REGENERATIVE POWER OF THE SUBMAXILLARY AND PAROTID SALIVARY GLANDS IN RATS

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According to most authors regeneration of the salivary glands is brought about by an outgrowth of tissue from the wounded surface [6-8, 10-12]. In experiments on the guinea pig parotid glands and on the external orbital gland of the rat we have shown [1,2,4] that the outgrowth of tissue from the wounded surface originating in the ducts of the gland, which leads to the formation of a structurally atypical glandular tissue, is not well marked and does not account for the recovery in the weight of the gland observed in our experiments. This regeneration is brought about by a hypertrophy which is the principal means of recovery. To establish this fact irrevocably we needed to show that the species-specificity and structural features of the gland do not exert an important influence on the means of their regeneration.

For this purpose in the present work we studied the regenerative power of the different rat salivary glands, in particular the submaxillary, which was the gland chiefly investigated by the authors mentioned. Particular attention was paid to determination of the dimensions of the atypical portion of the gland, and to a study of the structural features (structural units) of the remainder.

METHOD

The work was carried out on the submaxillary and parotid salivary glands of white male rats weighing 150-200 g. To study regeneration of the submaxillary gland we removed one gland entirely and half of the second, i.e. 136% of the glandular tissue (I series of experiments); in the II set of experiments we extirpated 33% of the tissue of one gland. The regenerative power of the parotid salivary gland was studied by complete removal of one gland and extirpation of a large proportion of the second, the total amount removed being equivalent to 158% of one gland (III series). In all cases the weight of the regenerated glands was expressed as a percentage of the weight of one gland of a control animal.

The animals were individually labelled. When a portion of a gland was extirpated it was the distal end which was removed. In no case was any ligature placed on a vessel. When one gland was removed entirely the vessels were ligated. At the end of the experiment the animals of series I, II, and III were killed with ether vapor one and a half or two and a half months, three months, and one and a half months repectively after the operation. The glands were removed, weighed on torsion scales, fixed in Zenker-formol, and embedded in paraffin. Serial sections 7-8 μ thick were stained with hematoxylin-eosin and impregnated with silver by the method of Gomori, in order to demarcate the boundaries of the acini.

Altogether 70 rats were used in these experiments.

To determine what portion of the whole of the glandular mass was built up of the atypical portion, every sixth section was drawn under a drawing apparatus (at a magnification of 3 ×) on millimeter paper; in the drawing the normal portion and the atypical structure were defined. The drawings of the gland were cut out, and weighed on torsion scales. The dimensions of the acini were determined in a similar manner (objected to 20, ocular 20 ×). In each case the mean value was calculated from measurements of 300-400 acini. In the experiments on the parotid

TABLE 1. Changes in the Weight of the Salivary Glands Due to Regeneration

Series of experiments	Time after operation (in months)	Percentage tissue removed	Number of animals		Ratio of weight of regenerated gland to weight of one gland (percentage)
			Used in the experiment	Showing regeneration	
I	1.5	136	7	5	82
	2.5	136	8	6	79.6
II	3	33	8	2	78
III	1.5	158	14	7	70

TABLE 2. Size of the Acini of the Parotid and Submaxillary Salivary Glands of the Rats in relative units (1 mg of millimeter paper)

Parotid gland		Submaxillary gland	
Control	Regeneration	Control	Regeneration
8.4	7.3	6.3	7.4
8.1	10.0	7.3	5.7
6.9	8.1	7.5	7.7
8.5	8.7	6.6	8.2
8.6	7.9	7.4	7.9
9.1	7.7	7.0	6.2
9.1	10.9	7.9	—
8.0	—	6.0	—
8.3	8.6	7.0	7.2

gland we divided up the acini into classes according to their weight. The 1st, 2nd, 3rd, and 4th classes comprised acini weighing 1-4 mg , 5-8 mg, 9-12 mg, and 13-16 mg respectively, etc. All the numerical values were treated statistically by the method of Fisher-Student.

RESULTS

The glands reacted variously to damage. First of all we must note the incompleteness of the regeneration. Regeneration of both the submaxillary and parotid glands was always only partial. As can be seen from Table1 the weight of the regenerating glands at these times was averaged 79.6-82%(I series), 78%(II series), and 70% (III series) of the weight of one control gland.

Typically regeneration proceeded in by no means all the animals. To study regeneration of the parotid gland, weight recovery was found in 7 out of 14 rats used in the experiments. In the experiments on the submaxillary gland an increase in weight of the residual portion of the gland after two and a half months was observed in only 6 out of the 8 rats, and after one and a half months in 5 of the 7 animals.

Although the salivary glands are incapable of compensatory hypertrophy [5,9,11], the number of animals in which regeneration was demonstrated was greater in cases when the operation was upon both glands, i.e. in the

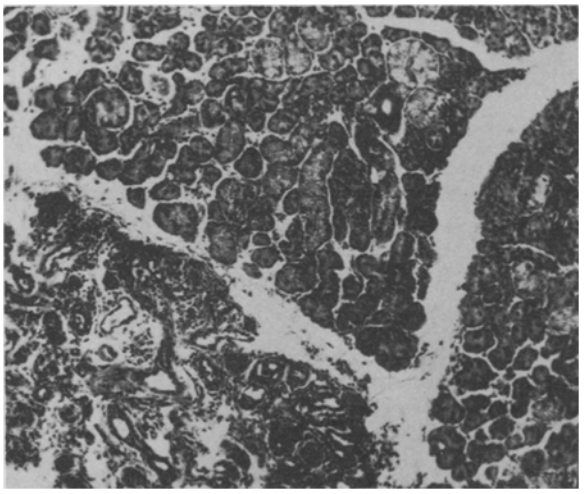

Fig. 1. Glandular tissue of atypical structure formed on the wounded regenerating surface of the submaxillary gland $2\frac{1}{2}$ months after operation. Micrograph. Hematoxylin-eosin. Magnification 5 × 20.

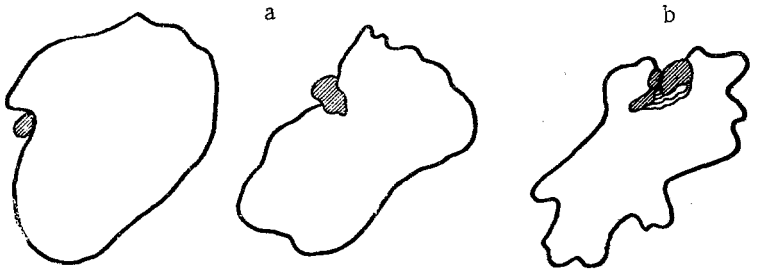

Fig. 2. Sections of the (a) submaxillary and (b) parotid glands of rats in which the atypical region (shaded area) was the greatest in size. Drawn under a drawing apparatus.

experiments in which a large amount of tissue had been removed. When 33% of the submaxillary gland had been removed it was only in 2 out of the 8 animals that regeneration occurred.

A histological study showed that the reaction of the different glands to damage was broadly the same, and resembled the reaction of the guinea pig parotid glands. In many cases, usually in the regeneration of the submaxillary glands, glandular tissue of an atypical structure formed on the wounded surface (Fig.1). We must emphasize that such tissue formed very rarely. Fig. 2 shows separate sections of the parotid glands of rats in which the atypical portion was greatest in size (shaded areas). They occupy a very small proportion of the area of the sections. The volume occupied by the atypical portion formed no more than 1.9% by volume of the whole gland, or 0.8% of the volume of the whole submaxillary gland. At the same time, during regeneration there was a considerable increase in weight of the gland. Therefore, despite the general opinion, regeneration of the salivary glands, and in particular the submaxillary glands, is brought about not by the formation of new glandular tissue on the wounded surface but through regenerative hypertrophy which accounts for the observed increase in weight. The details of this regenerative hypertrophy in the salivary glands are not very clear.

Measurements of the structural units of the salivary glands (acini) showed that in the parotid and submaxillary glands, just as in the external orbital lacrimal gland [3], there are no differences between the regenerated and the control gland with respect to either the mean size of the acini (Table 2) or the number of separate classes (Fig. 3). However, in the experiment classes occurred which had not been found in the controls.

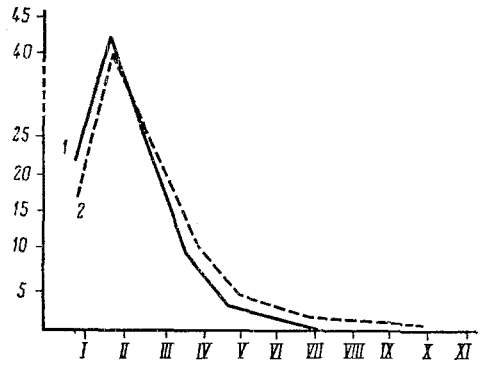

Fig. 3. Distribution of the size of the acini in classes; relative units. 1) Control; 2) regeneration. Abscissa — classes of acini; ordinate — percentage of each class.

The absence of any marked differences between the size of the acini in the experimental and control groups gives reason to suppose that the structural units are formed anew throughout the whole gland. However, an unequivocal assertion that there is no hypertrophy of the acini and that they are formed anew could be made only if the experiments were conducted in such a way that the increase in the weight of the organ during regeneration was really well shown.

The results we obtained lead us to conclude that the salivary glands do in fact possess the power of regenerative hypertrophy; however the recovery in weight brought about by this means is by no means complete, and did not occur in all animals. Therefore the idea that has grown up from the work of many authors [8,10,12] that the salivary glands have a considerable regenerative power is erroneous. These investigators were guided by observations on the formation of new tissue over the wounded surface; in the salivary glands this process is considerably more developed than in other viscera. In the work we have mentioned regeneration over the wounded surface is interpreted as a manifestation of typical regeneration. This conclusion is by no means correct. The atypical portion of the gland developing as a result of regeneration, as has been pointed out above, is very small, and apparently plays no important part in the regenerative process. At the same time the regeneration of the salivary glands occurring through regenerative hypertrophy, because it is incomplete, cannot be considered as good, because it is much less manifest than it is in other viscera.

LITERATURE CITED

1. A. G. Babaeva. In book: Problems of Reparative and Physiological Regeneration. [in Russian] Moscow, (1960), p. 25
2. A. G. Babaeva. Byull. Éksper. Biol., No. 10, (1960), p. 113.
3. A. G. Babaeva and R. S. Bugrilova. Byull. Éksper. Biol. No. 5, (1961), p. 92.
4. A. G. Babaeva. Byull. Éksper. Biol., No. 12, (1962), p. 114.
5. A. G. Babaeva. In book: Contributions to the Third Conference on Problems of Regeneration and Cellular Multiplication. Moscow, (1962), p. 14.
6. E. Sh. Gerlovin. In book: Histogenesis and Reactivity of Tissues. Transactions of the Leningrad Public Health Medical Institute, 42, (1958), p. 132.
7. E. Sh. Gerlovin. In book: Histogenesis and Reactivity of Tissues. Transactions of the Leningrad Public Health Medical Institute, 42, (1958), p. 155.
8. V. V. Podvysotskii. Beitr. path. Anat., 1887, Bd. 2, S. 19.
9. A. Alho. Acta path. microbiol. scand., Suppl. 149, (1961).
10. A. Carraro and Z. Frankfurt. Path., 1909, Bd. 3, No. 1, S. 26.
11. B. B. Milstein. Brit. J. exp. Path., 31, (1950), p. 664.
12. H. Ribbert. Arch. Entwickl.—Mech. Org., 1895, No. 1, S. 69.

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