Levels of Mercury in the Organs of Normal and Acatalasemic Mice Exposed to Metallic Mercury Vapor

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Abstract

The levels of mercury in the organs of normal and acatalasemic mice exposed to metallic mercury vapor after administration of ethanol or aminotriazole was investigated. Levels of mercuric ion in the liver of normal and acatalasemic mice immediately and after 6 hours following exposure to metallic mercury vapor increased in order to mice pretreated with ethanol(ET), pretreated with aminotriazole(AT) and control mice, respectively. Levels of mercuric ion in the lungs of both mice after 6 hours following exposure to mercury vapor decreased than those of mice immediately after exposure. On the other hand, levels of mercuric ion in the liver of both mice pretreated with ethanol or aminotriazole was significantly higher than that of control mice, which indicated that catalase plays a role in oxidizing and taking up mercury.

The amounts of metallic mercury in the arterial and orbital venous bloods of normal and acatalasemic mice exposed to metallic mercury vapor were investigated. The amounts of metallic mercury and ratios of metallic mercury to total mercury in the both bloods of acatalasemic mice were significantly higher than those of normal mice. On the other hand, the amounts of total mercury in the both bloods of normal mice were significantly higher than that of acatalasemic mice.

Introduction

Metallic mercury is rapidly oxidized by catalase to mercuric ion when animals are exposed to metallic mercury vapor. Kudsk[1] reported that ethyl alcohol depressed the pulmonary absorption of metallic mercury vapor. Magos et al.[2] found that alcohol affected the *in vivo* oxidation rate of metallic mercury, i. e. the amount of metallic mercury vapor exhaled from rats injected with metallic mercury was higher in rats pretreated with alcohol than that in untreated control rats. Ogata et al.[3] reported that the oxidation of metallic mercury by red blood cells suspensions from normal mice *in vitro* was higher than that of red blood cells suspensions from acatalasemic mice with or without hydrogen peroxide, indicating that catalase-hydrogen peroxide system plays a role in mercury oxidation. A similar result was observed in the oxidation of

metallic mercury by red blood cells suspensions from normal and acatalasemic Japanese humans *in vitro*.[4] Aikoh[5] and Ogata et al.[6-7] also reported that metallic mercury in the venous blood of acatalasemic mice after intraperitoneal injection of metallic mercury was significantly higher than that of normal mice, and that metallic mercury in the arterial blood of acatalasemic mice after exposure to metallic mercury vapor was also higher than that of normal mice. Clarkson et al.[8] reported that the exhalation of small amounts of mercury from anesthetized rats injected with mercuric chloride and suggested that mercuric ion was reduced to metallic mercury in the blood.[9] Dunn et al.[10] reported that the rate of mercury exhalation in mice injected with mercuric chloride was increased dramatically after administration of ethanol solution vs. that in control mice.

The present report concerns the oxidation of metallic mercury which was demonstrated by mean of catalase in the blood and organs of normal and acatalasemic mice pretreated with ethanol or aminotriazole.

Experimental

Materials and Method

Animals: Normal($C_3H/AnlC_s^a$) and acatalasemic($C_3H/AnlC_s^b$) female mice of inbred strain weighing 20-25g were used.

Reagents: Mercuric chloride($^{203}HgCl_2$: specific activity = 0.52mCi/mg) was purchased from New England Nuclear, Boston, Massachusetts. Hopcalite(I) composed of MnO_2, Cuo, Co_2O_3 and Ag_2O was purchased from Nakarai Chemicals Ltd., Kyoto, Japan. Hopcalite tube used for glass tubing with a diameter of about 8mm and a length of about 5cm loosely filled with Hopcalite(I) and plugged with cotton wool in both sides. All other reagents used were of analytical grade.

Exposure to metallic mercury vapor: Metallic mercury vapor was generated by adding a stannous chloride(10%) to an aqueous solution of mercuric chloride as described previously.[7] Normal and acatalasemic mice after administration of ethanol or aminotriazole were exposed to metallic mercury vapor. The exposed concentration of metallic mercury was 3.54mg/m³. Just after exposure and after an elapse of 6 hours after exposure, the mice were anesthetized with diethyl ether and samples of the arterial blood were removed from the left ventricle of the heart and immediately mixed with 2ml of 3% ethyl alchol-silicon-heparin solution. The samples of the blood were kept at 0℃. On the other hand, venous blood from the orbital vein of mice anesthetized with diethyl ether was immediately mixed with 2ml of 3% ethyl alchol-silicon-heparin solution. The blood samples were kept at 0℃. Metallic mercury in the arterial and orbital venous bloods were bubbled with pure nitrogen gas and the evaporated mercury was trapped in the Hopcalite tube. After bubling, the remaining blood was used for determination of mercuric ion.

The amounts of metallic mercury and mercuric ion in the arterial and orbital venous bloods, and in organs of normal and acatalasemic mice were determined by the auto-well gamma system (Model: ARC-500, Aloka Co. Japan).

Results and Discussion

Concentration of mercury in organs of normal and acatalasemic mice exposed to metallic mercury vapor

The concentration of mercury in the organs of control(N-C, A-C), normal(N-AT, N-ET) and acatalasemic(A-AT,A-ET) mice after administration of ethanol(ET) or aminotriazole (AT) immediately or 6 hours after following exposure to metallic mercury vapor are shown in Fig. 1 and 2. The mercury concentrations in the lungs and blood of acatalasemic mice exposed to metallic mercury vapor were lower than those of normal mice, respectively. The result suggests that the primary oxidative site of the inhaled elemental mercury existed in the lungs on the route from alveolar air to alveolar cells and extended to the alveolar vein. On the other hand, the mercury concentrations in the liver of acatalasemic mice were higher than that of normal mice.

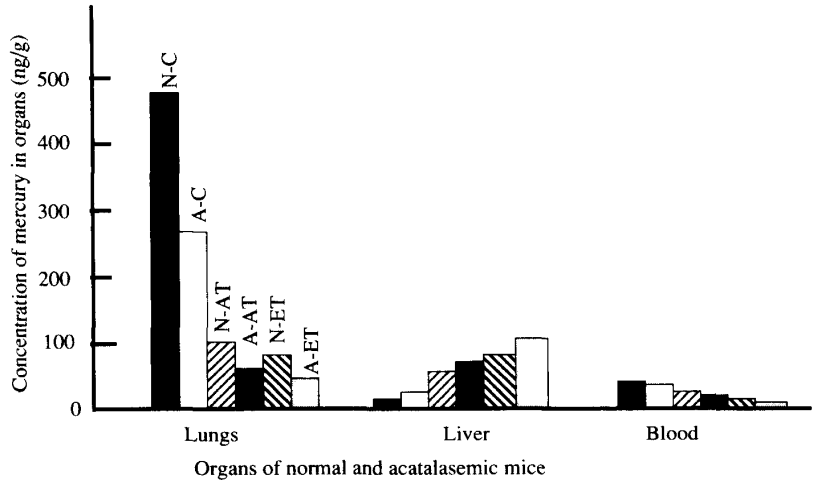

Fig. 1 Concentration of mercury in organs of normal and acatalasemic mice immediately after exposure to mercury vapor.

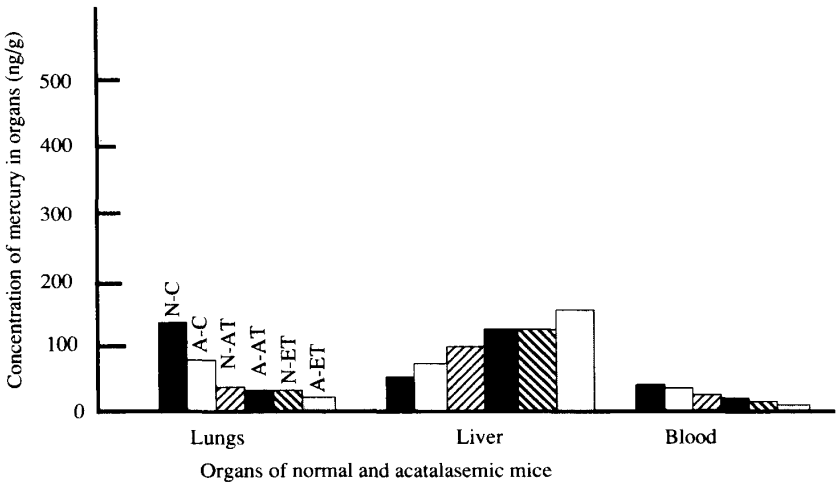

Fig. 2 Concentraoion of mercury in organs of normal and acatalasemic mice 6 hours after exposure to mercury vapor.

The mercury concentrations in the liver of both mice immediately after exposure to metallic mercury vapor tended to be lower as compared with that of mice after an elapse of 6 hours after exposure. On the other hand, the mercury concentrations in the lungs of both mice immediately after exposure tended to be lower than that of mice after an elapse of 6 hours after exposure.

Mercury concentration in the arterial and orbital venous bloods of normal and acatalasemic mice exposed to metallic mercury vapor in vivo

Levels of metallic mercury and mercuric ion in the arterial and orbital venous bloods of normal and acatalasemic mice immediately after exposure to metallic mercury vapor are shown in Fig. 3. The levels of metallic mercury in the arterial blood of acatalasemic mice was significantly higher than that of normal mice. On the other hand, the levels of mercuric ion in acatalasemic mice had decreased levels as compared with that of normal mice, indicating that the differences of catalase activity between normal and acatalasemic mice may play an important role in oxidizing mercury. Thus, the ratio of metallic mercury to total mercury of acatalasemic mice was significantly higher than that of normal mice. Moreover, the ratio of metallic mercury to total mercury in the arterial blood in normal and acatalasemic mice was higher than those in the orbital venous blood.

To investigate the levels of metallic mercury, total mercury, and ratio of metallic mercury to total mercury, mercury in the arterial and orbital venous bloods of normal and acatalasemic mice exposed to metallic mercury vapor was measured. The levels of metallic mercury in the arterial and orbital venous bloods of acatalasemic mice was significantly higher than those of normal mice. Thus, the ratio of metallic mercury to total mercury of acatalasemic mice was significantly higher than that of normal mice. This data corresponds with results that the level of metallic mercury and the ratio in

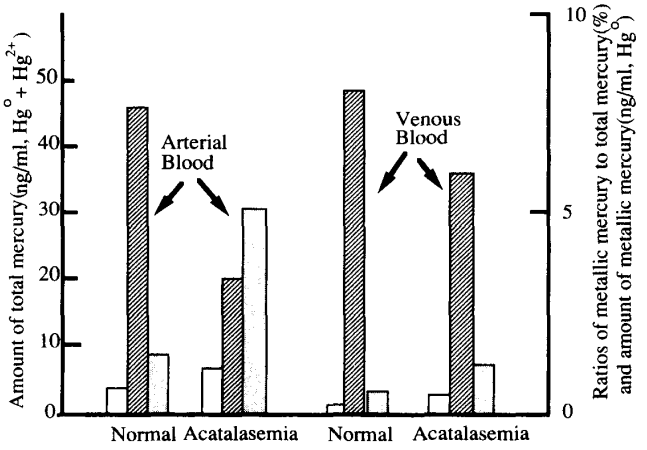

Fig. 3 Amount of metallic mercury, total mercury, and ratio of metallic mercury to total mercury in the arterial and orvital venous blood of normal and acatalasemic mice exposed to mercury vapor.
□ : Metallic mercury, ▨ : Total mercury, ▩ : Ratio

the arterial and orbital venous bloods of acatalasemic mice were significantly higher than those of normal mice.

Transformation of mercury in the blood of normal and acatalasemic mice

The foregoing data indicate that lipotrophic metallic mercury in the blood passed through the blood-brain barrier, the brain having a higher concentration of metallic mercury in the blood. Similar results were obtained in the liver and heart of acatalasemic mice exposed to metallic mercury vapor.Transformation of mercury from the blood of normal and acatalasemic mice is shown in Fig. 4. Data indicate that the ratio of organ to blood in acatalasemic mice is higher than that of normal mice. The levels of metallic mercury in the blood or in the respination exhaled from acatalasemic mice are higher than that of normal mice, respectively. This may be

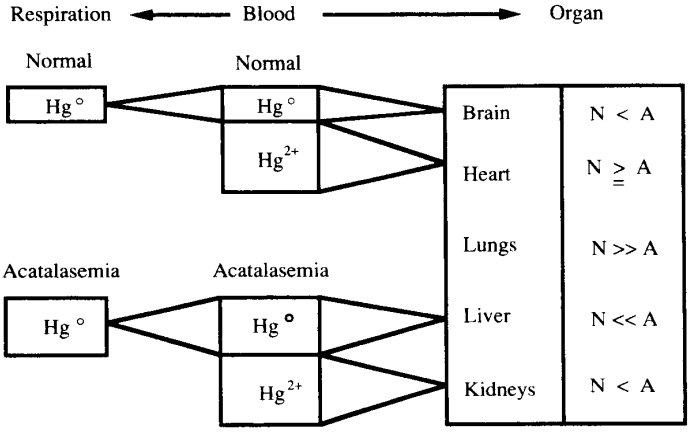

Fig. 4 Conversion of mercury in the blood of normal and acatalasemic mice.
N : Normal mice, A : Acatalasemic mice

explained by assuming that the catalase activity in the brain, liver, kidneys, and heart of acatalasemic mice has sufficient activity to fix metallic mercury as mercuric ion. Metallic mercury in the blood and its lipotrophic properties may determine the distribution of metallic mercury to the brain, liver, kidneys, and heart, in that lipotrophic metallic mercury passed through the brain-blood barrier resulting in a higher concentration of metallic mercury in the brain. The kidneys/blood ratios were lower in mice injected with metallic mercury or in mice exposed to metallic mercury vapor than in those injected with mercuric ion, indicating that mercuric ion was accumulated in the kidneys.

Relationship between mercury distribution and catalase activity in the organs

Mercury distribution per catalase activity in the organs of normal, hypocatalasemic and acatalasemic mice exposure to metallic mercury vapor was investigated. The result is shown in Fig. 5. Mercury distribution in the blood and liver of normal, hypocatalasemic and acatalasemic mice showed an lower values in spite of a high value of catalase activity. On the other hand, mercury distribution in the brain, heart,

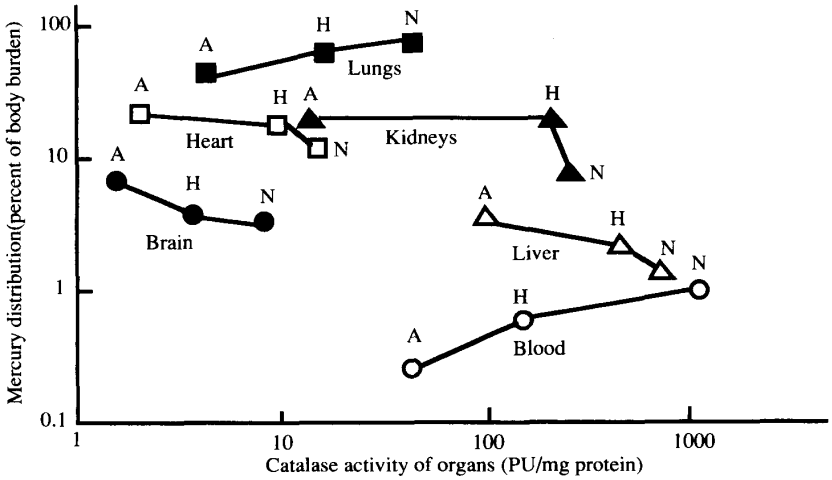

Fig. 5 Relationship between mercury distribution and catalase activity in the organs of normal and acatalasemic mice exposed to metallic mercury vapor.
A : Acatalasemic mice, H : Hypocatalasemic mice, N : Normal mice

and lungs of each mice showed a higher values than those of the blood and liver. Mercury distribution in the organs of normal, hypocatalasemic and acatalasemic mice increased in proportion to the magnitude of catalase activity. The data suggest that catalase plays an important role in oxidizing mercury.

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