CHANGES IN THE PANCREAS FOLLOWING DIVISION OF THE RIGHT VAGUS NERVE BELOW THE DIAPHRAGM

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The findings published on the subject of the influence of the vagus nerve on the pancreas are contradictory [1, 3, 8, 10, 12, 13, 14]. The conclusions reached by writers are frequently based on mathematical computation of results obtained in a limited area of a histological section.

Investigations of isolated pieces of the gland cannot provide sufficiently reliable information on the state of the islets of Langerhans and the acinar tissue in the gland as a whole, for the distribution of islets throughout the pancreas is irregular. The tail of the human pancreas contains many islets, and there are significantly fewer in the body and head. In several animals (frogs, snakes, dogs, cats, rodents, whales, etc.) the splenic portion of the pancreas is twice as rich in islets as in the median and duodenal portions. Moreover, in all parts of the gland individual lobules can be found which do not contain islets [5, 7, 9]. Our findings agree fully with those in the literature. In white rats, as in other species of experimental animals, the "density" of distribution of the islets is variable.

Determination of the insulin concentration as an index of the hormonal activity of the pancreas is also carried out, as a rule, without taking into account the relative proportions of islet and acinar tissues.

The object of the present investigation was to ascertain the role of the nervous mechanism in the function of the islet and acinar tissues of the pancreas. For this purpose we used the method of exclusion of the right vagus nerve by subphrenic vagotomy. We did not exclude both nerves, for the additional changes in the function of the whole gastro-intestinal tract could distort the results. As our special investigations using the dissection method showed, the vagus nerve in white rats gives off branches of the pancreas, the solar plexus, the liver, and the stomach. Branches from the left vagus pass to the anterior wall of the stomach, the liver, and the root of the mesentery.

EXPERIMENTAL METHOD

Experiments were conducted in 105 male white rats weighing 120-180 g; 150 intact animals were used for control estimations of the number of islets of Langerhans, the relative volumes of islet and acinar tissues, and the insulin content. Right subphrenic vagotomy was performed on the experimental animals under ether anesthesia.

It was impossible to study the changes in the relative proportions of acinar and islet tissues and in the number of islets of Langerhans in the whole gland during chronic experimental conditions, and we therefore limited our observations to two periods – $1^1/_2$ and 3 months after operation, from which we were able to detect a definite trend in the changes arising in the pancreas after partial denervation.

The number of islets of Langerhans and the volumes of islet and acinar tissues were determined by the method of vital differential staining of the pancreas [5, 7], as modified by ourselves. A solution of neutral red in glucose, in a concentration of 1:15,000, was injected into vessels of the trunk of the living animals. After perfusion, the pancreas was extracted, freed from lymph glands, and divided up into 150-200 small parts. By reflection of stained pieces of fresh pancreatic tissue through a microprojector, using the clamps of the apparatus to compress the pieces of gland between glass slides with a special grid for counting fields, the outlines of the islets of Langerhans and the acini could be traced on to a paper strip. By weighing the traced figures, we determined the total area of the islet apparatus and acinar tissue, expressed in sq. cm. The area of the acinar and islet tissues were determined under a magnification of 40 ×. The function of the islets of Langerhand was estimated by determining the amount of insulin in 1 g of pancreatic tissue by means of a convulsive method in mice. The crude insulin was extracted by the method of Fisher and Scott. The animals were weighed regularly and their blood sugar was determined periodically by the Hagedorn-Jensen method.

EXPERIMENTAL RESULTS

During the first days after the operation the weight of the experimental animals fell slightly, after which it rose as in the control animals. The pigmentation of the organs and skin was similar to that in the controls. The number of vitally stained islets of Langerhans fell $1^1/_2$ months after partial denervation, the respective figures being 1347-1663 in the control and 628-787 in the experimental animals. As special counts of "small", "middle sized", and "large" islets showed, the decrease in the number of islets was due to a decrease in the number of the first. The total area of islet tissue fell very slightly: normally it was 4.6-11 cm^2, and in the experimental series 3.0-6.4 cm^2. At the same time its value in relation to the body weight was almost halved (normal 0.03-0.06%, experiment 0.01-0.04%). The volume of the acinar tissue was significantly altered. In the control animals the area of the acinar tissue was 45-84 cm^2 and in the experimental animals 21.7-38.0 cm^2. The fall in the absolute values of the area of the acinar tissue affected its ratio to the body weight. In the control series this index was 0.25-0.59% and in the experimental series 0.12-0.26%. The absence of correlation between the change in the areas of the islet and acinar tissues led to an increase in the ratio between the area of islet tissue and the area of acinar tissue. In the control animals this index was 0.07-0.15, and $1^1/_2$ months after operation its value reached 0.11-0.17%.

Three months after operation the number of vitally stained islets rose, but it did not reach the control figure. The ratio between the total area of islet tissue and the body weight rose to the normal level. The increase in the number and area of the islets was not, however, due to the formation of new islets, for their mean diameter increased to 7-8μ compared with 4-5μ in the normal animals. Consequently, the existing "small" islets increased in size.

These results show that division of the right vagus nerve has a much greater effect on the state of the external secretory part of the pancreas, for 3 months after partial denervation of the area of the acinar tissue in proportion to the body weight was not restored to normal (normal 0.30-0.49%, experiment 0.21-0.34%). The amount of islet tissue, which fell during the first period, was restored. Its morphological activation was accompanied by a functional, as shown by an increase in the insulin content of the pancreas. In the control rats from 3 to 4.6 convulsive mouse units of insulin was contained in 1 g of tissue, but $1^1/_2$ months after partial denervation the amount of insulin per 1 g of pancreas rose to 5.4-5.8 units, and 3 months after operation to 17-18 units.

The increased insulin content of the pancreas after division of the right vagus nerve is explained by a relative increase in the volume of islet tissue at the expense of a decrease in the acinar, for the calculations were made in terms of 1 g of pancreatic tissue. After 3 months, however, the rise in the insulin content was no longer correlated with the change in the relative proportions of acinar and islet tissue, so that it is more correct to consider that the amount of insulin formed is increased at the same time. The level of the blood sugar and the character of the increase in body weight of these animals were similar to those of the controls.

The volume of acinar tissue, which fell after division of the right vagus nerve, was not restored to normal in the course of 3 months. This fact shows that the external secretory tissue of the pancreas is more dependent upon extraneural influences than are the islets of Langerhans. It is obvious that the relatively rich nerve supply peculiar to the islets [1, 2, 8, 11], in the form of large numbers of discrete nervous ganglia and cells situated in the islet tissue, ensures the required level of neurotrophic influences.

LITERATURE CITED

1. B. N. Mogil'nitskii, Prakt. Med., (1928), No. 3, p. 172.
2. A. E. Rabkina, Probl. Endokrinol. i Gormonoter., (1955), No. 1, p. 92.
3. I. P. Razenkov, Zhurn. Eksper. Med., (1929), 2, No. 1-2, p. 84.
4. N. P. Speranskaya, Probl. Endokrinol. i Gormonoter., (1956), No. 3, p. 3.
5. R. R. Bensley, Am. J. Anat., (1911), v. 2, p. 297.
6. J. Grossland, K. A. Elliot, and H. M. Pappius, Am. J. Physiol., (1955), v. 183, p. 32.
7. R. E. Haist and E. J. Pugh, J. Am. J. Physiol., (1948), v. 152, p. 36.
8. E. Geiger, Arch. exp. Path. Pharmak., (1933), Bd. 172, S. 295.
9. E. L. Opie, Bull. Johns. Hopk. Hosp., (1900), v. 11. p. 205.
10. A. Pi-Suner, In: Problems in Biology and Medicine [in Russian], Gosizdat, Moscow-Leningrad, 1935, p. 99.
11. O. Ritter, Acta anat. (Basel), 1946, v. 2, p. 162.
12. M. Seregeyeva, Anat. Rec. (1938), v. 71, p. 319.
13. E. G. Shipley and K. H. Beyer, Endocrinology, (1947), v. 40, p. 154.
14. C. Theret, Biol. med. Paris, (1953), v. 42, p. 609.