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Hematological Study on the Effect of Mercury Chloride and Ionizing Radiation in Immature Rats

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ABSTRACT

Mercury, one of the most diffused and hazardous organ-specific environmental contaminants, exists in a wide variety of physical and chemical states. Although the reports indicate that the mercury induces a deleterious damage, little has been known from the investigations of its effects in living organisms. The purpose of this study is to evaluate the effects of mercury chloride and ionizing radiation. Prepubertal male F344 rats were administered mercury chloride in drinking water throughout the experimental period. Two weeks after whole body irradiation, organs were collected to analyze the induced injury. Serum levels of GOT, GPT, ALP, and LDH were checked in the experimental groups and the hematological analysis was accomplished in plasma. In conclusion, the target organ of mercury chloride seems to be urinary organs and the pattern of damage induced by mercury differs from that by irradiation.

I. INTRODUCTION

Ionizing radiation, a widely used therapeutic modality in oncology, not only eradicates neoplastic cells but also generates inevitable side effects on normal tissues (Inano et al. 1989). A deleterious effect of radiation is the production of reactive oxygen species (ROS) which include superoxide anion (O_2^-, a free radical), hydroxyl radical ($OH\cdot$), and hydrogen peroxide (H_2O_2). These reactive species may contribute to radiation-induced cytotoxicity (e.g., chromosome aberrations, protein oxidation, and muscle

injury) and to metabolic and morphologic changes (e.g., increased muscle proteolysis and changes in the central nervous system) in animals and humans (Maitra et al. 2001). Toxic metals (lead, cadmium, mercury and arsenic) are widely found in our environment (van Veizen et al. 2002). Humans are exposed to these metals from numerous sources, including contaminated air, water, soil and food. Mercury (Hg), one of the most diffused and hazardous organ-specific environmental contaminants, exists in a wide variety of physical and chemical states, each of which has unique characteristics of target organ specificity. Although the reports indicate that the mercury induces a deleterious damage, little has been known from the investigations of mercury effects in living organisms. In the present study, radio-immunoassay of cortisol in serum and analysis of hematological components and enzymes related to tissue injury were carried out to evaluate the effect of mercury chloride in comparison with that of ionizing radiation.

II. MATERIALS AND METHODS

Animals; Fisher 344 male rats were purchased from Daehan Biolink (Chungbuk, Korea). The rats were acclimated for at least 3 days before the experiment was started. They were kept in cages containing chip bedding, three rats per cage. All rat were maintained under the following conditions; temperature (23℃) and lighting (12 hr light: 12 hr dark) and allowed free access to feed and water.

Irradiation and Treatment; The fifteen rats were allocated randomly into three groups of five rats each. Irradiated groups were exposed to γ -radiation from a ^{60}Co source with a total dose of 6.5 Gy, and a dose rate of 12.8 Gy/hr (Kim et al. 1999). Mercury chloride ($HgCl_2$) was administered 1 mg/kg in drinking water. All the rats were euthanized two weeks after

irradiation. Immediately after death, blood was collected from the heart.

Measurement of Serum Enzymes Activity; Activity of glutamate-oxalate transaminase (GOT), glutamate-pyruvate transaminase (GPT), lactate dehydrogenase (LDH), and alkaline phosphatase (ALP) was measured by using the automatic analyzer (Hitach, 747/200 type), which is based on the spectrophotometric quantification of NADPH loss using lactic dehydrogenase as a coenzyme (Lustig et al. 1988).

Measurement of Cortisol; Cortisol concentrations in serum of the experimental groups were determined in a radioimmunoassay by using a Diagnostic Products (Diagnostic Systems Laboratories, USA) with a sensitivity of 8.28 nmol/liter (Kerdelhue et al. 2002). The inter- and intra-assay coefficients of variation were <8.3% and <10%, respectively.

Statistical Analysis; Statistical analysis was performed by Students *t* test for a simple comparison of each treatment group with the control group.

Table 1. The weight of body and organs in experimental groups(‡)

	CON	IRR	$HgCl_2$
Body wt	144.6 ± 0.73	123.8 ± 3.35*	151.6 ± 1.25
Liver wt	6.60 ± 0.23	6.07 ± 0.27*	6.83 ± 0.11
Kidney wt	0.64 ± 0.03	0.62 ± 0.02	0.77 ± 0.01*
Spleen wt	0.42 ± 0.003	0.25 ± 0.01*	0.43 ± 0.006
Testis wt	0.87 ± 0.02	0.58 ± 0.02*	0.89 ± 0.01

‡ , All values expressed as means ± SEM (n = 5 in each group).

*, $P<0.05$ versus control group.

Abbreviations; CON, control; IRR, irradiated group; $HgCl_2$, mercury chloride treated group.

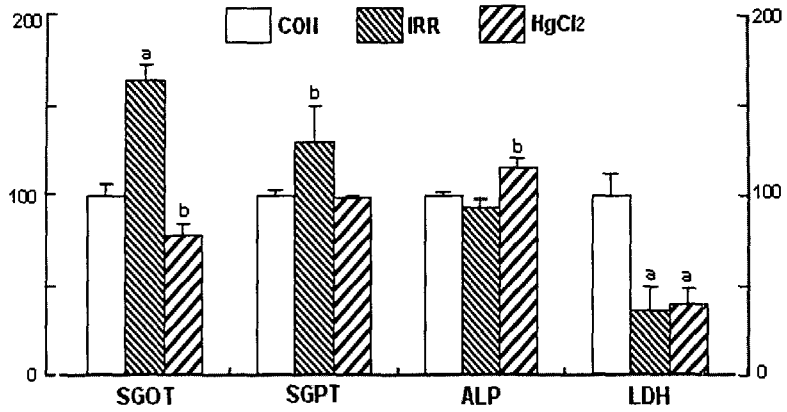

Fig. 1. Ratio of serum glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), alkaline phosphatase (ALP), and lactate dehydrogenase (LDH) was measured by using the automatic analyzer (Hitach, 747/200 type) in the experimental group. a, $p<0.02$ and *b*, $p<0.05$.

III. RESULTS AND DISCUSSION

This study was done to see the effect of mercury chloride in drinking water on the whole body irradiated rats. The loss of body and organ (liver, spleen and testis) weights in the irradiated rats was as obvious as expected. However, the weights of body and organ show a rising tendency compared to those of the control group. The kidney weight went upto the distinguishable values. It is suggested that the target organ of mercury chloride is urinary organs. According to the hematological analysis, values of RBC and platelet in the rats that were given mercury chloride increased markedly compared to the control. These values, when compared to the irradiated rats, increased by 2.37 times and 4 times, respectively ($p<0.05$). Other checks in hematological criteria show a similar pattern to that of the irradiated rats. Serum levels of the GOT and GPT indicated the hepatocellular damage in the irradiated and mercury chloride-treated groups. ALP, an indicator of renal injury, increased in the rats that were

given mercury chloride. Elevated levels of circulating cortisol in both of the groups may indicate the ACTH hypersecretion, adrenal dysfunction, and biological stress. Particularly, the ratio of circulating cortisol of the irradiated rats increased higher than that of the mercury chloride treated group. It was shown in this study that mercury chloride gave lesser damage than ionizing radiation. Taken together, mercury chloride affects the organs including liver, kidney, spleen, and testis as ionizing radiation does. Especially, the main target organ of mercury chloride seems to be urinary organs since it induced changes of the kidney weight and ALP levels.

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