Effect of Phosphates, Carbonates, and Magnesium Oxide upon the Intestinal Absorption of Sr-85 in Rats

In our previous communications, various sulphates and their combinations were shown to be effective means for diminishing the absorption of radioactive strontium from the intestine shortly after exposure[1,2]. Furthermore, the effect was compared of various posphates, carbonates, and magnesium oxide upon the metabolism of orally administered Sr-85 in rats.

Methods. The same experimental procedure was used as with sulphates; details have been reported previously[2]. In all, 93 starved male Wistar albino rats, weighing 170 to 200 g, were used. The substances tested were administered by stomach tube (1.6 mM each), 10 min after an oral dose of carrier-free Sr-85 chloride solution. The animals were sacrificed 48 h later.

Results. The Table summarizes data from 4 experiments. In the skeleton of rats treated with disodium, calcium hydrogen or tricalcium phosphates, 40–65% less Sr-85 was retained in comparison with controls. In the group receiving tricalcium phosphate in combination with disodium phosphate, the average skeletal retention of Sr-85 was reduced by nearly 90%.

Among the various carbonates tested, only calcium carbonate proved effective, reducing the whole body retention of Sr-85 by 40% in comparison with controls. In rats receiving magnesium oxide, 50% less Sr-85 was retained. When the carbonates were administered, each in combination with an equimolar dose of magnesium oxide, the average retention of Sr-85 decreased in all treated animals by about 50–60% in comparison with controls, i.e. approximately as much as with magnesium oxide alone.

Calcium and magnesium carbonates, each with an equimolar dose of sodium hydrogen carbonate, were also administered. No significant effect on the retention of Sr-85 was observed, although there was a trend towards lower values with the former combination.

Discussion. Copp and Greenberg[3] found that a 5% suspension of tricalcium phosphate in 12.5% disodium phosphate solution reduced intestinal absorption of radiostrontium in rats, but only when given immediately afterwards. 10 min later, disodium phosphate or sodium bicarbonate were without effect. MacDonald et al.[4] reduced skeletal retention of orally administered Sr-90 by up to 60% when administering simultaneously disodium or trisodium phosphates. According to Bruce[5], calcium hydrogen phosphate mixed with cellulose and moistened with a solution of sucrose, when given shortly after radiostrontium, reduced its intestinal absorption in rats by up to 85%. In our previous experiments[6], the skeletal retention of orally administered Sr-90 decreased approximately to the same extent when rats were treated immediately afterwards with a special tricalcium phosphate preparation. In the present study, the decontamination effect of various phosphates did not differ substantially, whereas a mixture of tricalcium and disodium phosphates was significantly more effective.

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The effect of various phosphates, carbonates, magnesium oxide and their combinations administered orally in doses of 1.6 mM 10 min after contamination with Sr-85

Substances tested	No. of animals	% of Sr-85 administered					
		Whole body				Skeleton[a]	
		After 24 h		After 48 h		After 48 h	
		$\bar{x} \pm ts_{\bar{x}}$[b]	% of control	$\bar{x} \pm ts_{\bar{x}}$	% of control	$\bar{x} \pm ts_{\bar{x}}$	% of control
Controls	6	42.4 ± 10.2	100	34.8 ± 11.0	100	26.8 ± 9.1	100
Na_2HPO_4	5	31.2 ± 10.7	n.s.[c]	21.0 ± 7.8	56	13.5 ± 3.7	50
$CaHPO_4$	5	16.5 ± 2.3	39	11.5 ± 1.7	33	9.4 ± 2.8	35
$Ca_3(PO_4)_2$	5	19.4 ± 3.5	46	13.8 ± 2.0	39	10.3 ± 2.6	38
$Ca_3(PO_4)_2 + Na_2HPO_4$	5	11.4 ± 9.4	27	6.3 ± 2.5	18	3.6 ± 1.2	13
Controls	6	39.5 ± 10.2	100	33.1 ± 10.1	100	25.3 ± 8.0	100
$NaHCO_3$	5	33.1 ± 5.1	n.s.	26.4 ± 19.1	n.s.	22.6 ± 3.8	n.s.
$CaCO_3$	5	25.4 ± 6.1	64	19.5 ± 6.0	59	17.4 ± 7.9	n.s.
$MgCO_3$	5	38.0 ± 17.0	n.s.	27.3 ± 10.5	n.s.	20.6 ± 5.7	n.s.
MgO	5	25.9 ± 7.8	66	15.5 ± 7.4	47	12.5 ± 7.5	49
Controls	6	50.1 ± 21.0	100	46.1 ± 22.0	100	31.8 ± 7.6	100
$NaHCO_3$ + MgO	6	30.2 ± 16.7	n.s.	24.5 ± 13.5	n.s.	14.6 ± 7.9	46
$CaCO_3$ + MgO	6	36.1 ± 8.2	n.s.	25.2 ± 6.5	n.s.	14.9 ± 4.1	47
$MgCO_3$ + MgO	5	31.0 ± 23.7	n.s.	19.6 ± 5.2	43	13.8 ± 3.2	43
Controls	6	28.4 ± 9.2	100	25.3 ± 10.0	100	20.2 ± 9.9	100
$CaCO_3 + NaHCO_3$	6	22.5 ± 8.1	n.s.	16.2 ± 7.3	n.s.	12.0 ± 5.9	n.s.
$MgCO_3 + NaHCO_3$	6	31.2 ± 8.0	n.s.	26.2 ± 5.6	n.s.	17.1 ± 4.6	n.s.

[a] Content of Sr-85 in 1 femur times 20. [b] Arithmetic mean ± standard error of the mean multiplied by t-value for 95% confidence level. [c] The difference is not statistically significant.

It seems not unreasonable to attribute the inhibitory effect of phosphate to a precipitating action on radiostrontium in the gut[4]. This might be the case should carrier strontium be present. With tricalcium phosphate, radiostrontium is most probably bound mainly by adsorption and ion exchange, especially when excess phosphate ions are added in the form of disodium phosphate. It should also be remembered that the latter acts as saline cathartic which is a certain advantage, because tricalcium phosphate alone causes constipation.

The carbonates tested, and also magnesium oxide, act as antacids. In vitro, calcium and magnesium carbonates in equimolar doses neutralize twice as much hydrochloric acid as sodium hydrogen carbonate; magnesium oxide has even greater antacid effect, because no carbon dioxide is formed during neutralization. In vivo, sodium hydrogen carbonate is a systemic antacid with a high neutralizing power, while calcium and magnesium carbonates and magnesium oxide act in the stomach as local antacids. The resulting calcium chloride is a mild astringent, whereas the magnesium chloride formed is a mild purgative.

In our experiments, magnesium oxide reduced the retention of Sr-85 twofold; carbonates, with the exception of calcium carbonate, were ineffective. Magnesium oxide was also administered immediately before the carbonates, because it was expected that in the alkalinized medium of the stomach they might be effective. In addition, the mixture of magnesium oxide and sodium hydrogen carbonate has both local and systemic antacid effect and the constipating effect of calcium carbonate might be balanced by the laxative effect of magnesium salt. However, the combinations were no more active than magnesium oxide alone.

Similarly, when sodium hydrogen carbonate was administered with calcium or magnesium carbonates, no marked effect on the retention of Sr-85 was observed. These results would indicate that strong alkalization of the stomach contents was not as important as the presence of magnesium oxide as such[7].

Zusammenfassung. Unter diversen Phosphaten, Karbonaten und Magnesium-Oxyd zeigte die Kombination Trikalzium-Dinatriumphosphat im Skelett die stärkste Reduktion des Radiostrontiumgehalts (fast 90%).

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A Histochemical Study on the Fundamental Plan of the Central Nervous System

As an architectural principle of the central nervous system, it has been known that the sulcus limitans of HIS runs rostrocaudally on both lateral walls of the neural tube and that the visceral areas derive from the portions along the sulcus. According to KINGSBURY[1], the sulcus limitans terminates rostrally in the hypothalamus, which plays the most important role as the automatic centre. On the other hand, BRODIE and SHORE[2] reported the significance of norepinephrine and serotonin as chemical transmitters for the visceral functions in the brain. Therefore, the authors decided to trace the distribution of monoamine oxidase metabolizing catecholamines and serotonin in the central nervous system, with due consideration of the sulcus limitans.

As material, chick embryos of 5, 9 and 14 days' incubation were used. The fresh and unfixed head of the chick embryos were cut into serial frontal and sagittal sections of 30 μ with use of the cryostat. The Glenner method was utilized for demonstrating monoamine oxidase. At the same time, the distribution of succinic dehydrogenase was demonstrated with the Nachlas method, in order to compare with the distribution patterns of monoamine oxidase.

After 5 days' incubation, the brain and the spinal cord scarcely show the reaction of monoamine oxidase and succinic dehydrogenase. After 9 days' incubation, the monoamine oxidase activity (Figures 1 and 2) is markedly demonstrable in the septal part, preoptic area, hypothalamus, periventricular part of the thalamus, central grey of the mesencephalon and areas along the sulcus limitans and the raphe of the medulla oblongata and spinal cord. After 14 days' incubation, the hippocampus and paleo- and archistriatum show an intense activity of monoamine oxidase, besides the portions representing the activity of this enzyme after 9 days' incubation. On the other hand, the succinic dehydrogenase reaction is not shown in areas which are positive for the monoamine oxidase activity, but appear faintly in the parts of each striatum facing the lateral ventricle, optic tectum and nucleus rotundus after 9 days' incubation, and moreover, in each nucleus of the thalamus after 14 days' incubation.

From the above-mentioned results, monoamine oxidase activity is recognizable intensely and clearly in the visceral portions adjacent to the sulcus limitans and the hypothalamus, and, moreover, the preoptic and septal areas, which are thought to be functionally the visceral parts extending rostrally to the hypothalamus. Furthermore, the hippocampus, the phylogenetically old parts of the striatum, and the raphe originating the floor plate, show a strong reaction of monoamine oxidase compared with the somatic areas. In contrast to the distribution pattern of monoamine oxidase, the succinic dehydrogenase activity is shown to be relatively intense in the somatic areas. It is emphasized that the activity of the enzymes metabolizing the chemical regulators, such as catecholamines and serotinin, is clearly shown in the neighbourhood of the sulcus limitans in early stages of the development of the brain compared with the activity of succinic dehydrogenase, which participates in aerobic respiration.

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