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Influence of Trace Elements on Cadmium and Mercury Absorption in Sucklings

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The high intestinal absorption of toxic metals in neonates found in experimental animals and humans (NORDBERG et al. 1978, KOSTIAL et al. 1978) is a matter of general concern specially in conditions of increased environmental exposure. The reason for the high absorption is not yet clear. The low concentration of iron in milk, which is the only nutrient at this age, was supposed to be one of the factors influencing the increased absorption of metals. However, we have found recently that the suckling rats artificially fed on milk with iron additive (100 ppm Fe) retained the same fraction of orally administered cadmium, mercury and manganese as control rats fed on cow's milk (KOSTIAL et al. 1980). Milk, however, is not only low in the iron content but also in the content of other essential trace elements which might influence the absorption of toxic metals (NORDBERG et al. 1978).

The purpose of this work was to evaluate whether a simultaneous increase in the concentration of several essential trace elements in milk i.e. iron, zinc, manganese and copper influences the retention of the orally administered cadmium and mercury in sucklings.

METHODS

The experiment was performed on six-day-old suckling albino rats. They were kept with their mothers in litters of six (adjusted to this number within 24 hours after birth) throughout the experiment which lasted eight days. Two sucklings from each litter (16 litters altogether) were artificially fed over three days: one with cow's milk (control) and the other with cow's milk with a trace element additive (TE): 100 ppm Fe, 50 ppm Zn, 200 ppm Mn, 20 ppm Cu. The trace elements were added as chlorides with the exception of iron which was added as sulphate.

The artificial feeding was performed by the method of KOSTIAL et al. (1967). Milk was administered

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by means of a dropper for seven hours daily. Each suckling received a volume of about 0.5 ml of milk daily. During the second day of the artificial feeding radioactive isotopes were added to milk. The sucklings from nine litters (nine sucklings on cow's milk, nine on milk with TE additive) received about 10 µCi ^{115m}Cd and sucklings from seven litters (seven sucklings on cow's milk, seven on milk with TE additive) received about 2 µCi ^{203}Hg. Both radioisotopes were supplied from the Radiochemical Centre, Amersham, England and their specific activity was about 0.5 mCi/mg Cd and 1 mCi/mg Hg. The sucklings were killed seven days after the administration of the radioactive isotopes by excess of ether. The total intestinal tract distal to diaphragm (including the contents) was removed and radioactivity was determined in the gut free carcass and in the intestinal tract (gut) in a double crystal scintillation counter (Tobor, Nuclear Chicago). The radioactivity of the liver, kidneys and brain was determined in an automatic gamma counter (Nuclear Chicago). All values were expressed as a percentage of the administered dose after adequate corrections were made for radioactive decay and sample geometry. Whole body retentions were calculated as the sum of the carcass and gut retentions, and the gut retentions were also expressed as the percentages of the whole body radioactivity (G%WB). The results are presented as arithmetic means and standard error of the means. Student's t-test was used for evaluating the statistical difference between the arithmetic means.

RESULTS

The addition of trace elements to milk caused an increase in the whole body retention of ^{115m}Cd (1.8 times higher than in controls) (Table 1). The increase was due to a much higher cadmium retention in the gut (2.5 times) since the addition of trace elements decreased cadmium retention in all other parts of the body (carcass 1.4, liver 1.5, kidneys 1.6, brain 1.5 times lower than in controls). Gut retention in the trace element treated animals represented a higher fraction of the total body radioactivity than in controls (1.4 times).

The addition of trace elements to milk caused no changes in the whole body retention of ^{203}Hg (Table 1). The gut retention was slightly decreased (1.3 times lower than in controls) and the retention in other parts of the body was slightly increased (carcass 1.4, liver 1.3, kidneys 1.6, brain 1.5 times higher than in controls). The gut retention in the trace element treated animals represented a lower fraction of the total body radioactivity than in controls (1.2 times).

TABLE 1

Influence of trace element additives to milk on ^{115m}Cd and ^{203}Hg body and organ retention in six-day-old suckling rats (per cent oral dose seven days after administration)

Compartment presented	Dietary treatment		Level of significance P<
	Milk	Milk + TE[a]	
	^{115m}Cd		
No of rats	9	9	
Whole body[b]	18.19 ±0.65[c]	31.90 ±5.20	0.02
Carcass[d]	7.78 ±0.72	5.40 ±0.31	0.01
Gut[d]	10.42 ±1.23	26.50 ±5.13	0.01
Gut%Whole body[b]	56.09 ±5.22	80.04 ±2.64	0.001
Liver[d]	5.00 ±0.56	3.29 ±0.27	0.02
Kidneys[d]	0.41 ±0.03	0.25 ±0.02	0.001
Brain[d]	0.047±0.006	0.031±0.002	0.05
	^{203}Hg		
No of rats	7	7	
Whole body[b]	52.86 ±3.08	48.85 ±2.70	n.s.[e]
Carcass[d]	12.28 ±0.91	17.25 ±0.53	0.001
Gut[d]	40.57 ±2.93	31.59 ±2.90	0.05
Gut%Whole body[b]	76.36 ±2.17	63.98 ±2.37	0.01
Liver[d]	3.96 ±0.29	5.25 ±0.19	0.01
Kidneys[d]	2.26 ±0.20	3.58 ±0.20	0.001
Brain[d]	0.18 ±0.01	0.27 ±0.02	0.001

[a]TE = 100 ppm Fe, 50 ppm Zn, 200 ppm Mn, 20 ppm Cu

[b]calculated values: Whole body = Carcass + gut;
Gut%Whole body = Gut x 100/Whole body

[c]arithmetic means ± SEM

[d]measured values

[e]not significant

Radioactive isotopes were administered to rats during the second day of the three-day artificial feeding with cow´s milk or cow´s milk with TE additives.

DISCUSSION

It is known that the effects of exposure to a toxic element such as cadmium or other metals may vary depending on interactions with other elements which are present in the diet in different concentrations (FOX 1979). Among a wide range of nutritional factors which influence the susceptibility to heavy metal toxicity the intake of essential metals including calcium, iron, zinc and copper is of particular importance (BREMNER 1979). The effect is assumed to occur mainly at the level of the gastrointestinal absorption (BREMNER 1974). The fact that the addition of trace elements to the diet fed to sucklings had very little influence on the absorption of cadmium and mercury is in agreement with our previous findings, that absorption processes in sucklings are generally very different from those in adults (KOSTIAL et al. 1979). Our results also clearly indicate that the lower concentration of trace elements in milk is not the main reason for a higher metal absorption in neonates since the sucklings which received trace elements in milk had a much higher whole body and carcass retention of cadmium and mercury than adult rats (one per cent or less of the oral dose - KOSTIAL et al. 1978).

The addition of trace elements caused small but statistically significant changes in the whole body, gut and organ retention of orally administered ^{115m}Cd and ^{203}Hg. While the effect of cadmium resulted in an increased gut, but decreased organ retention, the effect of mercury was opposite i.e. decreased gut and increased organ retention. This indicates a different mechanism in trace element interaction in the process of cadmium and mercury absorption in neonates which deserves further attention.

Our present results confirm the importance of the "gut compartment" of metals in sucklings pointed out earlier (KOSTIAL et al. 1979). More data on the significance of this compartment in evaluating the metabolism and toxicity of metals in the youngest age group are needed.

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