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Original Research

Effect of boric acid on some elemental levels on rat's liver and kidney tissues during mercury chloride exposure

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Abstract: In this study, the effect of boric acid on the important trace elements copper (Cu), iron (Fe), zinc (Zn), manganese (Mn) and nickel (Ni) in liver and kidney tissue of rats treated with mercury chloride was investigated. Twenty-four male Wistar albino rats (weighing 200 ± 300 g) were divided into 3 groups: Control (C), Mercury chloride ($HgCl_2$), Mercury chloride ($HgCl_2$) + boric acid (BA). Iron and copper were decreased whereas Mn, Zn and Ni levels were increased in liver tissue in Hg administered group compared to control. Cu ($p<0.01$) and Mn ($p<0.001$) levels were increased in Hg + BA administered group compared to Hg group. Renal tissue Cu ($p<0.01$), Mn and Zn levels were increased whereas Ni ($p<0.05$) and Fe levels were decreased in Hg administered group compared to control group. Cu ($p<0.001$) and Zn ($p<0.05$) content increased in Hg + BA group compared to control group. As a result, it is thought that boric acid may have an effect on important trace element levels such as copper (Cu), iron (Fe), zinc (Zn), manganese (Mn), nickel (Ni) in case of oxidative stress caused by mercury chloride.

Key words: Boric Acid; Mercury Chloride; Trace Elements; Liver; Kidney.

Introduction

Trace elements have important impacts and roles in processes which are vital for life. Different studies revealed that trace elements are related with many common diseases (1-3). Trace element concentrations affect certain organs in both human and animals (4). Lack of such elements causes serious metabolic anomalies and excess of them causes toxicity. Some diseases such as chronic kidney, liver and lung diseases, trace elements were shown to have substantial impact (5-7). Copper (Cu) is an important element contributing to significant intracellular metabolic events, but also as a secret toxic element that causes chemical element poison as a result of excessive accumulation (8). Cu is an essential trace element in plants and animals (9). Iron (Fe) is a trace element necessary for the transport and storage of oxygen, electron transport, oxidative metabolism, cell growth and proliferation, catalysis of essential reactions (10,11). Zinc (Zn) is an important trace element that acts as a cofactor for certain enzymes involved in metabolism and cell growth, found in approximately 300 specific enzymes (12). Manganese (Mn), which is essential for normal physiological function in humans and animals, but is toxic at higher exposure levels (13). Nickel (Ni) was defined by the World Health Organization as a possible essential element in 1996 (14). Ni is considered an important element in animals, microorganisms and plants and has been a component of enzymes and proteins (15). Mercury (Hg), is an environmental and industrial pollutant. Accidental exposure to mercury is known to cause damage in some organs (16-18). Hg, changes intracellular redox homeostasis (19). Hg, which is a carcinogenic heavy metal causes brain damage and dysfunctions in liver, kidney, gastrointestinal system and central nervous system (20-22). During accumulation in body Hg causes harmful effects via over production of reactive oxygen species (ROS) and augmented lipid peroxidation (23). ROS includes superoxide, hydrogen peroxide and hydroxyl radicals. ROS causes oxidative damage of membrane lipids and proteins thereby causes cellular dysfunction (24). Boric acid (BA) is a boronized molecule and found as a mineral in nature. It has wide applications in health as well as industrial, agricultural and cosmetic applications. BA is absorbed rapidly and distributes to body. Following administration of boric acid blood and tissue boric acid concentration is reported to be 1: 1 in ratio (25). BA, supplementation in animal and human nutrition has important impacts on metabolic and physiological systems (26). BA, is an important trace element for plants, animals and human which support metabolic processes (27). It enhances antioxidant defense mechanism however mechanism of this enhancement is not solved yet (28). This study aims to effect of BA on some important trace element levels copper (Cu), iron (Fe), zinc (Zn), manganese (Mn), nickel (Ni) in livers and kidneys of mercury chloride administered rats.

Materials and Methods

Animal and treatment

In this study 24 male Wistar albino rats (200±300 g) were used. Animals were obtained from Bingöl University Experimental Research Center (BUHADYEK). Study was performed after acceptance of protocols by BUHADYEK (Date:03.04.2018/2018/04, Decision:04/02). Animals were kept under 20±2ºC stable

temperature and 12hours of light-dark cycle (lights were on 07:00-19:00; light were off 19:00-07:00). Commercial pellet chow and water was given *ad libitum*. Rats were divided into three groups including eight animals in each group.

1st Group: Control (C): Animals in this group was administered 10 days of intraperitoneal (i.p) isotonic saline and liver as well as kidney tissues were obtained at the end of 10th day.

2nd Group: Mercury (Hg) administered group: Rats in this group was administered 10 days of oral $HgCl_2$ (0.01 g/kg/day). Liver and kidney tissues were obtained at the end of 10th day (29).

3rd Group: Mercury (Hg) + boric acid (BA) administered group: Rats were administered 10 days of oral $HgCl_2$ (0.01 g/kg/day) + BA (3.25mg/kg/day)(i.p) and liver as well as kidney tissues were obtained at the end of 10th day (29,30).

Analysis of tissue samples

0.5 gr rat liver and kidney tissue samples were weighed and 10 mL HNO_3 were added onto it. Then samples were prepared for analysis with CEM - MARS 6 ONE TOUCH (USA) model microwave. Liver and kidney tissue samples were kept in 210 C for 30 minutes in microwave confined sample burning setup. During this period 400-1800 W power was spent. Samples in Teflon tubes from device were opened under fume hood. They were transferred into lidded glass Erlenmayer tubes with 10 mL ultrapure water and filtered (31,32). Then they were analyzed with Perkin Elmer AAS 800 Model (USA) device. They were measured with AAS according to element specific lamp, wavelength and standard graphic. Each sample was measured 3 times and mean was calculated for each of them**.**

Statistical analysis

Statistical evaluation of our data was performed with SPSS 10.0 software. Results are expressed as mean X ± S.E. Groups were compared with analysis of variance Kruskal-Wallis and LSD tests.

Results

Decrease in copper and iron content in liver tissue of Hg administered group compared to control whereas an increase in Mn, Zn and Ni levels were observed. Hg + BA administered group showed an increase in Cu level ($p<0.01$) and Mn level ($p<0.001$) compared to Hg administered group (Figure 1). Kidney tissue analysis showed that increase in Cu ($p<0.01$), Mn and Zn levels and decrease in Ni ($p<0.05$) and Fe levels in Hg administered group compared to control group. In addition an increase in Cu content ($p<0.001$) and Zn content ($p< 0.05$) in Hg + BA administered group compared to control group was determined (Figure 2).

Discussion

Trace elements are inorganic elements which incorporate into catalytic, enzymatic and structural processes in organism and they should be consumed via food and water sources (33). Trace elements are found in minute quantities in live tissues (34). Even though they are found in trace quantities they have substantial impact on human health (35). Trace elements are important for enzymatic reaction which converts substrate molecules into some certain end products. During production and utilization of metabolic energy redox reactions are vital and they release or trap electrons. Some of those trace elements have structural roles and are responsible for stability of biological molecules. Some other trace elements have important roles in biological processes. For example iron can bind, transport and release oxygen (36,37). Trace elements are primary components of biological entities. Excessive amounts of those elements can be toxic for body health and may cause some deadly diseases such as cancer. Toxicity may also be true for other non-trace elements which may mimic reactivity of trace elements due to their similarity in atomic number. Therefore, toxicity may directs the biological system to improve its ability to reach and deliver the metal without allowing it to enter toxic reactions. (12,38,39). Trace elements consumed by organisms bind to proteins in blood and distributes to all tissues. Trace element levels are related with some factors such as nutrition, age and disease. Especially Zn, Cu and Mn are immunity factors in infectious diseases as well as they are protective against oxidative stress and cancer (33). Copper (Cu) is one of the most important heavy metals (40).Cu is found in trace amounts in all tissues in the body and is an important nutrient that plays a role in hemoglobin, myelin, collagen and melanin production (41). Cu deficiency affects various physiological functions that may be important in immunological defense and against pathogens (42). In our study; When the liver Cu mineral level was evaluated, the decrease in Hg group compared to the control group and the increase in Hg + BA group

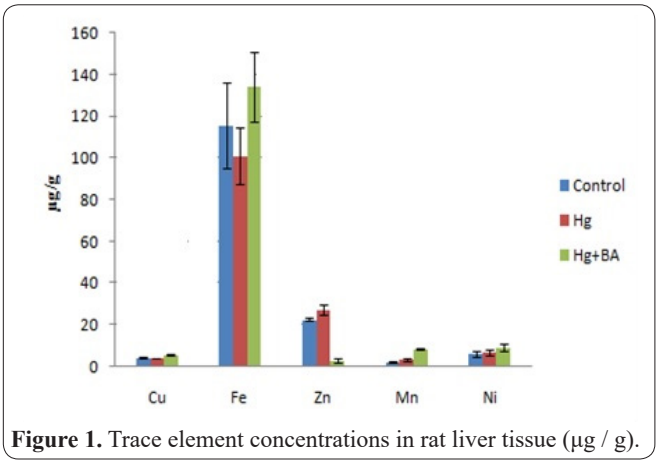

Figure 1. Trace element concentrations in rat liver tissue (µg / g).

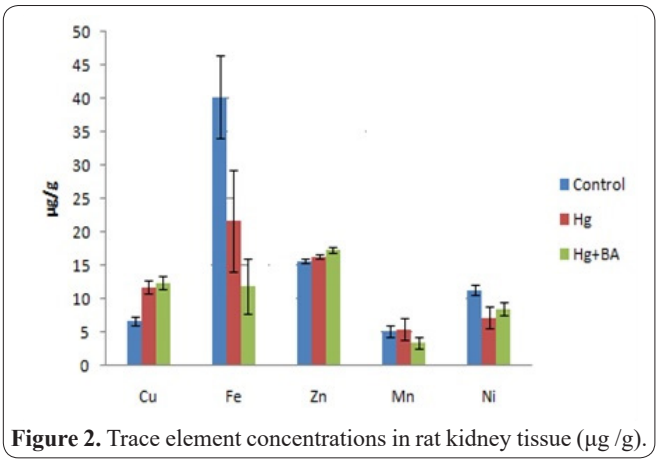

Figure 2. Trace element concentrations in rat kidney tissue (µg /g).

compared to the control group ($p<0.05$) was observed (Figure 1). Muto H. *et al.* (1991) determined that the levels of Cu in the rat liver tissues were lower than the control group in rats exposed to methyl mercury chloride and mercury chloride (43). In this regard, Ansar S. (2016) conducted a study to evaluate the protective effect of selenium on mercury chloride ($HgCl_2$)-induced toxicity. In their study when serum Cu level was evaluated, it was determined that there was a decrease in mercury chloride group compared to the control group (44). In our study, when Cu mineral level of kidney tissue was evaluated, Cu ($p<0.01$) was increased in Hg group compared to control group (Figure 2). Muto H. *et al.* (1991) determined that the levels of Cu in the rat kidney tissues were higher than the control group in rats exposed to methyl mercury chloride and mercury chloride(43). Blanusa M. *et al.* (1994) exposed chronic inorganic mercury to rats and tested whether DMPS decreases mercury accumulation in rat kidneys. They reported that in the kidney after the exposure to chronic inorganic mercury, they had increased mercury accumulation. As a result of the application of 1,2,3 months, there was an increase in the kidney tissue in mercury group compared to the control group (45). Feng W. *et al*. (2004) in their study showed that the levels of Cu in the kidney tissues of mercury treated rats increased in maternal and adults compared to the control group (46). As stated in the literature studies above, mercury exposure is thought to effect kidney and liver tissue. Iron (Fe) is an important trace element for all organisms and that are very important for normal cell function, and its deficiency or excess is associated with the disease state. Excess Fe intake and Fe deficiency are known to cause oxidative DNA damage (13). In our study, when the liver and kidney Fe mineral levels were evaluated, it was found that there was a decrease in Hg group compared to the control group (Figure 1and Figure 2). In their study, Feng W. et al determined that liver Fe levels were decreased in the maternity period of mercury treated rats and Fe kidney levels in infancy (46). Zinc (Zn) plays an anti-carcinogenic role through the structural stabilization of deoxyribonucleic acid (DNA), ribonucleic acid (RNA) and ribosome. Zn, is important for the functions of many transcription factors and proteins involved in the identification of specific DNA sequences and in the regulation of gene transcription. Zinc has a protective effect against free radical injuries (47). In our study, when the Zn mineral level of the liver was evaluated, an increase was observed in Hg group compared to the control group (Figure 1).When the renal tissue Zn mineral level was compared with the control group, Hg group was had increased level. Zn was increased in Hg + BA group compared to the control group (Figure 2) ($p<0.05$). Liu X. *et al.* (1992) have administered mercury chloride and found that Zn content of liver and kidney tissue in the study were higher compared to the control group (48). Manganese (Mn) is a basic element required for various enzyme activities (49). Mn deficiency of liver, brain, heart and lungs decreases SOD and enzymes activity therefore reducing the antioxidant activity and causing serious changes in lipid and carbohydrate metabolism (8). In our study; When the Mn mineral level of the liver was evaluated, it was found that an increase was determined in Hg administered group compared to the control group. In group Hg + BA, Mn ($p<0.001$) levels increased compared to the Hg administered group (Figure 1). Renal tissue Mn levels increased in group Hg compared to control group (Figure 2). Feng W. et al. in their study found an increase in liver and kidney tissue Mn content of Hg administered group compared to the control group during the maternity period (46). Nickel (Ni) is a naturally occurring element found in soil, water, air and biological materials. It is a natural component of the Earth crust and is found in magmatic rocks (12). Once in the body, nickel penetrates all organs and is primarily accumulates in the bone, liver and kidney (50). In our study, liver Ni, mineral analysis results were evaluated; An increase was observed in the Hg group compared to the control group (Figure 1). When the kidney tissue analysis results are evaluated; When compared with the control group, a decrease in Hg group was observed (Figure 2). ($P<0.05$).

BA, may have a beneficial effect on some important trace elements such as copper (Cu), iron (Fe), zinc (Zn), manganese (Mn), nickel (Ni) during oxidative stress due to mercury Chloride.

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