

# EFFECT OF X-RAY IRRADIATION ON THYROID GLAND REGENERATION IN RATS WITH OR WITHOUT SARCOMA 45

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The state of the thyroid gland was studied after resection of three-quarters of its volume in 240 rats. The animals of series I formed the control, those of series II received whole-body irradiation in a dose of 360 R 24 h before the operation, the rats of group 3 were inoculated subcutaneously with sarcoma 45 eight days before the operation, and the animals of series IV were similarly inoculated but also were irradiated 24 h before the operation. Comparison of the results by series showed that irradiation of the animals without a tumor inhibited growth of the thyroid epithelium by 3.8 times, the presence of a tumor reduced it by 7 times, while irradiation of animals with tumors reduced it by only 1.6 times. Consequently, irradiation of animals with tumors abolished the inhibition of thyroid regeneration induced by the tumor, while the presence of a tumor reduced the effect of irradiation.

Several investigations [2-4] have been made of regeneration in the thyroid gland after resection, but the effect of radiation on this process has received little study [1]. No information on regeneration of the thyroid in animals with tumors, with the exception of findings published from the authors' laboratory [5, 6], could be found in the literature.

This paper describes a comparative study of regeneration in the thyroid gland after removal of three-quarters of its volume in control animals and unirradiated and irradiated animals with tumors.

## EXPERIMENTAL METHOD

Altogether four series of experiments were carried out on 240 noninbred albino rats weighing 120-160 g. In series I the whole of the right lobe and half of the left lobe of the thyroid gland was resected from control animals (without tumors, without irradiation), in series II the resection was performed 24 h after whole-body x-ray irradiation in a dose of 360 R (RUM-17 apparatus, 160 kV, 3 mm Al, 88 R/min), in series III the gland was resected 8 days after subcutaneous inoculation of sarcoma 45, and in series IV the resection was performed on the 8th day of growth of the tumor in rats irradiated 24 h before the operation. The animals were sacrificed immediately and 1, 2, 4, 8, 16 and 24 days after the operation, the thyroid glands were weighed and fixed in Bouin's solution, and paraffin sections were stained with hematoxylin-eosin, by the methods of Van Gieson and Mallory, impregnated with silver by Foot's method, and treated by the PAS reaction. During examination of the specimens the height of the follicular epithelium and diameter of the follicles were measured, and the percentages of epithelium, colloid, and connective tissue were determined [7]. The index proposed by the authors of [5], the calculated weight of epithelium (CWE) (obtained by multiplying the percentage of epithelium by the weight of the regenerating gland), also was used. The numerical results were subjected to statistical analysis.

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# EXPERIMENTAL RESULTS

In all the series of experiments inflammation developed on the wound surface of the thyroid gland, and granulation tissue formed and subsequently developed into scar tissue. Some cells of the damaged follicles degenerated while others formed bands and islets which invaded the young connective tissue. Mitoses were found in these structures and also in the walls of the follicles. New, small follicles appeared, and some of them atrophied during maturation of the connective tissue. The difference between the series of experiments were shown by the fact that edema, hemorrhage, and infiltration with leukocytes were all most marked in the unirradiated animals with tumors, while proliferation of the epithelium was most marked in the control animals.

However, the changes were not confined to the zone of the wound, but were found throughout the remainder of the organ. The results for the series explain the state of the gland at the beginning and end of the experiment are given in Table 1. They show that the height of the epithelium in all series was increased, but the original values in the irradiated animals were significantly smaller than in the unirradiated animals. The follicles decreased in size during the experiment in the animals without tumors, and increased in size in those with tumors, especially in those which were not irradiated. The percentage of epithelium by the end of the experiment was increased in the animals of series I and IV and reduced in the rats of series II and, in particular, in the rats of series III. The weight of the regenerating gland was increased by the end of the experiment in all series, but in the animals with tumors and the irradiated animals the percentage of epithelium was reduced. Analysis of the CWE index shows that the increase in weight of the epithelium in the experiments of series I was 4.2 mg, in series II 1.1 mg, in series III only 0.6 mg, and series IV 2.7 mg.

It can be concluded from these results that in irradiated rats without tumors (series II) growth of the epithelium was inhibited by 3.8 times compared with the control (series I), and in irradiated animals with tumors (series IV) it was inhibited by only 1.6 times compared with the control, although compared with the unirradiated animals with tumors (series III) the growth of the epithelium was stimulated by 4.5 times. Bearing in mind that growth of the epithelium after resection was inhibited by the tumor by 7 times (compare the results of series I and III) it follows that irradiation of the animals with tumors abolished the inhibition of regeneration induced by the tumor, while the presence of a tumor reduced the effect of irradiation (compare the results for series II and IV).

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TABLE 1. State of the Thyroid Gland after Resection in Unirradiated and Irradiated Rats with and without Sarcoma 45

Index	Animals without tumors				Animals with tumors			
	series I (unirradiated animals)		series II (whole-body irradiation, 360 R, 24 h before resection)		series III (unirradiated animals)		series IV (whole-body irradiation, 360 R, 24 h before resection)	
	immediate - 16-24 days after operation	16-24 days after operation	immediate - 16-24 days after operation	16-24 days after operation	immediate - 16-24 days after operation	16-24 days after operation	immediate - 16-24 days after operation	16-24 days after operation
	Height of epithelium (in $\mu$ )	7.9 $\pm$ 0.1	11.1 $\pm$ 0.6	5.8 $\pm$ 0.3	7.2 $\pm$ 0.1	9.1 $\pm$ 0.4	5.4 $\pm$ 0.1	7.1 $\pm$ 0.3
Size of follicles (in $\mu$ )	50.2 $\pm$ 0.4	46.0 $\pm$ 1.0	63.7 $\pm$ 4.2	57.6 $\pm$ 1.4	43.3 $\pm$ 1.0	76.3 $\pm$ 1.5	53.5 $\pm$ 0.5	57.2 $\pm$ 0.2
Percent of epithelium	52.2 $\pm$ 0.3	67.5 $\pm$ 1.4	38.9 $\pm$ 2.1	30.6 $\pm$ 0.5	51.0 $\pm$ 1.4	26.5 $\pm$ 1.1	30.4 $\pm$ 0.6	35.5 $\pm$ 0.4
Weight of regenerating gland (in mg)	4.9 $\pm$ 0.1	10.0 $\pm$ 0.2	5.0 $\pm$ 0.2	8.4 $\pm$ 0.2	4.2 $\pm$ 0.2	10.5 $\pm$ 0.5	5.0 $\pm$ 0.3	11.9 $\pm$ 0.3
CWE (in mg)	2.5 $\pm$ 0.05	6.7 $\pm$ 0.15	1.9 $\pm$ 0.2	3.0 $\pm$ 0.03	2.1 $\pm$ 0.1	2.7 $\pm$ 0.02	1.5 $\pm$ 0.05	4.2 $\pm$ 0.6