THE STRUCTURE OF THE REGENERATING PAROTID SALIVARY GLAND IN RATS

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Of the large number of studies of regeneration of different viscera, comparatively few deal sufficiently with the structure of the regenerating organ. Also, most of these studies need to be reviewed in the light of new results concerning the regeneration of the viscera in mammals. According to these results, most of the viscera do not regenerate by growing out from a wounded surface, as had been supposed until now, but by a cellular proliferation of all parts of the organ. On this account, the mode of regeneration which M. A. Vorontsova has called regenerative hypertrophy [4], the organ may completely recover its weight while preserving its specific structure.

Despite the widespread occurrence of regenerative hypertrophy, it is not yet known in detail how it is brought about or what structural rearrangements occur. It remains to be found whether there is a new formation of structural units, or whether cellular proliferation brings about merely hypertrophy of existing units; we do not know whether there is merely a hyperplasia of the cells or whether at the same time there is a hypertrophy and a change in the relationships between the nucleus and cytoplasm, etc.

From the small amount of data available we know that regenerative hypertrophy occurs differently in different organs. After removal of two-thirds of the rat liver, the intensive proliferation of the liver cells which follows causes hypertrophy of the lobules, so that they are increased about two-fold. The hypertrophy is maintained for a long time [11]. In the regenerating rat kidney [10] a similar increase in the size of the structural units (nephrons) occurs. The course of events is somewhat different in the hypertrophy of the spleen. In mice, according to L. D. Liozner and G. V. Kharolva [8], not only do the Malpighian bodies hypertrophy, but they also increase in number. From one tenth portion of the spleen they were reported to increase in numbers by two and a half times.

Until recently it was thought that regeneration in the salivary glands occurs by the formation of atypical glandular tissue from the wounded surface, and that it starts from cells of the salivary ducts [5, 7, 9, 12, 13, 14]. Therefore, all descriptions of the structure of the regenerating gland concern only the way in which this atypical growth occurs. The differences between the different investigators concerned mainly their estimates of the functional properties of the newly formed terminal portions. Because we have shown that the parotid gland of guinea pigs [1] and rats [2] regenerates chiefly through a regenerative hypertrophy, and that the formation of atypical outgrowths is not of great importance, the question arises as to how the structure of the gland changes during regeneration.

In the work reported here we set out to find whether the size of the terminal portions and the number of cells which compose them increase, and we hoped thereby to be able to determine whether the regenerating gland becomes restored through a process of hypertrophy or through the formation of new terminal portions.

METHOD

The work was done on seven regenerating parotid salivary glands of white rats. The glands were extirpated $1\frac{1}{2}$-2 months after removing the whole of one and approximately half of the other parotid gland. The weight of these glands was approximately the same as that of glands in control animals, which indicated that regeneration had occurred. The control glands were taken from intact rats of the same age and weight (close control).

The glands were fixed in formalin, and treated by normal histological methods. The sections were stained by Gomori's method. In each gland a count was made of the number of terminal portions per 100 fields of view; the magnification was 90 x 7 and the field was defined by a square window in the eyepiece measuring 7 x 7 mm. A count was also made of the number of nuclei present in each terminal portion.

The results of the count are shown in the Table.

It can be seen from the Table that there is no great difference between the number of terminal portions in the control and experimental gland, the numbers being 490 and 450 respectively. There is no statistically significant difference which shows that with our method of performing the experiment the terminal portions do not hypertrophy, and there is no increase in the number of cells in the different terminal portions. A count of the number of nuclei in the terminal portions showed that it varies greatly, but that this variation occurs both in the normal and in the regenerated gland. The difference in the average number of nuclei per terminal portion is not great: it varies from 6.9 to 11.9 in the experimental gland, and from 6 to 10.7 in the control. It can be shown statistically that the difference between the mean numbers of nuclei in the experimental (9.1) and control (8.1) glands lies within the range of possible chance variation ($P = 0.12$).

Number of Terminal Portions and Nuclei in a Regenerated and in a Normal Rat Parotid Salivary Gland

Regenerated gland		Intact gland	
number of terminal portions per 100 fields of view	mean number of nuclei per terminal portion	number of terminal portions per 100 fields of view	mean number of nuclei per terminal portion
288	10,9	436	6,9
461	11,6	480	8,8
682	7,6	505	8,2
644	8,0	589	9,3
717	6,9	458	7,3
381	8,8	252	6,0
319	9,8	358	10,7
—	—	498	7,9
mean 490	9,1	450	8,1

From these experiments it may be concluded that after complete removal of one parotid and half the other because the size of the terminal portions remains unchanged and yet the mass of the gland increases 2-3 times that the regenerative hypertrophy occurs not through the growth of existing terminal portions but through formation of new ones. Naturally, it is possible that with some other arrangement of the experiment (as for example by removing a still greater amount of glandular tissue) there might be some growth in the terminal portions in addition to an increase in their numbers, though the possibility of this occurring is not great. In any case, it should be noted that when a similar proportion of liver or kidney is removed, there is not only hyperplasia, but also a considerable cellular hypertrophy. The results we have obtained, therefore, indicate that regenerative hypertrophy proceeds differently in different organs.

In certain organs, hypertrophy of cells and structural units of the organ plays an essential part in regeneration (as in the liver and kidney); in others, such as the salivary gland, there is no hypertrophy, but new cells and new terminal portions are formed. It appears that regeneration takes a similar course in the spleen [8] and in the small intestine [3].

SUMMARY

The number of terminal portions and of their nuclei in 100 fields of view were counted in normal and in regenerating parotid glands. There was no difference either in the number of terminal portions or in the nuclei in them. This result suggests that regeneration of the salivary glands occurs by the formation of new end portions within the boundaries of the remaining portion of the gland, and not as a result of an increase in their size.

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