Influence of Lead on Calcium Metabolism

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Calcium content in the food is known to affect lead metabolism (TOMPSETT, 1939; SCHROEDER and BALASSA, 1961; SIX and GOYER, 1970; ANONYMOUS, 1971; HSU et al., 1975), but lead changes some parameters of calcium metabolism, too (YAMAMOTO et al., 1974; HSU et al., 1975). The total calcium transfer through the duodenal wall was significantly decreased in rats treated with certain doses of lead acetate (GRUDEN et al., 1974), while the active transport was not influenced by the same lead doses (GRUDEN, 1975).

The purpose of this study was to find out whether any other parameter of radioactive calcium metabolism in the animals treated with the same lead doses is changed as well.

Methods

The experiments were performed on five-week old female albino rats, 80-100 g body weight. Before and during the experiments the animals were fed a stock diet (1.1% Ca; 0.65% P) and received drinking water ad libitum. Although all animals were treated with lead acetate by gastric intubation, the schedule partly differed from experiment to experiment. The details are given in Tables 1 to 3. Three types of experiments were carried out.

a/ Both lead and radioactive calcium were given to the animals orally only once on the first day.

b/ Lead, ^{47}Ca and a 10 percent $CaCl_2$ solution were administered orally daily for seven days. During the experiment all animals were placed in metabolic cages which enabled separate collection of urine and feces for each animal.

c/ Only lead was given orally for seven days. On the seventh day ^{47}Ca (1 μCi) was administered intraperitoneally.

In all experiments animals were killed on the third day after ^{47}Ca application and all radiocalcium determinations were done by means of Tobor Twin crystal assembly (Nuclear Chicago).

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Results and Discussion

The results are expressed as the mean percent of the dose received by the group, with the standard error of each mean.

The lowest lead dose found to decrease significantly the duodenal calcium transport in vitro, 0.2 mg of lead per day (GRUDEN et al., 1974), did not change the whole body activity of calcium-47 (type "a" experiment) as shown in Table 1.

TABLE 1.

Whole body retention of ^{47}Ca in rats after a single oral dose of lead acetate

No. of rats	Pb/day (mg)	^{47}Ca (% ± S.E.)
8	0	41.99 ± 2.37
8	0.2	43.14 ± 3.18
8	20.0	61.25 ± 2.45

1 µCi ^{47}Ca was applied by gastric intubation either alone (control) or simultaneously with lead acetate (experimental groups) in 1 ml distilled water per animal.

The whole body activity of ^{47}Ca was determined three days after the application of the radioisotope.

A hundred times larger dose, however, increased the whole body retention by 40 percent ($P<0.001$). The effect was of the same level of significance, although not so pronounced after seven days of continuous and simultaneous application of 20.0 mg lead acetate and radioactive calcium (type "b" experiment, Table 2), when the experimental procedure was very near the in vitro experiments (GRUDEN et al., 1974), at least as far as lead pretreatment is concerned.

As the absorption of calcium-47 is equal to its retention in the carcass plus urinary excretion it is obvious that the larger lead dose increased the absorption of radiocalcium from the intestinal tract. In a way, this is contrary to our observations with the isolated intestinal segment (GRUDEN et al., 1974).

Since in the experiment with the everted gut sac the kidneys are excluded we were interested to

see what would happen when radiocalcium is applied intraperitoneally to animals pretreated with lead. There was no difference in the results between the control and the lead treated animals in this type of experiment (Table 3).

The everted gut sac technique also excludes the neurohumoral factors and the variability of the intestinal blood reservoir. Besides, the material transport in vivo takes place mainly through the mucosa and submucosa to blood vessels, while in the isolated intestine we measure the amount of the substance transferred through all layers of the intestinal wall, including lamina muscularis and serosa. All this is, of course, a serious transport barrier (MARTIN and DELUCA, 1968). On the other hand the lead uptake in the intestinal wall is much higher than that of calcium (STANTIĆ and GRUDEN, 1974; GRUDEN and STANTIĆ, 1975). This could partly explain why in vitro certain lead doses diminished calcium transport through the duodenal wall without changing its absorption from the intestinal tract. Further explanation may be sought in the fact that in the in vivo experiments calcium has at its disposal the entire intestinal tract. Although appreciably more calcium would pass through the duodenal wall in a time unit, its absorption will be larger in the more distal parts of the intestine, because of a longer period of time spent there.

Since 20.0 mg per day per 100 g body weight corresponds to a dose of 200.0 mg lead per kg, which is well above the toxic oral dose (POLSON et al., 1971) all this is, fortunately, of a purely academic interest. It is certainly out of the question whether this extremely high lead dose could be "useful" to humans for increasing calcium absorption from the gastrointestinal tract and its retention in the bone.

Summary

Five-week-old female albino rats were given 0.2 or 20.0 mg of lead acetate by gastric intubation daily for seven days. Calcium-47, applied orally or intraperitoneally, was used as marker to assess calcium retention in the body and its excretion by faeces and urine. The animals were killed three days after the last application.

Calcium metabolism was unaffected by the 0.2 mg lead dose, while 20.0 mg lead per day increased its absorption from the intestinal tract.

TABLE 2.

Influence of lead acetate on percent ^{47}Ca activity in the whole body, carcass, urine and feces

No. of rats	Pb/day (mg)	Whole body	Carcass	Urine*	Feces*
10	0	37.65±1.78	38.45±1.87	1.66±0.12	51.47±1.20
9	0.2	34.51±0.73	37.67±1.29	1.74±0.04	47.13±1.45
10	20.0	51.17±2.39	53.04±2.35	1.92±0.24	39.39±1.52

Lead and ^{47}Ca in a dose of 1 μCi were applied to the experimental groups by gastric intubation simultaneously daily, during 7 days.

All measurements were done three days after the last application.

*The ^{47}Ca activity was determined in the total urine and feces collected for each animal during the entire experimental period.

TABLE 3. Influence of lead treatment on retention and excretion of ^{47}CA intraperitoneally applied to rats.

No. of rats	Pb dose (mg)	Whole body	Urine	Feces
11	0	86.56 ±1.19	6.85 ±0.74	7.76 ±0.42
11	20.0	85.30 ±1.59	7.64 ±1.20	7.77 ±0.53

1 µCi ^{47}Ca was applied intraperitoneally to all animals; measurements were performed three days after application.

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References

ANONYMOUS: Nutr. Rev. 29, 145 (1971).
GRUDEN, N., M. STANTIĆ and M. BUBEN: Environ. Res. 8, 203 (1974).
GRUDEN, N. and M. STANTIĆ: Sci. Total Environ. 3, 288 (1975).
HSU, F.S., L. KROOK, W.G. POND and J.R. DUNCAN: J. Nutr. 105, 112 (1975).
MARTIN, D.L. and H.F. DELUCA: Arch. Bioch. 134, 139 (1969).
POLSON, C.J. and R.N. TATERSALL: Clinical toxicology. London:Pitman Medical Scientific Publishing Co. Ltd. 1971.
SCHROEDER, H.A. and J.J. BALASSA: J. Chron. Dis. 14, 408 (1961).
SIX, K.M. and R.A. GOYER: J. Lab. Clin. Med. 76, 933 (1970).
STANTIĆ, M. and N. GRUDEN: Arh. hig. rada 25, 423 (1974).
TOMPSETT, S.L.: Biochem. J. 33, 1237 (1939).
YAMAMOTO, T., M. YAMAGUCHI and Y. SUKETA: Toxicol. Appl. Pharmacol. 27, 204 (1974).