REGENERATION OF THE PANCREAS IN SOME MAMMALS

K. A. Zufarov and N. D. Aseeva

UDC 612.6.34:612.6.03]-019:597/599

Regeneration of the pancreas after resection follows a similar course in the monitor, pigeon, and rat. The basic form of regenerative hypertrophy. The role of formation of glandular elements de novo at the edge of the defect is insignificant.

* * *

Many experimental investigations on the pancreas have shown that restoration of this organ after crushing or burns, takes place through regenerative processes at the edge of the defect and in the residue of the organ [2-4]. However, data in the literature on regeneration of the pancreas after resection are conflicting. Many investigators report that restoration of the organ takes place mainly by regenerative hypertrophy [1, 5-9], while others pay more attention to proliferation of gland tissue from the edge of the defect.

The object of the present investigation was to study regeneration of the pancreas not only in mammals (rats), but also in birds and reptiles (pigeons and monitors).

Because of the specialized structure of the pancreas in pigeons, consisting of two large lobes lying within a loop of small intestine, it was possible to study the morphological state of the resected and relatively intact lobes after excision of half of the organ.

EXPERIMENTAL METHOD

Experiments were carried out on 60 rats, 64 pigeons, and 20 monitors. Wedge-shaped areas of the gland (monitors, rats) or half the organ (pigeons) were removed and the animals were sacrificed in a fasting state after decapitation at periods of between 12 h and 360 days after the operation. Pieces of tissue taken from the edge of the operation wound and some distance from it were fixed in 12% neutral formalin, in Carnoy's and Regaud's fluids, by Aoyama's method, and in 80° alcohol. Paraffin sections were stained with hematoxylin-eosin and by Van Gieson's and Gomori's methods. Nucleic acids, polysaccharides, alkaline phosphatase, mitochondria, and the Golgi apparatus were demonstrated. The dimensions of the cells were estimated indirectly from the decrease in their number per field of vision of the microscope (the field of vision was restricted by a window in the ocular measuring 2×2 mm). The results were subjected to statistical analysis. The mitotic index was calculated per 10,000 cells.

EXPERIMENTAL RESULTS

The response of the exocrine cells to mechanical injury was uniform in all investigated animals and was directly dependent on the severity of trauma. Some cells died and disintegrated. Cells further from the site of trauma, i.e., under more favorable conditions underwent dedifferentiation. This distinctive response of the pancreatic epithelium was analogous in the different vertebrates (monitors, pigeons, rats). It took the form of flattening of the gland cells lining the terminal portions and ducts situated at the edge of the defect. The epithelium was characterized by absence of secretory granules, differentiation of the cytoplasm into zones, changes in the shape and localization of the mitochondria, and Golgi apparatus, redistribution and relative decrease in the nucleic acid content, and appearance of granules of glycogen and alkaline phosphatase, normally absent, in the cytoplasm of some of its cells. As a result of dedifferentiation of the terminal portions and ducts, most of them were converted subsequently into cyst-like spaces while others served as the source for formation of a few ducts and terminal portions of glands de novo.

Department of Histology and Embryology, Tashkent Medical Institute. (Presented by Active Member of the Academy of Medical Sciences of the USSR N. N. Zhukov-Verezhnikov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 67, No. 3, pp. 84-87, March, 1969. Original article submitted June 19, 1967.

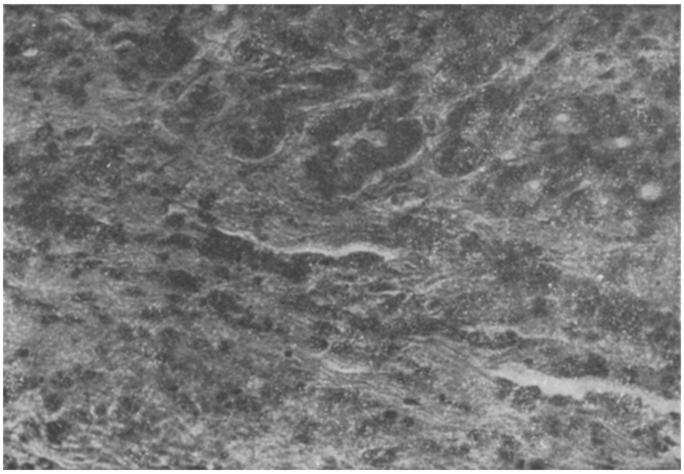

Fig. 1. Edges of wedge-shaped excised zone of pancreas in a monitor 4 months after operation. Negligible new gland formation at border with condensed connective tissue. Hematoxylin-eosin, 400 ×.

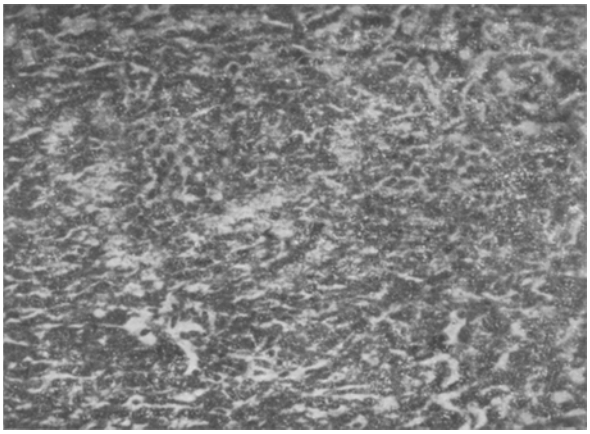

Fig. 2. Parenchyma of resected lobe of pancreas in a pigeon one year after operation. Hematoxylin-eosin, 200 ×.

However, the negligible formation of new glandular structures at the edge of the defect on account of differentiated and proliferating cells of the terminal portions and ducts was of no essential importance, because in every case the area of regeneration was microscopically small, and most of its structures showed cystic degeneration or were compressed by coarse connective tissue. Only in the pigeon, after resection of one-fifteenth of the gland, did the small number of newly formed gland structures play a substantial role in correction of the wedge-shaped defect. By 3 months this defect could no longer be detected, being filled with pancreatic tissue indistinguishable from that surrounding it (however, the possibility of repair processes taking place at a distance from the site of injury could not be excluded). In the monitor, however, the small area of gland removed (1-15th of the organ) was replaced by coarse connective tissue, and the small number of newly formed terminal portions remained functionally imperfect even after 4.5 months (Fig. 1). Evidence of this was given by the absence of zymogen granules and of division of the cytoplasm into zones, and also by the atypical state and arrangement of nucleic acids, and organoids.

The results obtained by examination of the relatively intact and resected lobes of the pancreas after removal of half this organ from the pigeon were particularly interesting. On the 10th day after operation, proliferation of connective tissue was observed along with the formation of a few terminal portions and ducts at the edge of the defect. Subsequently, this connective tissue not only prevented the formation of new glandular tissue at the edge of the defect, but also compressed and caused atrophy of the parenchyma far from the site of injury (Fig. 2). For this reason the weight of the resected lobe was reduced, and in some cases after one year it was only 40 mg (normally 506 mg). The weight of the intact lobe of the gland in some animals 6 months after operation was more than twice or three times its normal weight. One year after operation the weight was a little lower. Hypertrophied cells of the terminal portions in this lobe contained a large nucleus richly supplied with DNA granules and a pyroninophilic nucleolus. The presence of substances staining intensely with pyronine, of many large and well outlined mitochondria, and of a hypertrophied Golgi apparatus in the basal parts of the cells indicated increased functional activity of the gland. Bearing in mind also that hypertrophy of the cells was accompanied by an increase in the mitotic index, the existence of regenerative hypertrophy of the lower lobe was evident. The lymphoid tissue of the pigeon's pancreas was particularly interesting. On the 3rd day after the operation it was present in large quantities at the edge of the defect, and later, throughout the period of investigation, it was found both at the site of injury and some distance from it.

Hence, in different classes of vertebrates (reptiles, birds, and mammals), a definite similarity exists in the course of restorative processes.

In every case the role of regenerative processes taking place at the edge of the defect is negligible and the principal form of restoration of the pancreas is by regenerative hypertrophy.

The cells in the regenerating pancreas are characterized by increased functional activity.

LITERATURE CITED

1. A. G. Babaeva, L. D. Liozner, and V. F. Sidorova, in: Proceedings of the 4th Conference on Regeneration and Cell Multiplication [in Russian], Moscow (1964), p. 9.
2. G. N. Voronin, in: Annual Report of the Institute of Experimental Medicine of the AMN SSSR for 1961-1962 [in Russian], Leningrad (1963), p. 170.
3. Yu. N. Kopaev, in: Problems in Regeneration and Cell Division [in Russian], Moscow (1959), p. 18.
4. L. N. Moralev, Data on the Problem of Reactivity of the Pancreatic Tissues, Candidate Dissertation, Kursk (1957).
5. S. S. Raitsina, L. M. Farutina, and V. N. Kashintseva, Arkh. Anat., Gistol. i Émbriol., No. 10, 43 (1965).
6. G. V. Segida, Byull. Éksperim. Biol. i Med., No. 11, 88 (1962).
7. G. V. Segida and E. Ch. Pukhal'skaya, Byull. Éksperim. Biol. i Med., No. 2, 102 (1965).
8. V. F. Sidorova and A. G. Babaeva, in: Conditions of Regeneration of Organs and Tissues in Animals [in Russian], Moscow (1966), p. 258.
9. I. A. Shevchuk, R. I. Polyak, T. F. Mel'nik, et al., in: Conditions of Regeneration of Organs and Tissues in Animals [in Russian], Moscow (1966), p. 325.