Sodium, Potassium, Magnesium and Calcium Levels in Polychlorinated Biphenyl (PCB) Poisoned Rats

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Since 1972, the use and production of PCB in Japan has been abandoned. However, PCB is still making a widespread contamination in environment as this compound is extremely stable and has a strong resistance to degradation. For an example, recent survey studies revealed that average PCB concentration in fat tissue of inhabitants in Kyoto City is about 4.7 ppm (MIZUTANI et al, 1972) and that in blood among the normal people in western Japan it is about 3.1 ppb (ABE et al, 1974).

Regarding the injurious effects of this compound, an outbreak of PCB poisoning due to a chronic ingestion of rice oil that had been contaminated with PCB was brought to the public attention (Yusho) in 1968. Among the various symptoms in these patients, it was clarified at autopsy that there was an accumulation of calcium in the heart and kidneys (KIKUCHI and MASUDA, 1973). This fact suggested that PCB has a some effect on calcium metabolism. However, little information is available concerning the relationship between PCB poisoning and mineral metabolisms. The present study was undertaken to determine the effect of PCB on mineral levels in rats.

MATERIALS AND METHODS

ANIMALS AND DIETS

Male rats of Wistar strain weighing approximately 150 grams were separated into two groups of 10 animals each. To one group commercial flour diet (Oriental Co., Japan) was given and to the other group 500 ppm of PCB (Kanechlor 500) supplemented diet was given. The animals were housed individually in stainless steel cages with a raised wire bottom.

ANALYSIS

After 30 days of these dietary regimens, blood was collected into a syringe from the aorta of rats anesthetized with sodium pentobarbital. Various tissues were removed and weighed. Blood and tissues were then put into Kjeldahl flask containing nitric acid and digested to a nearly colorless solution. Total volume

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of solution was diluted to an appropriate volume with distilled water and the amount of Na, K, Mg and Ca was determined by atomic absorption spectrophotometer (Shimadzu Co., Model AA-650, Japan). In the case of Ca determination, strontium was added (2 mg/ml final concentration) to eliminate interference with other cations and anions (MAGILL and SVEHLA, 1974).

RESULTS

In PCB treated rats, prominent dark brown pigmentation and increase in weight (average: 1.64±0.58 times as compared to control rats) of liver were remarkable similar to those outlined in the previous papers (ITOKAWA et al, 1973. ITOKAWA et al, 1975. ITOKAWA et al, 1976).

Table 1 represents Na, K, Mg and Ca concentration in blood and various tissues. In PCB treated rats, Na levels in blood, liver and kidney decreased, K levels in heart and kidney decreased, Mg levels in blood, liver and kidney decreased, Ca levels in bone, spinal cord and sciatic nerve decreased and in contrast, calcium in kidney increased.

DISCUSSION

Generally, there is a tendency for Na, K and Mg levels to decrease in almost every tissue of PCB treated rats. It is probable that these decreases due to the impairment in intestinal absorption of these minerals. Inhibition of Na-K-Mg-dependent ATPase has been reported PCB treated fish (YAP et al, 1971. DAVIS et al, 1972) and also in PCB treated rats (ITOKAWA et al, 1973, ITOKAWA et al, 1975). The decrease in these minerals could be attributed to the decrease in activity of Na-K-Mg dependent ATPase.

It is worthy to note that calcium concentration increased in kidneys and decreased in bone. This observation coincides with the autopsy finding in Yusho patient (KIKUCHI and MASUDA, 1973). It is feasible that the requirement of calcium in tissues is increased in PCB poisoned rats and calcium is released from the bones to other tissues thereby promoting a homeostatic adaptation. PCB may have some effect on regulating system of calcium metabolism, that is, either a parathyroid gland or some other organ.

In the nervous system, calcium levels decreased in the spinal cord and sciatic nerve but not in the brain in PCB poisoned rats. This finding suggests that PCB has a more toxic effect on peripheral nervous tissues rather than the central nervous tissues.

TABLE 1

Na, K, Mg and Ca concentrations in blood and various tissues

Tissue	Na		K		Mg		Ca	
	Normal	PCB fed	Normal	PCB fed	Normal	PCB fed	Normal	PCB fed
	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g
Blood	2125±113	1829±77 *	1784±52	1691±50	45±2	41±1	48±1	50±1
Brain	647±16	618±28	2376±178	1984±206	129±2	131±2	70±5	72±3
Spinal cord	864±70	804±96	2322±569	1839±182	165±16	150±10	151±11	110±11*
Sciatic nerve	1486±18	1463±41	848±20	853±25	166±8	164±8	171±27	92±10*
Liver	564±44	415±31 *	3468±299	3275±467	201±6	158±9 **	34±4	31±3
Heart	1293±110	1166±70	3277±276	2303±299*	210±5	197±8	86±8	94±4
Kidney	1963±87	1560±110**	3119±290	2026±212**	274±14	232±12*	59±3	89±12*
Muscle	281±5	258±34	1700±41	1481±222	332±12	345±37	72±1	72±5
	μg/g	μg/g	μg/g	μg/g	μg/g	μg/g	mg/g	mg/g
Bone	3181±318	3042±276	1677±201	1640±157	1346±36	1347±29	98±2	85±2 **

Values represent mean±SEM of 10 rats. Bone:femur Muscle:gastrocnemius muscle

* Significant difference from control at the $p<0.05$ level.

** Significant difference from control at the $p<0.01$ level.

Further experiments are necessary to elucidate the mechanism.

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REFERENCES

ABE, J., Y. INOUE, M. TAKAMATSU: Japan J. Hygiene 29, 93 (1974)

DAVIS, P. W., J. A. FRIEDHOFF, G. A. WEDEMEYER: Bull. Environ. Contam. Toxicol. 8, 69 (1972)

ITOKAWA, Y., K. KAMOHARA, K. FUJIWARA: Experientia 29, 822 (1973)

ITOKAWA, Y., R. TABEI, K. KAMOHARA, K. FUJIWARA: Arch. Environ. Toxicol. 3, 115 (1975)

ITOKAWA, Y., N. YAGI, H. KAITO, K. KAMOHARA, K. FUJIWARA: Toxicol. Appl. Pharmacol. (in press)

KIKUCHI, M., Y. MASUDA: Rinsho Byori (Japan. J. Clin. Pathol.) 21, 422 (1973)

MAGILL, W. A., G. SVEHLA: Z. Anal. Chem. 268, 177 (1974)

MIZUTANI, M., M. MATSUMOTO, K. FUJIWARA: Igaku no Ayumi 81, 666 (1972)

YAP, H. H., D. DESAIAH, L. K. CUTKOMP, R. B. KOCH: Nature 233, 61 (1971)