

ERYTHROCYTE ANTIOXIDANT PARAMETERS IN WORKERS OCCUPATIONALLY EXPOSED TO LOW LEVELS OF IONIZING RADIATION

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Abstract: It has been postulated that ionizing radiation generates reactive oxygen species (ROS). ROS are annihilated by an intracellular enzymatic system composed mainly of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx). Workers of X-ray departments are occupationally exposed to long-term low levels of ionizing radiation, which may affect their antioxidant status. Erythrocyte activities of SOD, CAT and GPx were measured in 45 workers of X-ray departments and 30 persons who constituted the control group. Subgroups with respect to sex and cigarette smoking were selected. Colorimetric method was used for determination erythrocyte activities of SOD, CAT and GPx. A significant decrease of GPx, SOD and CAT activity in workers as compared to controls was observed. Lower activity of SOD and GPx in female and GPx in male subgroup was found. SOD was significantly more elevated in smoking workers than in the non-smoking staff. Moreover non-smoking employees showed lower SOD and GPx activity in comparison to the non-smoking control. GPx decrease was found in smoking workers in comparison to the smoking control. Additionally, smoking workers showed lower activity of GPx and CAT compared to non-smoking control.

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INTRODUCTION

Ionizing radiation generates the production of reactive oxygen species (ROS) such as superoxide, hydrogen peroxide and hydroxyl radical in a variety of cells [20]. ROS manifest high reactivity to cellular macromolecule components including DNA, lipids and proteins [2, 15, 19]. They are also implicated in cellular radiation responses associated with signal transduction. Radiation affects genetic instability that leads to delayed biological effect such as gene mutation, chromosome aberration and cell death [8, 13, 22].

Workers operating X-ray equipment are exposed to long-term low doses of ionizing radiation. In this group, changes connected with damage of genetic material were found. Such abnormalities were also manifested in smoking workers [6, 8, 10, 13]. For degradation of ROS are responsible the following antioxidant enzymes: superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPx). SOD catalyses dismutation of the superoxide anion ($O_2^{\cdot-}$) into H_2O_2 , which is then deactivated to H_2O by CAT and/or GPx [3].

The aim of our study was to evaluate influence of low doses of ionizing radiation on erythrocyte antioxidant parameters in workers operating X-ray machinery.

MATERIALS AND METHODS

The study group covered 45 persons (14 men and 31 women) aged 25–54 years (average 44.5) operating X-ray equipment. The period of employment ranged from 2–33 years (average 15.3). With respect to sex and smoking the following subgroups were selected – a subgroup of 31 women aged 25–52 years (mean 42.8), a subgroup of 14 men aged 33–51 years (mean 43.3) and a subgroup of 9 smokers (8 women and one man) aged 25–53 years (mean 42) (19.9 pack-years). An annual effective dose of X-radiation was below 1 mSv. The control group, similar to the exposed group, comprised 30 clinically healthy individuals (12 men and 18 women) aged from 28–61 years (mean 40.4), not working in radiology who were never occupationally exposed to ionizing radiation. The female control group aged from 26–52 years (mean 38.7), whereas the male control aged 27–61 years (mean 46.8). Ten persons smoked cigarettes (8 women and 2 men), age of smokers ranged from 28–50 years (mean 40) (17.6 pack-years). All participants were subjected to medical examination and underwent basic hematological and biochemical assays to evaluate their state of health. No deviations in the basic laboratory tests, no infections during the month before the study and no acute or chronic diseases were found. Their economic and social state and place of residence was similar. The local bioethics commission approved the study.

In obtained blood samples, the erythrocyte activity of GPx and SOD were measured by the colorimetric method

using a commercial kit produced by Randox Laboratories (Ransel, glutathione peroxidase; Ramsod, superoxide dismutase). The erythrocyte activity of CAT was assessed as described by Aebi [1].

The results were compared in the following manner:

A. Between the total group of workers (45 persons) and the control group (30 persons);

B. Between the subgroups of exposed women (31 persons) and the respective control subgroup (18 women), and between the exposed subgroup of men (14 persons) and the respective control subgroup (12 men);

C. Between the subgroup of 36 non-smoking workers and 20 non-smoking persons in control group;

D. Between the subgroup of smoking workers (9 subjects) and 10 smokers in the control group;

E. Between the subgroup of 9 smoking workers and 36 non-smoking workers;

F. Between the subgroup of 9 smoking workers and 20 non-smoking controls.

The statistical analysis was performed using U Mann-Whitney test. P values of <0.05 were considered as significant.

RESULTS

The investigated group showed significantly lower activity of SOD, GPx and CAT. In the female subgroup, significant decrease of SOD and GPx was found, whereas in the male subgroup decline was observed in relation to GPx.

Table 1. Erythrocyte activity of SOD (U/g of Hb), GPx (U/g of Hb), and CAT (U/g of Hb).

Investigated group/subgroup	SOD	GPx	CAT
	$\bar{x} \pm SD$	$\bar{x} \pm SD$	$\bar{x} \pm SD$
Workers (total number) (n=45)	959.4 ± 198.8 ^a	29.1 ± 3.6 ^a	270.4 ± 54.7 ^a
Control group (n=30)	1154.7 ± 272.4	39.4 ± 6.6	301.8 ± 57.1
Workers (female subgroup) (n=31)	934.2 ± 161.5 ^a	27.1 ± 3.4 ^a	264.0 ± 60.1
Control group (n=18)	1140.2 ± 295.2	36.8 ± 5.7	284.5 ± 54.3
Workers (male subgroup) (n=14)	1051.9 ± 284.2	29.7 ± 2.9 ^a	298.4 ± 44.7
Control group (n=12)	1196.8 ± 245.8	38.4 ± 7.8	340.8 ± 58.3
Smoking workers (n=9)	1083.8 ± 197.9 ^a	26.8 ± 2.2	250.3 ± 35.8
Non-smoking workers (n=36)	917.4 ± 184.7	28.4 ± 3.5	278.8 ± 61.3
Non-smoking workers (n=36)	917.4 ± 184.7 ^a	28.4 ± 3.5 ^a	278.8 ± 61.3
Non-smoking control (n=20)	1187.5 ± 308.4	37.1 ± 7.6	309.7 ± 56.8
Smoking workers (n=9)	1083.8 ± 197.9	26.8 ± 2.2 ^a	250.3 ± 35.8
Smoking control (n=10)	1109.3 ± 206.3	37.9 ± 6.5	298.9 ± 56.3
Smoking workers (n=9)	1083.8 ± 197.9	26.8 ± 2.2 ^a	250.3 ± 35.8 ^a
Non-smoking control (n=20)	1187.5 ± 308.4	37.1 ± 7.6	309.7 ± 56.8

^a – statistically significant

Activity of SOD was significantly higher in smoking workers in comparison to non-smoking subjects exposed to radiation. Non-smoking workers revealed lower activity of SOD and GPx in relation to the non-smoking control.

Activity of GPx in smoking workers was significantly decreased in comparison to the smoking control. The same tendency was observed in respect to GPx and CAT values of smoking workers and the non-smoking control (Tab. 1).

DISCUSSION

Radiation is a well known factor that affects antioxidant status and increases free oxygen radical generation. In this study we have shown significant reduction in the activity of SOD, CAT and GPx in erythrocytes of workers exposed to low doses of ionizing radiation. Significant decrease of SOD and GPx activities in the female subgroup and GPx in the male subgroup was found. An insignificant decline in CAT activity in the women's subgroup and in the male staff in relation to SOD and CAT was observed. The significant decrease in SOD and CAT activity between non-smoking workers and non-smoking control was also observed. These findings indicate reduced antioxidant activity in erythrocytes of workers operating X-ray equipment and may be associated with constant exposure to low doses of ionizing radiation. Participants of the group involved in the Chernobyl accident who developed postradiation syndrome showed a decline in the SOD and CAT activity, whereas another group revealed higher activity of CAT in erythrocytes and lack of changes in SOD and GPx activity [7, 11].

These enzymes belong to enzymatic antioxidant defence and prevent oxidant stress [18, 21]. The observed decrease of parameters of the antioxidant system indicates that an increase in oxidative stress caused by radiation may overwhelm this enzymatic system.

Cigarette smoking, similarly to ionizing radiation, is involved in induction of ROS and increases oxidative stress, but comparison of antioxidant enzyme activities between smokers and nonsmokers showed large individual variability. Bolzan *et al.* [5] and Leonard *et al.* [12] did not observe any influence on antioxidant enzymes in the blood of smokers, whereas Yiditz *et al.* [24] and Zhou *et al.* [25] found lower activity of SOD and CAT. Higher activity of SOD and GPx in smokers aged from 18–45 years was observed, whereas in older smokers a decrease of these parameters was found [9]. The subgroup of smoking workers showed lower activity of GPx in relation to the smoking control. The same tendency was found in the activity of GPx and CAT comparing smoking workers to the non-smoking control. These observations can support view that cigarette smoking causes additional imbalance in the antioxidant mechanism. However, we also found that SOD activity was higher in smoking than in the non-smoking workers of X-ray departments. The observed higher SOD activity in this subgroup on the background of initially lower earlier analyzed antioxidant parameters may indicate adaptive

mechanism in relation to this enzyme. In cigarette smokers an increase of antioxidant activity was also observed [9].

Workers of X-ray departments are exposed to low-doses of ionizing radiation. This exposure may generate ROS, which can cause damage to DNA observed as chromosomal aberration or micronuclei [8, 13]. ROS are responsible for activation of nuclear factor NF- κ B (NF- κ B) and increase of cytokines production or expression of intracellular adhesion molecule-1 (ICAM-1) [4, 14, 23]. ROS induced by irradiation are involved in peroxidation of lipids, damage of mitochondria and apoptosis of cells [2, 16, 17]. The analyzed results showed lower level of antioxidant defence, which can be manifested as chromosomal aberration, formation of micronuclei or damage of DNA [6, 8, 10, 13]. These changes were also observed in smoking workers exposed to X-ray radiation [6, 13].

CONCLUSIONS

We conclude that long-term exposure to low doses of ionizing radiation in workers operating X-ray equipment diminishes their antioxidant defence. These changes are observed in both smoking and non-smoking subgroups of workers.

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