PATHOMORPHOLOGY OF THE PANCREAS IN ACUTE GENERAL HYPERTHERMIA

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The structure of the pancreas was investigated after acute hypothermia lasting 1 h. The pathomorphological picture comprised acute edema of the stroma, dilatation and congestion of the blood vessels with perivascular hemorrhages, intravascular leukocytosis, foci of infiltration with lymphocytes and leukocytes, capillary stasis, and degranulation of β-cells in the islets of Langerhans.

Exposure to a high external temperature and to insolation depresses the external pancreatic secretion in animals [7, 8, 11, 13, 14]: the volume of secretion produced is reduced, the total duration of period is shortened, and changes take place in the dynamics of secretion. Besides a decrease in the total pancreatic secretion, an increase in the enzyme concentration in the external pancreatic secretion has been observed [5, 9, 10, 12]. Unlike the exocrine function of the pancreas, its endocrine function is stimulated by exposure to a high external temperature [4, 15]. The activity and reaction of the pancreas, especially of its insular apparatus, are intimately connected with the function of the hypothalamus, pituitary, and adrenals [2, 3, 4, 15].

The object of the investigation was to study changes in the pancreas caused by hyperthermia.

EXPERIMENTAL METHOD

Experiments were carried out on 110 guinea pigs and albino rats. The animals were kept for 1 h in a chamber at 45°, and then sacrificed at intervals of 1, 6, and 24 h and 2, 5, and 8 days after the end of exposure. Pieces of pancreas were fixed in 10% neutral formalin and in Zenker-formol by Helly's method and embedded in paraffin wax; sections were cut to a thickness of 5-6μ. The following methods of investigation were used: staining with hematoxylin and eosin, with iron-hematoxylin by Heidenhain's method, by Mallory's method, with azocarmine by Heidenhain's method, with fuchselin and counterstained by Van Gieson's method, impregnation with silver by the method of Gomori and Foot, staining with aldehyde-fuchsin and counterstaining by Halmi's method, and the reactions of Brachet and Feulgen for nucleoproteins.

EXPERIMENTAL RESULTS

Histological examination of the pancreas 1 and 6 h after exposure of the animals in the chamber revealed hemodynamic changes: arteries of different caliber in the parenchyma of the gland and interstitial tissue were greatly dilated and congested, and marked edema of the interlobular connective tissue was present (Fig. 1). The veins also were sharply dilated everywhere and congested, and the blood in them showed a redistributive leukocytosis of varied degree. Against this background there were frequent perivascular hemorrhages around the arteries and veins of different caliber (Fig. 2). Small hemorrhagic foci were found principally in the connective-tissue stroma of the gland, while larger hemorrhages were dis-

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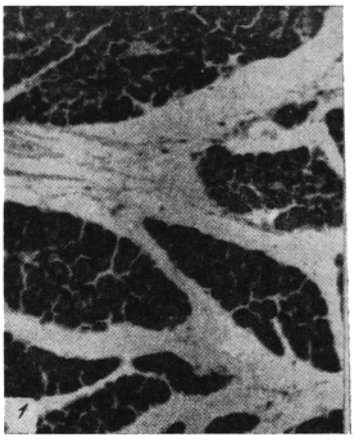

Fig. 1.

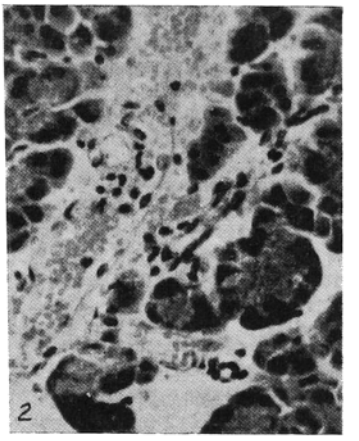

Fig. 2

Fig. 1. Marked edema of the pancreatic stroma (rat No. 1); 1 h after hyperthermia; hematoxylin–eosin; 75 ×.

Fig. 2. Perivascular hemorrhage around a grossly dilated and congested vein (rat No. 7); 1 h after hyperthermia; hematoxylin–eosin; 250 ×.

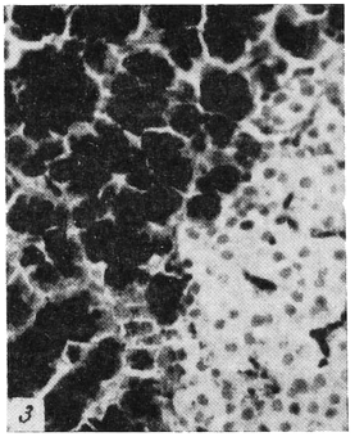

Fig. 3

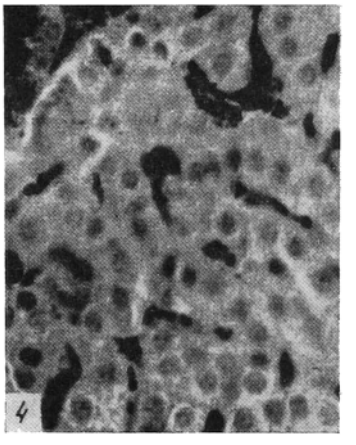

Fig. 4

Fig. 3. Dilated acini with a high content of secretion (rat No. 11); 1 h after hyperthermia; Mallory; 250 ×.

Fig. 4. Islet of Langerhans with dilated capillaries, showing signs of stasis and pericapillary hemorrhages (rat No. 9); 6 h after hyperthermia; Mallory; 500×.

tributed in the tissue of the gland, causing separation and compression of the lobules. Foci of disturbance of the normal arrangement of the acinar cells of the gland were seen. The argyrophilic skeleton of the gland was swollen in places and had lost its delicate pattern. Superimposed on these changes, small focal clusters of lymphocytes and leukocytes were common in the edematous interlobular connective tissue. Six hours after exposure, in individual cases massive areas of infiltration of the same character were found. The swollen acinar cells of the pancreas had a high content of secretion (Fig. 3), and the intralobular and interlobular ducts of the gland were dilated and distended with secretion. Whole lobules and, sometimes, whole lobes of the pancreas were occupied by foci of vacuolation of glandular cells.

The capillaries of the islets of Langerhans were dilated and their lumen packed with erythrocytes; signs of stasis were present (Fig. 4). Foci of exudation of plasma were numerous. Hemorrhages and

small foci of infiltration with lymphocytes and leukocytes were much less common and were less well developed than in the stroma. Irregular degranulation of the cytoplasm was observed in the β-cells of the islets of Langerhans, and in some cases the granules had almost completely disappeared.

The morphological changes described above were less marked 24 h after the end of the experiment. Edema of the stroma was reduced, the lumen of the blood vessels of the gland was contracted, the degree of their congestion was lower, and the intravascular leukocytosis was less severe. The changes in the pancreas were still less marked 48 h after the experiment. The structure of the gland was almost back to normal after 5 and 8 days.

Under the influence of hyperthermia pancreatic secretion is reduced. Experiments [6] have shown a correlation between the velocity of the blood flow and the rate of pancreatic secretion, which is depressed when the blood flow is reduced [5]. According to the results of the present experiments, acute general hyperthermia in small animals is accompanied by predominantly hemodynamic disturbances in the pancreatic blood vessels and by a characteristic pathological picture reflecting their effects on the secretory function of the gland.

The experiments now described revealed numerous zymogen granules, an increase in the volume of the acinar cells, distension of the dilated intralobular and interlobular ducts with secretion, and areas of marked vacuolation of the glandular cells. Most previous investigators, however, observed depression of the external secretion of the pancreas. In the writer's opinion, the discrepancy between the morphological and clinical data can be explained by stasis of the secretion in the glandular cells and ducts because of disturbance of the output of secretion.

Some time ago, Ricker [16] described the stages of disturbance of the hemodynamics. According to his observations, to begin with the vessels dilate and the blood flow becomes faster, but this is soon followed by slowing, initially of the capillary and venous, and later of the general blood flow, with exudation of plasma and palisading of leukocytes in the veins, followed by their migration into the tissue. All these phenomena were observed in the pancreatic vessels in different parts as a response to hyperthermia, thus indicating that the vascular reaction is focal in nature and varied in degree. Abrikosov [1] attached great importance to the disturbance of the circulation in the pancreas as a cause of disturbance of its function and considered that a frequent result of this disorder is hemorrhages, in his opinion reflex in character.

Investigation of the adrenals of animals has shown that thermal trauma causes the development of tissue reactions typical of the general adaptation syndrome. The changes in the adrenals are evidently directly dependent on changes in the pancreas, and they are due to the close functional links between the endocrine glands. Moreover the whole endocrine system participates in the response to stress and the adaptation reaction. In animals under hyperthermia it can be seen very clearly how the adrenals and pancreas react to an acute stimulus; this is particularly true of the insular apparatus of the pancreas, controlling carbohydrate metabolism. During hyperthermia there is degranulation of the β-cells, severe in places. This suggests that the reaction of the insular apparatus is stereotyped in character, similar to the reaction to other extremal factors: irradiation, repeated electrical stimulation, chronic tetracycline poisoning [3].

The findings described above are evidence of the complexity of the processes developing in the animal body during hyperthermia and, in particular, in the pancreas. The reaction of its vascular system can hardly be a purely local phenomenon, and there is no question that the changes described above are one of the components of a protective reaction of the body, directed at compensation of the effects of exposure to the extremal factor and at restoring the normal function of the organ, so that the complex process of adaptation of the new external environmental conditions can take place.

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