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LONG-TERM EFFECT OF IONIZING IRRADIATION ON RAT PARAFOLLICULAR CELLS AT VARIOUS ACTIVATION LEVELS OF THYROID FOLLICULAR CELLS

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ABSTRACT

The aim of this experiment was to study the effect of local thyroid gland irradiation in rats, treated in preirradiation period either with thyroxine subcutaneously (s.c.), water s.c. or perchlorate perorally (p.o.). In 3 months postirradiation period all the animals received perchlorate p.o. The parafollicular cells have been analysed under the light microscope qualitatively and stereologically.

The perchlorate in the postirradiation period provoked a significant decrease in the total volume, total number and average cell volume. The effect of the irradiation with 12 Gy was negligible, but strong and significant with 18 Gy. This was expressed in the thyroxine and control group, though only slightly indicated in the group drinking perchlorate in preirradiation period.

The possible mechanism of protective action of the perchlorate on the parafollicular cells is discussed.

Keywords: Ionizing irradiation, parafollicular cells, rat, sodium perchlorate, thyroid gland, thyroxine.

INTRODUCTION

The purpose of this experiment was to investigate the effect of irradiation on parafollicular cells in animals with various TSH concentrations in blood. Intermittent decrease in TSH concentrations has been obtained by exogenous thyroxine injections and a more constant TSH increase by peroral application of sodium perchlorate (Pajer et al. 1983).

MATERIAL AND METHODS

In this experiment 36 male rats were divided in 3 groups of 12 animals each. Animals in the first group were given L-thyroxine (T_4) 0,02 mg/100 g body weight in water solution subcutaneously daily through 13 days, the second, control group

was given water in the same way and the third group was given 1,2% sodium perchlorate ($NaClO_4$) in the drinking water during 30 days.

Afterwards, each of these 3 groups was divided into 4 subgroups. The first two subgroups were not irradiated, the first of them drinking tape water and the second 1,2% $NaClO_4$, until the end of the experiment. The second two subgroups were irradiated with X-rays in the neck area with 12 Gy or 18 Gy respectively (55 kV, HVL 0,8 mm Al, dose rate 6.13 Gy/min at 5 mm depth in the center of a circular field of 25 mm diameter). Following the postirradiation period of 3 months the animals were sacrificed (Table 1).

Table 1. Experimental conditions in different groups marked by numbers from 1 to 12.

treatment before irradiation			irradiation dose (Gy)	treatment in postirradiation period
thyroxine s.c.	water s.c.	$NaClO_4$ p.o.		
1	2	3	0	tape water
4	5	6	0	$NaClO_4$
7	8	9	12	$NaClO_4$
10	11	12	18	$NaClO_4$

Both lobes of thyroid gland were fixed in Bouin's solution and cut in step serial sections of 6 μm thickness, the step thickness being 120 μm. Sections were stained according to Fernandez-Pasqual. The absolute volume of the thyroid gland was stereologically determined. At objective magnification x60 volume density (V_V) of parafollicular cells by point counting and numerical density (N_V) according to Pajer, Kališnik (1984) were estimated. The absolute (total) volume (V) and number (N) of these cells were calculated. The average caliper diameter of the parafollicular cell nuclei was determined at objective magnification x100 by ocular micrometer. The average cell volume ($\bar{V}$) has been calculated from the volume density and numerical density of the parafollicular cells. The results were evaluated using analysis of variance, Tukey's, Student's and Mann-Whitney's test.

RESULTS

Microscopical examination of the parafollicular cells in the thyroxine group irradiated with 18 Gy has shown small degranulated cells with very small nuclei, some of the cells being ruptured; in one animal no parafollicular cells have been found at all. In the control group irradiated with 18 Gy these changes of the parafollicular cells were similar, but not as extensive. In the perchlorate group after 18 Gy irradiation the appearance of the parafollicular cells was almost normal (Fig.1).

Quantitative results can be summarized in the following statements. Firstly, drinking of the sodium perchlorate solution in the postirradiation period of three months provoked a significant

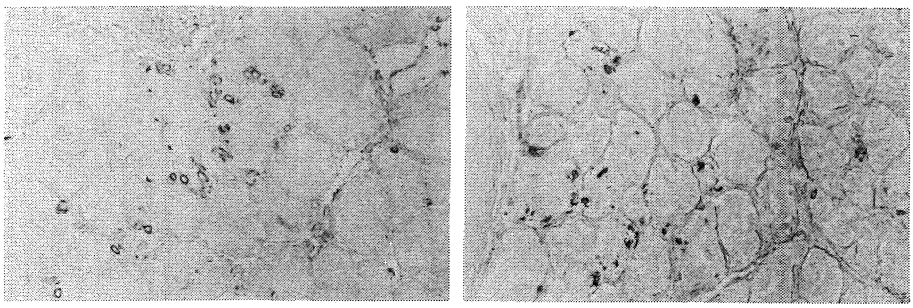

Fig. 1. Parafollicular cells after 18 Gy irradiation, Fernandez-Pasqual, x16
a: in the perchlorate group
b: in the thyroxine group

decrease in the total volume ($P<0,001$), total number ($P<0,001$) and the average cell volume ($P<0,02$) of the parafollicular cells. Secondly, the effect of the local irradiation of the neck region with 12 Gy showed a negligible and insignificant decrease, but with 18 Gy a significant decrease of the above values. Thirdly, the interaction of the irradiation with 18 Gy and of the various

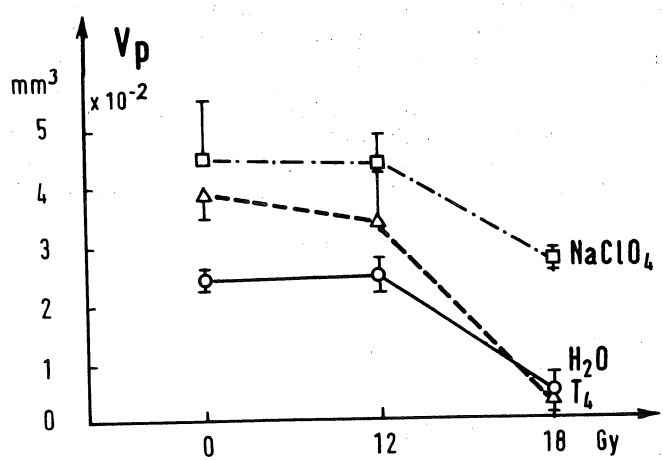

Fig. 2. The absolute (total) volume of the parafollicular cells in perchlorate ($NaClO_4$), thyroxine (T_4) and control (H_2O) group ($\bar{x} \pm 1SE$).

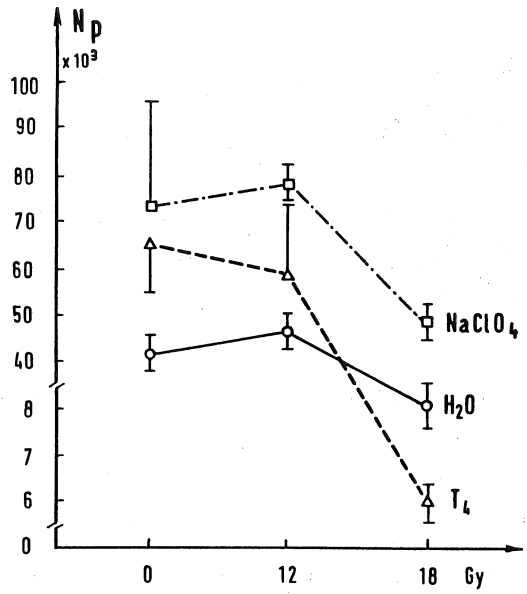

Fig. 3. The absolute (total) number of the parafollicular cells in perchlorate ($NaClO_4$), thyroxine (T_4) and control (H_2O) group ($\bar{x} \pm 1SE$).

TSH levels in blood was significant, i.e. the decrease of the above stereological variables was drastic and significant in the groups receiving thyroxine or water ($P < 0,005$, $P < 0,05$, $P < 0,01$), but there was only a small and insignificant decrease in the group drinking perchlorate one month before the irradiation. These results for all twelve groups are presented in tables 2 and 3, and for the groups 4-12 (tested in the postirradiation period with sodium perchlorate on radiosensitivity) in figures 2,3 and 4.

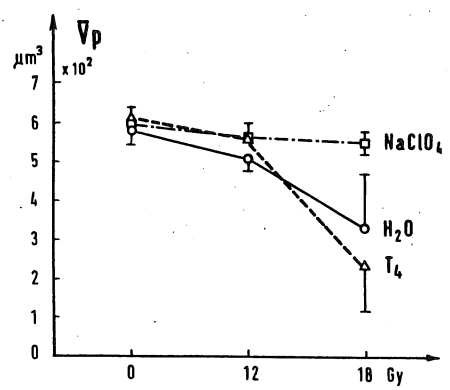

Fig. 4. The average volume of the parafollicular cells in perchlorate ($NaClO_4$), thyroxine (T_4) and control (H_2O) group ($\bar{x} \pm 1SE$).

Table 2. The absolute (total) number of the parafollicular cells in various experimental groups (1-12) ($\bar{x} \pm$ 1SEM).

Gy	thyroxine	water	$NaClO_4$	postirradiation periode
	1	2	3	
0	77896±8762	62707±12627	95504±10339	water
	4	5	6	
0	65806±10192	42280±4182	73685±22439	$NaClO_4$
	7	8	9	
12	59690±17507	47631±4517	79046±4110	$NaClO_4$
	10	11	12	
18	6148±4990	8119±5007	49567±4264	$NaClO_4$

Table 3. The absolute (total) volume in mm^3 of the parafollicular cells in various experimental groups (1-12) ($\bar{x} \pm$ 1SEM).

Gy	thyroxine	water	$NaClO_4$	postirradiation periode
	1	2	3	
0	0,060±0,010	0,032±0,008	0,0683±0,011	water
	4	5	6	
0	0,039±0,004	0,024±0,001	0,045±0,010	$NaClO_4$
	7	8	9	
12	0,034±0,010	0,025±0,003	0,044±0,005	$NaClO_4$
	10	11	12	
18	0,004±0,002	0,005±0,003	0,027±0,001	$NaClO_4$

DISCUSSION

The results of this experiment may be understood as an effect of a biphasic influence of perchlorate in the drinking water. Our previous observations on mice have shown that the total volume and number of the parafollicular cells have increased after perchlorate by the end of the first month and afterwards a decrease has been observed (Logonder-Mlinšek, Kališnik 1985). It could be expected, that the reaction of the parafollicular cells in the rat thyroid gland had a similar biphasic course, i.e. one month drinking of perchlorate before irradiation provoked a hypertrophy and hyperplasia of these cells; therefore we may assume that these cells resisted more efficiently the irradiation damage, which was obvious even after three months drinking perchlorate in the postirradiation period, when a general trend of decrease in the total volume, number and average volume of the parafollicular cells was observed.

On the other hand, daily injections of the thyroxine had probably an opposite, though intermittent effect on the blood TSH level, i.e. a decrease. Such a decrease of TSH blood level has been shown in a similar experiment on mice in the first 2 months by Pajer et al. (1983). If we assume that the lower level of the blood TSH after thyroxine applications provokes a decrease in the total volume, number and average cell volume of the parafollicular cells (which remains still to be checked), the greater radiosensitivity in this group would be understandable.

It has been shown for the first time by Nunez and Gershon (1983) by their experiments in vitro, that TSH has stimulated bat parafollicular cells. Our earlier experiments in vivo on mice and the present experiment have contributed to confirming the stimulatory effect of the TSH on the parafollicular cells. Therefore our understanding of the correlation of structure to function between the thyroid follicular and parafollicular cells, which represent two entities with two origins and two functions combined in one gland, has improved.

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