Effect of Chronic Oral Cadmium Exposure and Withdrawal on Cadmium Residues in Organs of Mice

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Introduction

Cadmium is an environmental contaminant of concern to human health. Exposure to people occurrs mainly by consuming plants and animals which contain varying amounts of cadmium (FLICK ET AL. 1971). It has been reported that cadmium accumulates in soft tissues and that turnover in certain mammalian organs is extremely slow (MATSUBARA-KHAN 1974). The biological half life for this element has been estimated to be 16 to 18 years in man (TSUCHIYA ET AL. 1971). Studies performed recently which estimate the rate of accumulation or loss of cadmium from animal tissues have utilized single oral doses or injections of some radioisotype of this element (MATSUBARA-KHAN, 1974; 1975; HORNER ET AL 1975; CASTERLINE ET AL, 1975). The question arises if these studies can be extropolated to predict similar effects after chronic oral exposure to cadmium which is the most common route of exposure to human beings. In view of the renal and hepatic toxicity of this compound and recently reported effects on liver and kidney enzymes (SINGHAL 1974), chronic exposure could alter pathways of cadmium metabolism and therefore affect excretion and/or accumulation of cadmium in body tissues. Differences in the biological half life of cadmium in mouse organs after oral verses intraperitoneal administration has been reported (MATSUBARA-KHAN 1974).

The purpose of this study was to examine the effects of chronic oral cadmium exposure and subsequent withdrawl on kidney and liver residues of this element.

Methods and Materials

One hundred and eighty 4 week old male SW/Sim mice were divided into three groups of 60 mice each and given either 0, 3 or 300 ppm cadmium as cadmium chloride in deionized drinking water. Mice remained on cadmium-water for 10 weeks and were then given deionzed water for the remainder of the study. Mice were housed in polycarbonate cages with stainless steel lids and fed OSU Rodent Chow ad Libitum which contained less than 0.05 ppm cadmium.

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Groups of 10 mice from each exposure regimen were killed by cervical dislocation at 0, 5, 10, 20, 40 and 180 days after removal from cadmium exposure. The liver and kidneys were collected from each animal immediately after death and stored in glass vials at -70°C. After dry ashing the tissues at 500°C the concentration of cadmium was determined using flame methods on a Varian Model 1200 atomic absorption spectrophotometer.

Results and Discussion

The concentration of cadmium in kidney tissue of mice exposed to 300 ppm Cd in drinking water remained relatively constant for 180 days after discontinuance of cadmium exposure (Table 1).

TABLE 1

Concentration of Cd (ppm wet weight) in Liver and Kidney Tissue of Male Mice Withdrawn After 10 Weeks Exposure to Cd.*

		Days after Cd Withdrawl					
		0	5	10	20	40	180
Control	Liver	<.06		<0.06			<.06
	Kidney	<.15		<0.15			<.15
3 ppm	Liver	1.0	1.1	0.7	1.2	0.8	0.5
	Kidney	2.8	1.9	1.5	2.8	2.0	1.7
300 ppm	Liver	45	44	42	47	34	24
	Kidney	44	42	49	51	52	50

* = average of 7-10 mice per group

Cadmium residues in the liver did not change significantly for the first 20 days after cadmium withdrawl but were decreased approximately 30% by 40 days and 50% by 180 days (Table 1). Cadmium levels in kidney tissue of mice given 3 ppm cadmium were often variable but contained similar cadmium residues at 5 and 180 days post exposure. Chronic oral exposure of mice to 300 ppm cadmium resulted in its accumulation in liver and kidney tissue at approximately a 1:1 ratio. Withdrawl from cadmium after 10 weeks exposure did not result in significant changes in hepatic or renal cadmium concentrations for the first 20 days. After 20 days, cadmium residues in the liver declined, and by 180 days were approximately 50% of the concentration at time of withdrawl. The concentration of cadmium in renal tissue, especially of mice exposed to 300 ppm cadmium, remained relatively constant or was slightly increased during 180 days after withdrawl from cadmium exposure. Since hepatic cadmium began decreasing 20 days after cadmium withdrawl and the renal cadmium remained nearly constant throughout, the liver:kidney ratios changed to 1:1.5 at 40 days withdrawl and

1:2 after 180 days. The data illustrates a difference in cadmium turnover in these organs after chronic exposure. The biological half life of cadmium in liver tissue was approximately 180 days as compared to 43-63 days following single oral doses or injections of cadmium (MATSUBARA-KHAN 1974). The duration and route of cadmium exposure may have affected the retention of cadmium in this organ possibly due to damaging or binding of liver detoxifying enzymes by cadmium.

An estimation of the biological half life of cadmium in renal tissue was not possible at this time due to the stability of this element in the kidney. It is apparent, however, that cadmium bound in the kidney is retained much longer than in hepatic tissue. It has been postulated that this is due to sulfhydral rich areas or the presence of metalothionine in the kidney cortex which selectively bind cadmium (COTZIAS ET AL 1961). Affinity of renal tissue for cadmium also may be an indication of some essential biological process occurring in the kidney which requires the presence of small amounts of cadmium but lacks necessary residue regulating mechanisms.

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