PASSAGE OF STRONTIUM-90 AND CALCIUM-45 THROUGH THE PLACENTA IN RATS

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In spite of the similarity of the strontium and calcium metabolism in the organism, a definite difference is observed at individual stages of the metabolism of these elements. It is manifested in a discrimination of strontium, expressed in a predominant accumulation of calcium in the skeleton in comparison with strontium. To characterize the differences in the mineral exchange of two such elements as strontium and calcium, Comar and co-authors [4] proposed the term "observed ratio" (OR) strontium/calcium, denoting the different behavior of these two elements with respect to accumulation in the skeleton (or any other tissue) in comparison with their content in the food.

It has been shown in a number of investigations that discrimination of strontium also exists during the period of pregnancy in the case of the passage of strontium and calcium through the placenta to the fetus. Table 1 presents the experimental data of various authors, showing the "observed ratio" Sr/Ca in the fetus in comparison with Sr/Ca in the diet of the mother or in the mother's organism. The first ratio defines the discrimination of strontium in the passage of both elements from the diet to the fetus, while the second defines the discrimination in the case of passage from the mother through the placenta to the fetus. The smaller the value of this ratio, the greater the discrimination of strontium with respect to calcium. We can see from Table 1 that when strontium and calcium pass from the food ration to the fetus, the "observed ratio" varies from 0.08 to 0.20, while in the case of passage from the mother through the placenta it varies from 0.43 to 0.65 in various species of animals and man.

The data cited were obtained under conditions of constant entry of radioactive strontium and calcium into the organism with the food during the period of pregnancy. In connection with this, it was of interest to determine the value of the discrimination of the placentary passage of strontium with respect to calcium in the case of entry into the mother's organism before the beginning of pregnancy. Under these conditions, the introduced strontium and calcium were found almost entirely in the mother's skeleton at the onset of pregnancy and would be liberated from there during the process of pregnancy.

EXPERIMENTAL METHODS

In the experiment we used the "double label" method, which consists of a simultaneous administration of two radioactive isotopes to the experimental animals, followed by separate measurement of their radioactivities in the same tissue samples.

The experiments were conducted on 21 sexually mature female rats, 150-180 g in weight, 5-6 months of age. The selected females were intraperitoneally injected with Ca^{45} and Sr^{90} (in equilibrium with Y^{90}) simultaneously (in two administrations): Ca^{45} in the form of an aqueous solution of calcium gluconate in amounts of 0.4 microcuries per gram of body weight, Sr^{90} in the form of a solution of strontium hydrochloride in amounts of 0.4 microcuries per gram of body weight.

The females were placed together with males 12 days after the injection of the radioactive isotopes. After another 28 days, the offspring were obtained from them. Each mother rat gave birth to an average of seven rats in a litter (fluctuations from three to 12), with an average weight of one newborn of 5.0 ± 0.3 g. Immediately after the births, the newborn rats and their mothers were killed. The cranium, spine, and femur were isolated from the mother rats to determine the $Sr^{90} + Y^{90}$ and Ca^{45} content, and samples were prepared from them by the method of

TABLE 1. Discrimination of Strontium with Respect to Calcium in Passage through the Placenta to the Fetus (Literature data)

Subject of Investigation	"Observed ratio" Sr/Ca		Investigation procedure	Authors
	fetus/food	fetus/mother		
Rats	0.17	0.65	Constant entry of Ca^{45} and Sr^{85} with the drinking water during pregnancy. Rats killed five days before labor	Wasserman et al. [8]
	0.20	0.61	Ca^{45} and Sr^{90} in the diet during pregnancy	Comar and Wasserman [5]
Rabbits	–	0.49	Intravenous injection of 6,000 microcuries Ca^{45} and 20 microcuries Sr^{85}. Comparison of Sr/Ca in the blood of the mother with Sr/Ca in the fetus	Wasserman et al. [8]
Sheep	0.09	0.43*	Feeding for six months with hay containing Sr^{90} (concentration of radioactivity 0.05 microcuries/kg of hay). Comparison of Sr^{90}/Ca in the skeleton of the mother and fetus (3-4 months of development)	L. N. Buldakov and Yu. I. Moskalev [1]
Man	0.08	–	Comparison of Sr^{90}/Ca in the diet of the mother and in the bones of the fetus under conditions of natural entry	Kulp and Schulert [7]

* We determined this index on the basis of the data of the literature source.

ashing in a muffle furnace for radiometric analyses. The amount of radioactivity that had passed through the placenta during the entire pregnancy was determined according to the amount of radioactivity in the newborn rats immediately after birth. The radioactivity content in the off spring was determined summarily for all the newborn rats of each litter from one mother. The crania of all the baby rats of one mother were isolated, pulverized, and mixed; crude samples on a target (30 mg) were prepared from them. The corpses of all the baby rats from each rat were ignited together, and weighed samples on a target (30 mg) were prepared from their ash. Then the $Sr^{90} + Y^{90}$ (with corresponding two-week exposure) and Ca^{45} (with corresponding correction for decay) contents were determined separately in all the samples, using radiometric analyses on the B setup.

The data obtained on the concentration of the introduced isotopes in the tissues of the mother and in the newborn rats were expressed in the form of the coefficient of differential accumulation (CDA), which was equal to the ratio of the concentration of the radioactive substance in one gram of tissue to the amount of the introduced dose of this isotope per gram of body weight of the animal. The total amount of each radioactive isotope in one newborn rat and in all the baby rats of the litter from one mother were expressed in percent of the amount of isotope administered to the mother.

EXPERIMENTAL RESULTS

In the case of intraperitoneal injection of Sr^{90} and Ca^{45} into the mother's organism and their passage to the offspring through the placenta during the period of pregnancy, discrimination of strontium in favor of calcium is observed.

The data presented in Table 2 the comparative deposition of these isotopes and the value of the discrimination of Sr with respect to Ca during the period of pregnancy. The Sr^{90}/Ca^{45} ratio in the new born rats was 0.54 ± 0.07 (according to the average concentration of the isotopes in the baby rats) of the Sr^{90}/Ca^{45} ratio observed after injection into the intraperitoneal cavity. On the basis of this index, we can conclude that during the period of pregnancy in rats, calcium possesses almost twice as great an ability as strontium to pass through the placenta from the organism

TABLE 2. Comparative Deposition and "Observed Ratio" $Sr^{90} + Y^{90}/Ca^{45}$ in the Mother and Newborn Rats at the Moment of Birth, 40 Days after Administration

Index determined	$Sr^{90} + Y^{90}$	Ca^{45}	"Observed ratio"*
CDA in mother rats:			
in cranium	3.85±0.84	3.45±0.64	1.11±0.08
in spine	0.81±0.14	0.85±0.14	0.97±0.08
in femur	2.39±0.40	2.27±0.29	1.06±0.06
CDA in newborn rats:			
in corpse	0.045±0.005	0.075±0.015	0.54±0.07
in cranium	1.06±0.09	1.95±0.20	0.54±0.03
Total radioactivity of one baby rat (in % of introduced amount)	0.10±0.01	0.20±0.03	0.54±0.07
Total radioactivity of all the rats of the litter (in % of the introduced amount)	0.73±0.03	1.53±0.05	0.56±0.07

* The values of the "observed ratio" were calculated from the individual "observed ratios."

of the mother and to accumulate in the developing embryos. The value of the "observed ratio" Sr^{90}/Ca^{45} obtained in our experiment upon passage from the mother to the offspring during the period of pregnancy corresponds to the data cited by other researchers (see Table 1).

The same "observed ratio" Sr^{90}/Ca^{45} was also obtained fro the developing rat cranium – 0.54 ± 0.03. The absence of any difference between the Sr^{90}/Ca^{45} ratio in the entire body of the baby rat and the Sr^{90}/Ca^{45} ratio in the cranium of the baby rat confirms the data existing in the literature [8], according to which Sr and Ca are deposited in equal ratio in the developing skeleton of the embryo when they are introduced directly into the amniotic fluid, i.e., there is no discrimination of Sr in this case. Thus, the discrimination of Sr observed in the accumulation of these radioactive isotopes in the fetus occurs during the passage of the elements through the placenta, while the process of deposition of the entered mineral salts in the developing skeleton does not differentiate between strontium and calcium.

It is not without interest to compare these data with the data on the deposition of Sr^{90} and Ca^{45} in the skeleton of the mother. As can be seen from Table 2, the "observed ratio" Sr^{90}/Ca^{45} in the skeletons of the mother rats is close to unity. From this it follows that when Sr^{90} and Ca^{45} are intraperitoneally injected simultaneously into mother rats, essentially no differences in the deposition of these isotopes in the skeleton are observed. This confirms the opinion of a number of researchers that the skeleton probably does not differentiate between strontium and calcium in trace amounts.

The described placentary discrimination during the period of pregnancy will also determine the ratio of the concentration of radioactivity in the skeleton of the mother and in the skeleton of the newborn rat. Thus, in our experiment the fraction that the concentration of radioactivity in the cranium of the baby rat should comprise with respect to the concentration of radioactivity in the cranium of the mother was equal to 0.27±0.04 for Sr^{90} and 0.56± 0.4 for Ca^{45}.

SUMMARY

As the results of a single intraperitoneal administration to rats of 0.4 C/gm of Ca^{45} and 0.4 C/gm of Sr^{90}, in equilibrium with Y^{90} 12 days before mating and 40 days prior to labour the passage of strontium to the fetus through the placenta during pregnancy was found to be discriminated against in favor of calcium. The extent of strontium discrimination, while from the maternal organism it reached the fetus via the placenta, was characterized by an "observed ratio" of Sr^{90}/Ca^{45} in the organism of the newborn ratling equaling numerically 0.54 ± 0.07. Comparative volume of strontium and calcium in the maternal skeleton during pregnancy was characterized by "observed ratios" of Sr^{90}±Ca^{45} which by the time of birth comprised: for cranial bones 1.11±0.08, for the spine – 0.97±0.08 and for the femoral bone – 1.06± 0.06.

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