

ORIGINAL ARTICLE

AGE FEATURES OF THE STRUCTURE OF THE BLOOD VESSELS OF THE SOME DIGESTIVE GLANDS AND ITS RESTRUCTURING IN THE INITIAL STAGES OF EXPERIMENTAL DIABETES MELLITUS

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ABSTRACT

The aim: The purpose of the work was to study the peculiarities of blood supply the pancreatic islet of the 24-month-old rat, and its restructuring during the initial periods of experimental diabetes mellitus.

Materials and methods: The work was performed on 20 white outbred rats - males weighing 340-420g. 24 months of age, kept in standard vivarium conditions in compliance with all accepted ethical rules. Experimental streptozotocin diabetes mellitus was simulated in 16 animals. The material was taken on the 14th and 28th day of the experiment.

Results: Reorganization of the endocrine part of the pancreas in the early stages of experimental diabetes is characterized by a decrease in the number and area of pancreatic islets, a decrease in the diameter of the lumen of arterioles, precapillaries, postcapillaries compared to the control group of animals by 7% and 5%. The diameter of the capillaries decreases by 16% and reaches $3.8 \pm 0.62 \mu\text{m}^2$, and the diameter of the venules increases by 12%. In some blood vessels there are phenomena of desolation and edema of perivascular connective tissue, which is manifested by a decrease in optical density and stratification of collagen fibers.

Conclusions: Thus, the reorganization of the circulatory system of the endocrine part of the pancreas of 24-month-old rats in the early stages of experimental diabetes mellitus is characterized by a decrease in the number and area of pancreatic islets.

KEY WORDS: diabetes mellitus, blood vessels, pancreatic islet

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INTRODUCTION

Diabetes is a priority problem for national health systems worldwide. The prevalence of this pathology is increasing. If today in the world there are about 425 million patients with diabetes, then in 2030 there will be about 620 million [1, 2]. Diabetes mellitus (DM) is recognized as one of the most common non-infectious diseases, because the number of patients is growing exponentially, and the pathology itself is characterized by a high risk of vascular complications such as diabetic retinopathy, nephropathy, diabetic foot. In addition, the number of incidence of myocardial infarction and stroke in patients with diabetes is significantly higher than the average in the population [3, 4]. All this leads to disability and premature death of such patients.

In the literature there is a large amount of work devoted to the study of the peculiarities of organs and systems in diabetes, but the results are often controversial because the focus is mainly on the functional aspects, clinical manifestations, but the features of morphofunctional changes, and their dynamics remain unaddressed, while they are the basis for unraveling the mechanisms of multifaceted complex pathogenetic transformations under such conditions [5, 6].

The foregoing defines the need for scientific research that constitutes the subject of this work and substantiates its relevance

THE AIM

The purpose of the work was to study the peculiarities of blood supply the pancreatic islet of the 24-month-old rat, and its restructuring during the initial periods of experimental diabetes mellitus.

MATERIALS AND METHODS

The work was performed on 20 white outbred rats - males weighing 340-420g. 24 months of age, kept under standard vivarium conditions in compliance with all accepted rules («Common Ethical Principles for Animal Experiments», approved by the First National Congress on Bioethics (Kyiv, 2001) and «European Convention for the Protection of Vertebrate Animals Used for experimental and other scientific purposes» (Strasbourg, 1985) [7]. For the experiment of animals was divided into two groups: the first - intact (6 animals), the second - experimental (14 animals), which simulated experimental DM by a single intraperitoneal injection of streptozotocin («Sigma», USA) at a dose of 5 mg / 100 g of body weight pre-diluted in 0.1 M citrate buffer with a pH of 4.5 [8] from the study structures and parts hemomicrocirculatory vessels at 14 and 28th day of the experiment, including 4 animals which served as controls.

Ultrastructural features of the vessels were studied under an electron microscope PEM-125 K with an accelerating voltage of 75 kV. Microphotography of the preparations

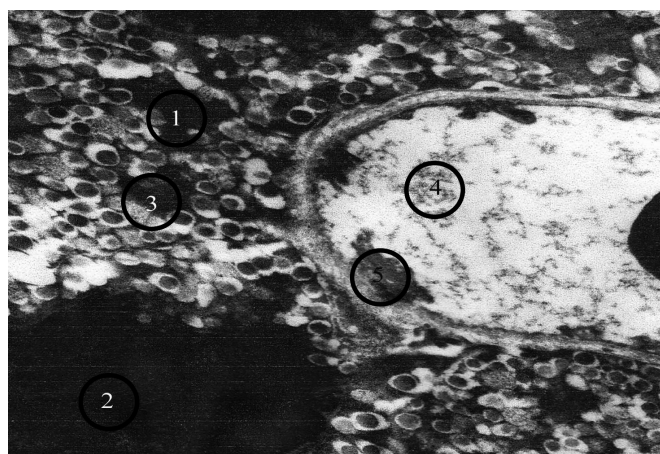


Fig. 1. The ultrastructure of the fenestrated type capillary in the pancreatic islet of a 24-month-old rat. (micrograph. Col. x 8000)

1- B-cell; 2 - core; 3 - secretory granules; 4 - hemocapillary of fenestrated type; 5 - outgrowths of the luminal plasmolemma of endothelial cells.

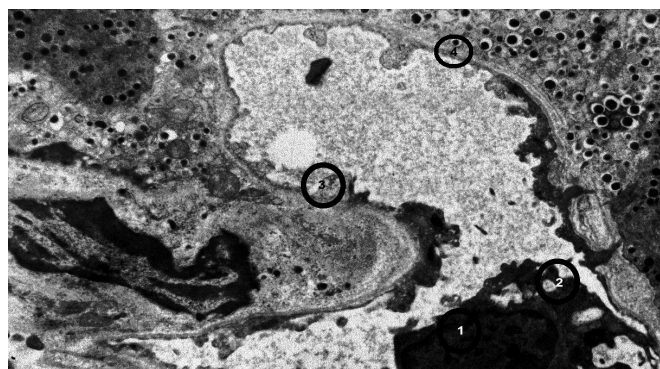


Fig. 2. Submicroscopic changes of the capillaries of the software after 2 weeks from the start of the simulation of the (micrograph. Col. x 9600)/

1 - the nucleus of the dark endothelial cell, 2 - the cytoplasm of the dark endothelial cell, 3 - the cytoplasm of the light endothelial cell, 4 - the fenestra.

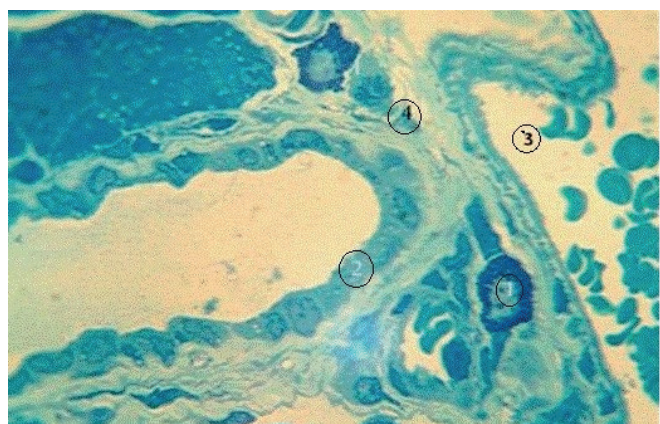


Fig. 3. Bloodvessels in rat peri-insular connective tissue of rat 24 months of age at 4 weeks from the start of simulation of streptozotocin diabetes. Semi-thin section: Coloring: toluidine blue: Lens: 10, eyepiece. 100.

1 - tissue basophil; 2 - arterioles; 3 - venules; 4 - macrophage.

was performed on a MC 300 trinocular microscope (TXR) with a DCM 900 connected Digital camera for microscope using Scope Photo software [9].

The preparations were examined under a Leica DM 750 light microscope and photographed using an industrial digital camera UHCCD05100KPA-U-NA-N-C-SQ-NA. Computer data processing was carried out using the statistical package Stat.Soft.Inc; Tulsa, OK, USA; Statistica 6 [10].

RESULTS

Studies have shown that the endocrine portion of the pancreas of 24-month-old male outbred rats is formed by pancreatic islets (PI), which are clusters of cells surrounded by a thin layer of connective tissue that separates them from the exocrine. Such islets are predominantly rounded or oval in shape and uneven contours, the average amount of PI per 1 mm² of the parenchyma is (9.87 ± 0.35) and their diameter in animals of this age group is (96.4 ± 2.23) μm, the area is $(11788,84 \pm 658,25)$ μm².

The endocrine cells PI on histological preparations look light against the background of the dark exocrine parenchyma. In the cytoplasm of the latter, a well-developed protein-synthesizing apparatus such as: Golgi complex, granular endoplasmic reticulum and secretory granules, and by their properties endocrine cells are divided into four main varieties: B-cells, A-cells, D-cells, PP- cells.

The blood supply PI of the pancreas software of rats is from the sources shared with the exocrine part.

Arterioles with an average diameter (20.6 ± 0.29) μm originate from the arteries and are located in the layers of connective tissue around the islets. Branching, they form precapillaries. Studying serial semi-thin sections PI of software we found that vessels, which we morphologically attributed to precapillaries, form open and closed loops, and surround the islets and give rise to capillaries lying between endocrinocytes, anastomoses, form a thick capillary grid.

Due to the alternation of narrowed and expanded areas, the lumen of the precapillaries looks uneven and their average diameter is (9.1 ± 0.15) μm. The diameter of the lumen of the capillaries is (4.7 ± 0.52) μm. The fusion capillaries form post-capillaries with a diameter (11.6 ± 0.15) μm emerging from the endocrinocytes and fusing to form venules with a diameter (32.7 ± 0.40) μm, which lie adjacent to the arterioles in the connective tissue layers. surrounds the software. As a result, we found a correlation between the area of the software and the number of vessels per 0.1 mm² of their area = 0.9; p = 0.037.

The capillaries of the software belong to the visceral type capillaries and are lined by fenestrated endothelial cells, which disperse on the basal membrane of uneven thickness, and their luminal surface forms a few broad protrusions into the lumen of the vessels (Fig. 1). The secretory compartments of endocrinocytes adjacent to the capillaries contain a large number of granules.

On the 14th day from the beginning of the experimental diabetes mellitus (EDM) simulation, the average amount of PI by 1 mm² compared to the control decreases almost 9 times and is (1.19 ± 0.12) (p < 0.01), and the area of the software decreases to (4919.52 ± 349.44) μm² (p < 0.001).

In the cytoplasm of cells, which mainly contain B-type granules with pronounced polymorphism - polymorphic optical density of the matrix, there are areas of fusion of granules of secretory material, and located chaotically in the cytoplasm, no concentration near the surface inverted to the microvessels.

Reorganization of vessels of the bloodstream on the software of animals of this age group in this period is characterized by a decrease in the lumen of the arterioles to $(20,1 \pm 0,49) \mu\text{m}^2$ ($p < 0,05$), precapillaries to $(8,3 \pm 0,12) \mu\text{m}^2$ ($p < 0,01$), capillaries up to $(4,7 \pm 0,67) \mu\text{m}^2$ ($p < 0,05$), and the growth of the lumen of post-capillaries and venules according to $(10,8 \pm 0,22)$ and $(35,3 \pm 1,65) \mu\text{m}^2$ ($p < 0,05$).

In some vessels, there are phenomena of perivascular connective tissue are swelling and characterized by a decrease in optical density and stratification of collagen fibers.

The cytoplasm of endothelial cells forms a «rope-like» region due to the large number of fenestrae and local thickening with growths on the luminal surface. The presence of light and dark endothelial cells was determined electronically microscopically (Fig. 2). Thickened basement membrane without clear borders, sometimes exposed.

On the 28th day from the beginning of the EDM simulation, the number of endocrinocytes in the composition of the software is still significantly reduced and is $88,6 \pm 1,37$ per $0,1 \text{ mm}^2$ of the software area ($p < 0,05$) due to A- and B-cells. The average number of islets per 1 mm^2 did not change significantly from the previous term of $1,15 \pm 0,21$, and the area of the software continued to decrease and was $4728,81 \pm 371,82 \mu\text{m}^2$ ($p < 0,05$).

The number of immunocytes in the peri-insular and insular zones is negligible with intravascular location. There is a considerable amount of tissue basophils, the cytoplasm of which is tightly filled with granules of secretory material (Fig. 3).

With regard to the lumen of the micro vessels at this time course of the EDM, the diameter of the lumen of arterioles, precapillaries, postcapillaries decreases compared to the previous term (14 days) and the control group of animals by 7%, 5% and 8%, respectively. The capillary diameter decreases by 16% to reach $3,8 \pm 0,62 \mu\text{m}^2$, and the diameter of venules increases to $41,6 \pm 1,26 \mu\text{m}^2$.

DISCUSSION

Thus, in the morphometric study of blood vessels in the early stages of experimental diabetes, there is a probable decrease in the average diameter of arterioles and precapillaries, while the values of the diameter of the lumen of the venules increased. The wall of precapillaries and postcapillaries is elegant, with numerous fenestrates, which is not typical for type 2 diabetes, because according to some authors in type 2 diabetes, along with lipomatosis, sclerosis and atrophy of the pancreas, which were found in all age groups, in the walls of blood vessels develop changes in both cellular and fibrous structures, characterized by plasmorrhagia and accumulation of hyaline in the vessel walls of the microcirculatory tract [11].

Interstitium has signs of hyperhydration. Monocytes and lymphocytes were observed in the perivascular connective tissue with signs of edema. What correlates with the data of other authors regarding the organs of the oral cavity, which note that against the background of diabetes the risk of periodontal pathologies increases, this somatic disease complicates the course of periodontal disease due to impaired microcirculation in the periodontal complex tissues [12]. Instead, other authors note the lack of phagocytic functions and immune protection of oral tissues, reduction of resistance to pathogenic microflora of the oral cavity, the accumulation of toxic products released due to disruption of all types of metabolism [13], which can be explained by the duration of the pathological process.

The cytoplasm of capillary endotheliocytes is thin, with a large number of closely spaced fenestrae, there are microvilli on the adluminal surface.

CONCLUSIONS

Therefore, the reorganization of the bloodstream of the endocrine part of the pancreas of 24-month-old rats in the early stages of experimental diabetes mellitus is characterized by a decrease in the number and area of pancreatic islets, narrowing of the arterial part of the hemomicrocirculatory tract, and dilation of its venous part.

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Conflict of interest:

The Authors declare no conflict of interest.

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