmonary circulation. According to the structure, qualitative and quantitative composition of the walls, the pulmonary trunk and pulmonary arteries belong to the vessels of the elastic type. The inner diameter of these arteries was larger than the outer one. Minor age-related changes in the arteries were observed. Age-related changes were observed in all layers of the arteries. In 21-day-old rats, an increase in elastic fibers in the wall of the pulmonary trunk was revealed. The growth rate of the pulmonary trunk was 30%, and of the pulmonary arteries, on average, 25%. In 21-day-old rats, the thickness of the adventitial layer of small blood arteries was higher than in the previous period. This indicator in the pulmonary trunk is 30%, in the right pulmonary artery - 32% and in the left arteries - 28%. There is an increase in the size of the inner and outer diameters, thickening of the walls of the

pulmonary trunk, right and left pulmonary arteries in 12-month-old rats. In the outer layer of these arteries, an increase in the number of collagen fibers compared with the previous age was observed. The thickness of collagen fibers in the lung trunk increased by 2.2 times, in the right lung - by 1.7 times, in the left - by 1.4 times. Thus, there was a decrease in the ratio of the middle and outer layers of these arteries. In the pulmonary trunk, this ratio was 1:0.95; in the right pulmonary artery - 1:0.91, in the left pulmonary artery - 1:0.89. During this period, compared with a young age, in the adventitia layer, one can see a thickening of collagen and elastic fibers by 75.2% and 50%. When comparing the morphometric parameters of the arteries of this age with the previous age period, an increase in the outer diameter was noted. A correlation was established between the outer and inner diameters of all arteries, regardless of the size of the arteries. There is a change in the size of the middle layer of the vessel. Significant changes were observed in the arteries of medium and large calibers. Compared to the previous period, there was an increase of 3.5 and 4.9 times.

In 24-month-old rats, morphological and morphometric changes were noted in all layers of the vessels of the pulmonary circulation. There is an increase in the number of collagen fibers in all layers of the pulmonary trunk and pulmonary arteries. By this time, there is an increase in the inner diameter of the pulmonary trunk and pulmonary arteries by 32%, 25% and 21%, and the outer diameter by 34.6%, 22% and 20% (see table 1).

Table 1

Indicators of the main arteries of the pulmonary circulation, mm

Arteries	**Показатели**			
	Outside diameter	Inner diameter	Average layer thickness	Outer layer thickness
lung trunk	3,5 ± 0,08	3,5± 0,08	1,003± 0,001	0,96 ± 0,0006
Right leg artery	1,94± 0,04	1,83 ± 0,04	0,105 ± 0,001	0,082 ± 0,0002
Left pulmonary artery	1,64 ± 0,03**	2,3± 0,01**	0,098 ± 0,001**	0,078± 0,0003

*Note: * - p‹0.05 significant in relation to the control group*

The thickness of collagen fibers in Truncus pulmonalis increased by 2.2 times, in arteria pulmonalis dextre - by 1.7, in arteria pulmonalis sinistre - by 1.4 times.

Thus, there was a decrease in the ratio of the middle and outer layers of these arteries. In truncus pulmonalis, this ratio was 1:0.95; in arteria pulmonalis dextre - 1:0.91, in arteria pulmonalis sinistre - 1:0.89. During this period, in the adventitial layer, one can see a thickening of collagen fibers by 75.2% and 50% compared with the previous age.

An increase in the outer diameter was observed in all arteries of the pulmonary circulation in rats of this age. In the arteries of the muscular type, these changes are clearly reflected. At this age, an increase in the outer diameter of the arteries of the muscular type by 56.2%, arteries of the muscular-elastic type by 25% was

established. However, the increase in internal diameter was not significant in all arteries. As for arteries of other ages, there is a correlation between changes in the outer and inner diameters of arteries at this age (r=0.96). There is a change in the thickness of the walls of the arteries.

In muscular arteries of large and medium caliber, the thickness of the middle layer varies from 3.1 to 4.3. However, no correlation was found between changes in the outer and inner diameters of the arteries and the thickness of the middle layer. The change in the thickness of the adventitial layer in all layers was 43–47%. The thickness of the adventitial layer of large arteries of the muscular-elastic type prevails over the thickness of the muscle layer, the ratio is 1:1.17. In arteries of other sizes, the thickness of the middle layer of the arteries prevailed, and in the muscular arteries of medium caliber, the ratio of the adventitial and medial layers is 1:0.36, in the small arteries of the muscular type, 1:0.6. In the course of the study, it was determined that the Kernogan index in the arteries of the muscular type and in the arteries of small caliber was higher, and in the arteries of the muscular-elastic type, due to the large internal diameter, the Kernogan index had low values. Our studies revealed a correlation between the inner and outer diameters of arteries and the Kernogan index. Also, a strong correlation was found between the average and outer diameters of the pulmonary arteries (r=0.89). In muscle-type arteries of smaller diameter, a correlation between the thickness of the adventitia layer and the diameter of the arteries was confirmed (r=0.98). There is also a positive correlation between the areas of the adventitial and middle layers (r=0.94). When comparing the weight of the rats of the control and experimental groups, the body weight of the rats of the control group in the early stages of the experiment was increased relative to the rats of the experimental group.

In order to verify diabetes mellitus in rats, the amount of sugar in the blood was determined at different times of the experiment. In dynamics, in the first days of the experiment, the blood sugar level in rats of the experimental group increased from 7.9 to 15.9 mmol/l and remained above 15 mmol/l. Against the background of diabetes mellitus, changes in the walls of the arteries of the pulmonary circulation were observed. On the 120th day of the experiment, some changes were revealed in the walls of the pulmonary trunk and pulmonary arteries relative to the control group. Mucoid and fibrinoid swelling of the inner layer are determined. Atherosclerotic plaques of a circular or segmental form of varying degrees of development were revealed, these plaques are built from collagen and elastic fibers, thickened areas are noted in the inner layer of the pulmonary arteries. In the thickened areas, dystrophic changes were not detected, but there was a thickening of the connective tissue. During these terms of the experiment, a decrease in the cross-sectional area of the arteries of the elastic type was noted relative to the control group.

During this period of research, a decrease in the inner diameter is noted due to hyperplasia of the inner layer of the pulmonary arteries. The surface layer of plaques

visible on the inner layer of the pulmonary arteries consists of dense connective tissue, and the part adjacent to the elastic membrane is represented by delicate connective tissue. In this part, cholesterol crystals are determined. In 12–24-month-old rats, one can see obvious changes in the wall of the arteries of the pulmonary circulation. In the inner layer of the pulmonary arteries in the area of hyperplasia, connective tissue fibers were located on the surface of the plaques, compacted and grew deep into the atherosclerotic plaque.

Neutral mucopolysaccharides were determined in all layers of the pulmonary arteries. Disintegration, thickening of the fibers of the elastic membrane along the wall of the blood vessel is noted. There is swelling of the subendothelial layer and the appearance of macrophages in these areas. Due to desquamation and proliferation of endothelial cells, the appearance of a parietal thrombus was noted. In the period of 24 months, you can notice the beginning of the process of sclerosis in the walls of the arteries of the elastic type.

In the initial periods of the experiment, changes were observed in small-caliber muscle-type arteries. These changes were manifested by hyperplasia of the inner wall of the arteries, followed by a thickening of the elastic membrane and the development of plaques. The presence of such changes in the main arteries has been scientifically substantiated. The appearance of the above signs is manifested by a narrowing of the cavity of the arteries. This, in turn, causes blood clots.

Visualization under a transmission electron microscope of the arteries of the pulmonary circulation in the experimental group. The space of the pulmonary capillaries in the experimental group is empty, but erythrocytes are visible in some capillaries, and they seem to be layered on top of each other in the form of coins. This indicates the process of stasis in the capillaries. Endotheliocytes in most capillaries are dystrophically changed according to the dark type.

It has been established that pericytes are of the light type. In some pericytes, formations of lipids and lipofuscin may occur. You can see the capillaries in which the normal structure of the basement membrane has changed. It can be seen that the capillary space is filled with collagen fibers. In some capillaries, the integrity of the basement membrane of the capillaries was broken; at the border with the pericapillary space, various levels of lipofuscin accumulation were observed.

Conclusion. As a result of the research, the following conclusions are presented:

At different stages of the period of postnatal ontogenesis in the walls of the arteries of the pulmonary circulation, there is an age-related increase in collagen fibers in the middle and outer layer of the vessel wall, thickening of the artery wall, and an increase in the Kernogan index.

A strong correlation (r=0.89) was established between the middle layer and the outer diameter of the main and intrapulmonary arteries of the lung. Also, there is a high correlation between the thickness of the adventitia and the diameter of the artery (r=0.98)

and a positive correlation (r=0.94) between the area of the adventitia and the middle layer of the artery.

Against the background of diabetes mellitus, atherosclerotic changes, hyperplasia of the connective tissue of the inner wall and narrowing of the vessel cavity are detected in the walls of the arteries. Scientifically substantiated changes in the arteries of the muscular type in the early stages of the experiment, and in the later stages of the experiment, changes were found in all types of arteries.

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