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*Peculiarities of the combined influence of hypothyroidism
and ionizing radiation on the oxygen-dependent metabolism
in hepatic tissues*

Cechy szczególne złożonego oddziaływania niedoczynności tarczycy i promieniowania
jonizującego na metabolizm tlenozależny w tkankach wątroby

INTRODUCTION

Thyroid is responsible for the formation of nonspecific adaptive reactions on the action of extreme factors of different genesis (including radiation), which is why it is very important to study the mechanisms of adaptive reactions specified by regulative influence of thyroid hormones. It is difficult to predict the combined influence of hypothyroidism and small doses of radiation on the organism, but the search for the preclinical criteria of the derangements of adaptative reactions among the metabolic changes caused by free-radical peroxidation is substantiated [8]. These membrane-dependent metabolic processes are the determinant nonspecific link of extranuclear effects of the action of thyroid hormones and small doses of radiation on the organism [2].

MATERIAL AND METHODS

With that purpose, the research of the peculiarities of lipoperoxidation changes (contents of malon dialdehyde (MDA) [9] and dijen conjugates (DC) [1]), antioxidant activity (activities of superoxid dismutase (SOD) [5], catalase (CAT) [4] and glutathione peroxidase (GPO) [7]) in hepatic tissues of male rats under the conditions of single and combined action of hypothyroidism (modelled by administration of thyrostatic preparation “mercazolilum” [3]) and small doses of radiation (summary dose – 1 Gr) was produced. General antioxidant activity (GAA) was estimated after the index of GAA (I_{AOA}) [6]. The functional activity of thyroid was estimated after the thyroid hormones contents.

RESULTS

A single action of radiation or hypothyroidism was shown by the activation of lipoperoxidation processes. Under the separate influence of these factors an increase in the content of MDA in hepatic tissues on the average by 1.5 times was detected. Results of the combined influence of mercazolilum and radiation (Table 1) demonstrate that a decrease in the activation of lipoperoxidation in hepatic tissues is the most prominent effect of it. The content of MDA in hepatic tissues was reduced almost to control level. At the same time GAA, activities of GPO and SOD were progressively decreasing. CAT activity exceeds the norm only by 15%, which means that the decrease in activation of lipoperoxidation is not the direct consequence of increase of the intensity of antioxidant defence (AOD). To find out the adequacy between the degree of the activation of the enzymes of antioxidant defence system (ADS) and the degree of the intensification of lipoperoxidation processes we introduced coefficients K_1 and K_2 ($K_1 = \text{SOD}/\text{MDA}$; $K_2 = \text{CAT} \cdot \text{SOD}/\text{MDA}$). These coefficients reflect the adaptative ability of the metabolic system. Their magnitudes in hepatic tissues under the joint influence of extreme factors were diminished almost twice.

Table 1. Lipoperoxidation and antioxidant activity changes in hepatic tissues of the rats-males under the joint influence of hypothyroidism and small doses of radiation ($M \pm m$, $n=10$)

Indexes	Control	Hypothyroidism	Radiation	Hypothyroidism + radiation
MDA, mmol/g	1392.61 ± 94.27	1730.76 $\pm 111.37^*$	2012.23 $\pm 104.16^*$	1402.09 $\pm 115.46^{\bullet\bullet}$
DC, un. E/g	18.6 ± 0.26	$13.3 \pm 2.4^*$	$29.8 \pm 0.41^*$	$8.85 \pm 0.32^{\bullet\bullet}$
I_{AOA} , relative units	3.08 ± 0.14	$2.14 \pm 0.15^*$	$2.08 \pm 0.18^*$	$1.83 \pm 0.13^{\bullet\bullet}$
CAT, mmol $\text{H}_2\text{O}_2/\text{g}\cdot\text{h}$	132.07 ± 6.12	106.60 $\pm 6.17^*$	154.56 $\pm 8.21^*$	152.46 $\pm 8.36^{\bullet\bullet}$
SOD, un. act./g·min	843.40 ± 41.55	312.56 $\pm 48.47^*$	1026.16 $\pm 47.66^*$	427.92 $\pm 60.45^{\bullet\bullet}$
GPO, mmol GSH/g·min	2.82 ± 0.34	$0.58 \pm 0.08^*$	$4.20 \pm 0.28^*$	$0.95 \pm 0.06^{\bullet\bullet}$
SOD/MDA	0.61 ± 0.12	$0.18 \pm 0.03^*$	$0.51 \pm 0.08^*$	$0.31 \pm 0.04^{\bullet\bullet}$
CAT·SOD/MDA	79.98 ± 0.06	$19.25 \pm 4.23^*$	$78.81 \pm 5.25^*$	$46.53 \pm 5.14^{\bullet\bullet}$

* Significance ($p < 0.05$) is in relation to control; $\blacktriangle$ significance ($p < 0.05$) is in relation to hypothyroidism; $\blacksquare$ significance ($p < 0.05$) is in relation to radiation

DISCUSSION

Peculiarities of lipoperoxidation changes under the combined influence of mercazolilum and radiation (comparatively with the changes of these processes under the separate influence) demonstrate that biochemical changes are not the consequence of their total relief effect, because lipoperoxidation

processes have a different specificity of AOD. Activation of free-radical peroxidation, which induces high activity of the enzymatic systems of AOD, is a criterion of adaptive ability of the investigated systems. Lipoperoxidation is a nonspecific component of the stress involvement of any genesis, because nonspecific metabolic reaction, directed for adequate to the intensity of influence adaptive and compensatory reactions, is a basis of modification (in spite of the specific influence of each of these extreme factors). At the same time, the activity of free-radical peroxidation determines adaptive modulation of membrane-dependent transformations and, what is important, intensity of AOD. Decrease in activation of lipoperoxidation under the joint influence of hypothyroidism and radiation, in relation to their indexes at a single action, and low activity of the AOD system display the reduction of pool of oxygenase reactions, and it is prognostically unfavorable.

CONCLUSIONS

Inhibition of lipoperoxidation processes with reduction of ADS (totally shown by the decrease in integrative coefficients K_1 and K_2) signifies the diminution of the adaptative ability of the compensatory reactions of these tissues. Such character of these processes is caused by chronic introduction of mercaptozolin and action on this background of ionizing radiation. Our research shows that development of hypothyroidism and influence of radiation are linked with the change of metabolic parameters, which in large part are caused by derangements in balance of pro- and antioxidant processes.

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SUMMARY

The search for the preclinical criteria of the derangements of adaptative reactions among the metabolic changes caused by free-radical peroxidation is substantiated. With that purpose, the research on the peculiarities of lipoperoxidation and antioxidant activity in hepatic tissues of male rats under the conditions of single and combined action of hypothyroidism and small doses of radiation was produced. The results of the joint influence of extreme factors demonstrate a decrease in activation of lipoperoxidation in hepatic tissues. At the same time, the general antioxidant activity, activities of glutathione peroxidase and superoxid dismutase were progressively decreasing. Such character of these processes signifies the diminution of the adaptative ability of the compensatory reactions.

Keywords: hypothyroidism, small doses of ionizing irradiation, hepatic tissues, lipoperoxidation, antioxidant activity, single action, combined action.

STRESZCZENIE

Poszukiwano kryteriów klinicznych dla zaburzeń reakcji adaptacyjnej wśród zmian metabolicznych spowodowanych peroksydacją. W tym celu zbadano cechy charakterystyczne lipoperoksydacji i aktywności antyoksydacyjnej w tkankach wątroby szczurów w warunkach pojedynczego i złożonego działania niedoczynności tarczycy i małych dawek promieniowania jonizującego. Wyniki badań nad wspólnym wpływem ekstremalnych czynników wykazały spadek aktywacji lipoperoksydacji w tkankach wątroby. W tym samym czasie ogólna aktywność antyoksydacyjna oraz aktywności peroksydazy glutationowej i dysmutazy nadtlenkowej progresywnie się obniżały. Taki charakter procesów oznacza spadek zdolności adaptacyjnej reakcji kompensacyjnych.

Słowa kluczowe: niedoczynność tarczycy, małe dawki promieniowania jonizującego, wątroba, lipoperoksydacja, aktywność antyoksydacyjna, działanie pojedyncze, działanie złożone